Competition and subsidy in commercial shipbuilding

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Dedication

Dedicated to the memory of my father Albert Edward Stott (1926 to 1978), who started life as an apprentice sheet metal worker at the Cammell Laird shipyard in Birkenhead and who would have made a much better job of this but was never given the chance. I still haven't read *Mathematics for the Million* (1936) by Lancelot Hogben (his recommendation for improving my mathematical ability), but plan to do so – some day!

Abstract

Limitations in the shipbuilding industry's understanding of the precise workings of its market have led to difficulties in the prosecution of a subsidy and countervailing measures case in WTO and to obstacles in the furtherance of an international shipbuilding agreement in OECD. Weaknesses stem in particular from lack of precision in the definition of the market, from incomplete understanding of the concept of 'like product' as it relates to commercial shipbuilding, and from limited research into cross price elasticity.

In this dissertation the nature and boundaries of the market are investigated, leading to a simple definition of the 'international commercial shipbuilding market'. This differs from existing definitions, for example in OECD and EU, in that it is based on the attributes of the shipbuilder, rather than attributes of the product. A meaning of 'like product' that is consistent with WTO case law is defined for commercial shipbuilding, with the conclusion that likeness between products should be determined by competition for the same units of capacity. Technical substitutability of a unit of shipbuilding capacity is analysed in relation to factors that determine competitiveness, concluding that substitutability is wide with few exceptions and that technical aspects of the products are therefore of limited significance in determination of 'likeness'. Correlation and linear regression are used to demonstrate empirically that cross price elasticity exists in the commercial shipbuilding market, thereby establishing that apparently dissimilar products, such as an LNG tanker and a capesize bulk carrier, may compete for capacity in the same market and can therefore be considered as 'like products'.

The nature of market leaders, pursuing competitiveness through high investment and economies of scale, and the persistence of cycles in demand mean that subsidy and conflict are likely to remain a feature of competition in international commercial shipbuilding. Conclusions presented in this dissertation will assist in the future analysis and definition of such conflicts and hopefully also in resolution. It is hoped that conclusions will also assist in the pursuit of improved governance of the industry at the inter-governmental level.

Contents

List of tables

List of figures

Abbreviations

AOA	WTO Agreement on Agriculture
BLS	United States Bureau of Labor Statistics
CESA	The Committee of European Shipbuilders' Associations
CGT	Compensated Gross Tons
CSSC	China State Shipbuilding Corporation
Cu.M	Cubic Metres
DSME	Daewoo Shipbuilding and Marine Engineering
Dwt	Deadweight Tonnes
EC	European Commission
EU	European Union
FPSO	Floating Offshore Production and Storage Vessel
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GRP	Glass Reinforced Plastic
GT	Gross Tonnage
HHI	Hyundai Heavy Industries
ICS	Institute of Chartered Shipbrokers
KG	Kommanditgesellschaft – German limited partnership investment company
Korea-commercial vessels	WTO case number DS273, with full title "Korea – Measures Affecting Trade in Commercial Vessels"
LM	Lane Meters, measuring capacity of roro vessels

LNG	Liquid Natural Gas (methane)
LPG	Liquid Petroleum Gas
LR	Lloyd’s Register of Shipping
obo	Oil / bulk / ore carrier
OECD	Organisation for Economic Co-operation and Development
OED	Oxford English Dictionary
OSV	Offshore Support Vessel (or, sometimes, Offshore Supply Vessel)
PCC	Pure Car Carrier
Roro	Roll-on-roll-off
S&P	Sale and Purchase
SCM	Subsidies and Countervailing Measures, with reference to WTO agreements
SNAME	The Society of Naval Architects and Marine Engineers of the United States
T2	Standard tanker built in large numbers in the United States in WWII
TEU	Twenty-foot Equivalent Unit
ULCC	Ultra Large Crude Carrier (NOT, as in current usage, Ultra Large Container Carrier)
VLCC	Very Large Crude Carrier
VLGC	Very Large Gas Carrier
VSM	Verband Fur Schiffsbau und Meerstechnik (German Shipbuilding and Ocean Industries Association)

WP6	Working Party 6 of the OECD, i.e. the working party on shipbuilding
WTO	World Trade Organization
WWII	World War Two (1939 to 1945)

Note on key commercial data sources

Two key commercial data sources have been used in producing this work: IHS Sea-Web and Clarksons Shipping Intelligence Network.

- Sea-web is available at www.sea-web.com. It is published by IHS Golbal Limited. The database contains, inter alia, technical, ownership and shipbuilding details of registered ships over 100 gross tons, and includes around 180,000 records as at January 2017. Sea-web retains records of ships that no longer exist (referred to as 'dead' ships in the database), which enables historic as well as current data to be accessed.
- Clarksons SIN is available at www.sin.clarksons.net. It is published by Clarkson Research Services Limited and provides monthly time series data on the main shipping markets, including prices, rates and demand.

Both data sets are provided on-line for use in real time.

Data annex

This dissertation is accompanied by a data annex, giving details of data and statistical results that are summarised in the text.

1. Introduction and statement of the problem

Shipbuilding is the manufacturing and assembly industry that creates new ships and this dissertation concentrates on the ‘commercial’ sector of that industry. What precisely is meant by the term ‘commercial’ in this context is an important part of this research but at the most basic level this separates the sector of interest from warship building, which is economically a very different business. The research also deals with shipbuilding yards, which means facilities for the construction, launching and delivery of new ships, as opposed to shiprepair yards that are part of the service sector of industry.

Commercial shipbuilding is periodically plagued by overcapacity, being slow to respond to changes in demand, and this is the status of the industry prevailing at the time that this research is being undertaken. Zannetos remarked on the general trend in his influential work on the tanker markets in the 1960s, rationalising what persons operating in the industry know to be a general truth: *“As soon as prices per Dwt start their upward trend, the shipbuilders rush to accept orders and, in general, become very accommodating. They promise early delivery, omit escalation clauses (that is, quote fixed prices), grant liberal credit terms, and so on. This situation, however, does not last long; soon the shipbuilders play “hard to get” and assume the upper hand with demands for the total payment even before delivery, escalation clauses, and five to six year delivery schedules. At the same time, instead of devoting all their capacity to shipbuilding, they start employing part of their organization efforts to expansion, thus cutting their capacity somewhat for the purposes of building future capacity”* (Zannetos, 1966, p. 79). The capacity developed tends to be persistent in the face of periodic downturns in demand, leading to the cyclical periods of overcapacity. Shin and Lim, for example, comment in considering shipbuilding competitive strategy in the post-2008 era that: *“Widespread overcapacity has pushed ship prices to below economic levels for quite some time”* (Shin and Lim, 2013). The Editorial Comment section of the Naval Architect Magazine in February 2014 was titled: *“Overcapacity policy key to balanced shipbuilding industry”* and in a 2013 publication funded by the State of Finland, aiming to identify best practise in surviving the prevailing downturn in commercial shipbuilding, the authors stated:

“During the last century, the European shipbuilding industry ran into two similar crises caused by the overcapacity of shipyards”. (Keltiniemi et al., 2013).

The prevailing problem is only the latest incarnation of an issue that the OECD has been trying to resolve since the 1960s and which, in reality, is probably as old as the industry itself. In discussing investment in British shipyards between 1860 and 1880 for example, leading up to the apogee of British dominance of the industry, Pollard and Robinson note of investors: *“The highly cyclical nature of the industry, however, weakened them financially and tempered their enthusiasm for expansion”* (Pollard and Robertson, 1979, p. 26). At this early stage, however, downturns tended to be relatively short lived: *“The amount of tonnage produced fluctuated tremendously over short periods and facilities built during a boom were often under-employed for five or more years”* (*ibid*.). Even earlier than this Slaven notes: “*Between 1815 and 1883…the industry experienced seven great cycles of expansion and contraction, each roughly of nine to ten years duration”* (Slaven, 2013, p. 16) and, referring to earlier times again, notes that: *“New shipbuilding had few equals as an industry beset with cyclical fluctuations. This was hardly less true in the days of wooden ships than it was after the arrival of metal hulls, although from that time onwards the larger yards frequently meant that the consequences of these fluctuations were more disastrous for both workers and their employers”* (Clarke, 1997, p. 1). The echoes of the pitfalls of larger yards have a very strong resonance with the current era, as will be discussed later. Clarke further notes that: *“Variations in demand for shipbuilding were already evident in the 17th Century as reflected in the fluctuations of new apprentices enrolled in the Newcastle Shipwrights”* (*ibid*., p. 5).

Significant peaks in output in global shipbuilding have, in fact, recurred every 25 to 30 years for the past century. The nature of this cyclicality is analysed in the next section of this dissertation. It is useful to summarise the views of others on this subject, however, here. A succinct statement made by Parkinson in 1960 sums up the effects of a key underlying driver: *“Improvements in freights lead to a tendency to over-order and depressions to a tendency to postpone even replacements”* (Parkinson, 1960, p. 79). Because replacements are postponed the supply of shipping capacity becomes tighter over time, as seaborne trade grows, leading to increased freight rates, which starts the up-cycle once more. The knock-on effect of the cycle of peaks of over-ordering of new ships followed by a period of correction whilst the over-capacity built is absorbed have always been a feature of commercial shipbuilding. Slaven, for example, notes in relation to the growth of shipbuilding in the period between 1815 and the 1850s: *"Consequently, although the industry was expanding, its overall experience to the 1850s was of three short booms separated by two long periods of slack trade, as the market slowly absorbed the capacity produced at the peaks of production"* (Slaven, 2013, p. 17). The average period between peaks was 35 years, suggesting that the cycle pre-dates the problems faced in the 20th and 21st centuries. For example, Slaven notes the output from British shipyards in 1776 as 528,128 tons, falling to 182,143 tons in 1801 (Slaven, 2013, p. 9). It is not only the existence of the cycle that has been a constant feature of the industry, therefore, but also the order of magnitude of the swings between boom and bust.

These recurring larger peaks are different to the general volatility of the industry that was noted in the period between 1860 and 1880, discussed above. The business opportunity presented by such peaks is substantial and shipbuilders have historically taken the opportunity to build new capacity to try to maximise the profit potential from expanding demand. This is also not a new phenomenon as noted in the quotation above from Zannetos in 1966 and as pointed out by Daniel Todd when discussing the most recent phase of expansion in South Korea: *"This exuberance displayed by some South Korean new entries, while liable to costly failure in adverse circumstances, is not without its historical precedents. In fact, it is reminiscent of the great fanfare attending UK shipbuilding in 1918-19 when expectations of unlimited shipping demand caused existing shipbuilders and newcomers alike to lay down excessive capacity. These British entrepreneurs were to rue the day they gave way to such schemes long before the 1920s were out"* (Todd, 2011).

The cyclical nature of demand causes economic problems for shipbuilders, summarised succinctly by Pollard and Robertson (1979, pp. 26 - 30). As demand rises so raw material costs and wages rise with it. In a rising market the cost increases are covered by corresponding price increases. As the market approaches the peak, however, price will start to turn down but, due to the lag between ordering and output, input costs will continue to rise. *"This created a paradoxical situation in which the best years in terms of tonnage constructed were amongst the worst for shipbuilders profits"* (Pollard and Robertson, 1979, p. 28). There are also economic advantages to be gained. For example, in the late 1990s as prices began to rise, Korean shipyards were able to take down-payments on significant order volumes for future delivery, the cash generated being used to significantly reduce debt (First Marine International Limited, 1999 to 2005).

The longer term underlying economic cause of the problems that result from the cyclical nature of output is that capacity developed to cope with the peak is persistent long after the peak has gone. When output turns down dramatically, as it has done four times over the past 120 years, capacity is slow to react. The outcome of this repeating pattern and the economic difficulties it causes is likely to include conflict between suppliers and a reliable mechanism to address such conflicts would therefore be desirable.

The problem of subsidies in shipbuilding and the resulting difficulties are far from recent, therefore. What has changed, however, is the regulation of international trade and commerce, and such subsidies in the modern era can be countered if they cause distortions in trade to the detriment of another competing nation.

One possible mechanism for resolution of international disputes that may result from subsidisation, whereby one nation believes it is being damaged by injurious pricing of another, would be by recourse to the World Trade Organization. Just such an action was brought before the WTO in 2003, to settle a dispute between the shipbuilding industries of the European Union and the Republic of Korea, resulting from the rapid expansion of South Korean shipyards in the 1990s. In considering the case, however, the dispute panel reached certain conclusions that effectively mean that commercial shipbuilding may be outside the ambit of the dispute resolution procedures of that Organization unless the problems identified by the panel can be resolved. It is the possible resolution of these problems, to bring commercial shipbuilding within the sphere of influence of the WTO, which this dissertation sets out to examine.

Whilst the primary objective of this dissertation relates to the specifics of the regulation of shipbuilding in WTO, a further aim is that it should address the relatively low level of published research on the shipbuilding market, and the work therefore has a conceptual element in defining the market and determinants of price and competitiveness. "*Conceptual research helps us to see the world – and decision* *making phenomena – through new lenses, enabling us to find new trailheads and emerging problem-solving quests"* (Fawcett *et al.*, 2014). This conceptual element is in line with the work of the shipbuilding working party of OECD, OECD WP6, which concluded in 2012 that: : "*The termination of the Shipbuilding Agreement negotiations at the end of 2010 ended an important phase in the WP6's consideration of market distortions in the shipbuilding industry. Negotiations ceased because it was felt a deeper understanding was needed of factors that could cause distortions in the market, so that they could be more effectively identified."* (OECD Working Party 6, 2012a). This dissertation aims to address the *"deeper understanding"* required in this context.

2. Background and literature

2.1 The evolution of commercial shipbuilding

2.1.1 The evolution of technical and engineering aspects

Prior to the 16th Century shipbuilding was a very small craft industry serving limited local needs. Global or even national issues in this early era were to all intents and purposes non-existent. In Britain, Henry VIII and Elizabeth I realised the need to expand the navy and the merchant fleet to serve colonies and trading routes that had started to develop following voyages of discovery: to the 'New World' and Eastwards to India and eventually China (Stopford, 2009; Slaven, 2013). It was this expansion that formed the early beginnings of a coherent industry although early shipbuilding, up to about 1815, remained localised and built predominantly small wooden vessels. For example, in Newcastle the industry built colliers (coal carriers) for the trades between the Tyne and London. Military shipbuilding and larger vessels for protected government trades, for example the East India Company, tended to be built in the South East. Similar local industries would be found in other shipbuilding nations.

Wooden shipbuilding saw its peak in terms of tonnage built in 1855 (Slaven, 2013, p. 18) but the switch to iron (then steel), rather than wood, and to steam, rather than sail, was rapid. By 1880, 90% of all ships built were iron or steel and British shipbuilding had a share of over 80% of all vessels built anywhere in the world. Britain's dominance resulted essentially from the coincidence of three factors: technological leadership in iron and steam, the need for a substantially expanded Navy to protect the country's rapidly expanding global interests and the availability of a rapidly growing market for merchant ships to serve the vast British Empire. The technological element was essential: Britain could not compete with US shipbuilders for wooden vessels because the country lacked the reserves of wood to use for shipbuilding. The industrial revolution therefore came to the rescue of a pressing problem that would otherwise have limited the growth of Britain's economy as a whole (Slaven, 2013).

It could be stated that the modern commercial shipbuilding industry commenced with the first 'modern ship', which is generally accepted to have been Brunel's 'SS *Great Britain'*, built between 1839 and 1843: *"which can claim to be the fore-runner of all* *ships of significance afloat today"* (Corlett, 1971). *'SS Great Britain'* was made of iron, a shipbuilding material that had been made possible by improvements in the Iron manufacturing process, patented in 1784 by Henry Cort (Fairburn, 1865; Corlett, 1975), which led to the economic availability of the material in the form of plates. Without the availability of plates or sheets of iron the material did not come in a form that could be riveted together to form the shell of a ship's hull and the use of iron was limited to ships' frames or parts of frames for composite wood and iron ships. Iron shipbuilding proper commenced in 1812 with the construction of canal boats in the United Kingdom, with the first iron sea-going ship, the *'Aaron Manby',* constructed in 1822 (Fairburn, 1865). The industry in the USA was a little later in adopting iron because the cost was so much higher than in UK whilst timber was in more plentiful supply: *"The first iron steamboats were probably the river paddlers 'John Randolph', 122 tons, 'Chatham', 198 tons and 'Lamar' 196 tons, which were put together at Savannah between 1828 and 1834 of materials imported from England" (Fassett, 1948, p. 43).*

Iron and wood continued to be used for shipbuilding through much of the nineteenth century until steel, the material used in the modern industry, was introduced in the latter decades of the century. The first steel ship was a small river vessel built "*for Niger expedition*" by J. Laird of Birkenhead in 1858. A number of other smaller vessels followed but the first sea-going cargo vessel built of steel was the 452 ton '*Jason'* built in 1859 by Samuda Brothers of London (Newcastle University Marine Technology Special Collection, 2014). The use of steel became more common in the 1880s, with Lloyd's Register's first set of rules for steel ships being published in 1888 (Blake, 1960). Steel became more widely available after the invention of the Bessemer process in 1855 but early Bessemer steel was of variable quality. The trigger for the viability of steel as a shipbuilding material was the development of the Siemens-Martin process for steel manufacture: "*Siemens-Martin open hearth steel of consistent quality became available from about 1878, with production rapidly expanding. The transition from iron to steel hulls took only ten years. Small quantities of cast steel had been available from the late 1850s but its high price of around £20 per ton compared with £9 for wrought iron limited its use to lightweight vessels like river steamers and blockade runners for the American Civil War, although it had been used to build masts and spars of lighter topweight. But bulk* *manufacture in Scotland and north-east England soon reduced the price of steel to about £6 per ton, even below that of iron. Its greater strength reduced steelweights by around 15% and its greater ductility improved survivability in the event of grounding or collision, while the larger size of plates possible (up to 8ft wide in place of 4ft) reduced riveted joint length and construction cost"* (Buxton, 2010). Thus the modern industry, in terms of its construction material, was established by the late 19th century but the industry of the 21st century has little else in common with the industry of that time. The material remains the same but the building technologies and methods, the producers, the products and the scale of the industry would have been unrecognisable to shipbuilders from a century ago. Technically and economically, therefore, the modern industry started at some point in the 20th Century.

Technically the great change in the 20th century came with the advent of welding as a viable joining method for steel. Riveting was the prior method, which had many downsides. From the shipyard's viewpoint It was labour-intensive, heavy and skilled work, which would be very difficult to automate. Film of work in the UK shipyards collected by the National Film Archive shows the only development in riveting between 1900 and WWII to have been the introduction of pneumatic hammers in place of heavy manual hammers. Little other development in the technique was possible (Rotha *et al.*, 2011). Lloyd's Register introduced experimental rules for welded shipbuilding in 1918 and the first experimental all welded ship, '*MV Fullagar*', was built at Cammell Laird in Birkenhead in 1920 (Blake, 1960).

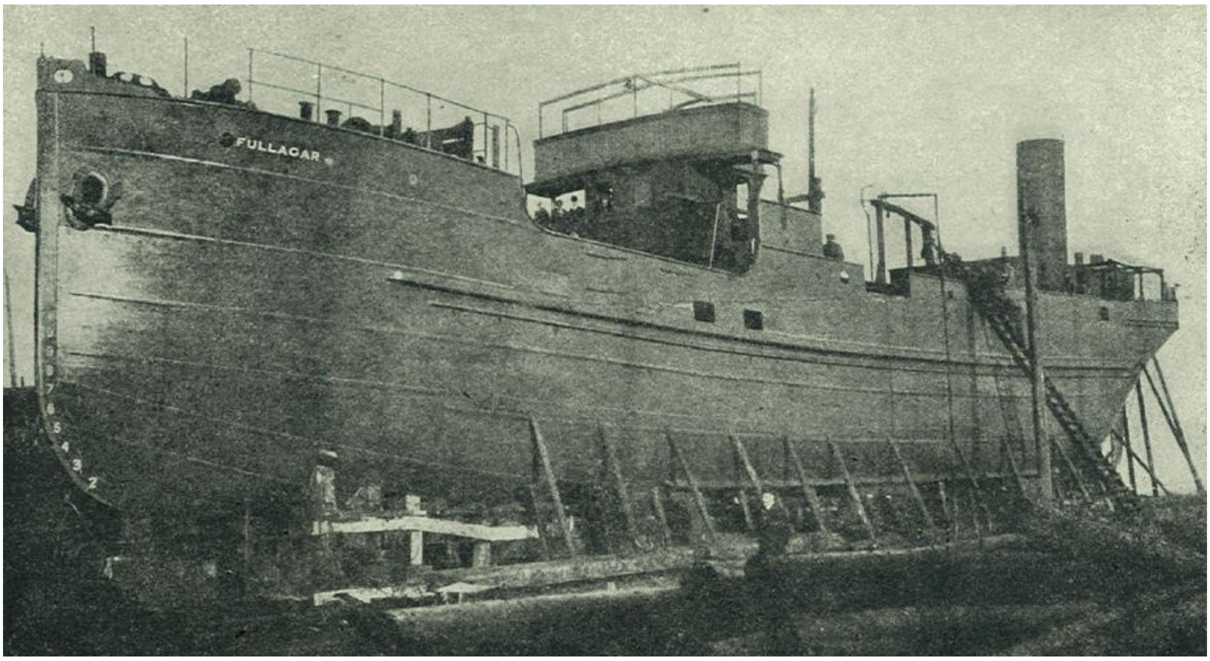


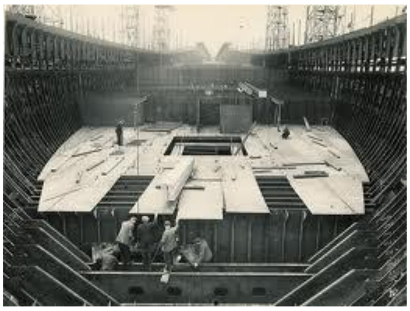
Figure 2.1 - MV Fullagar, the world's first all welded ship (Lords Commissioners of the Admiralty, 1943, p. 283)

The use of welding to repair stern frames prior to this time had been only partially successful and LR indicated that "*until experience had been gained with welded vessels at sea, the classification would remain experimental. The principal deterrent, at that time, to the fuller use of electric welding was the distrust of the ductility of the welds*." (Lords Commissioners of the Admiralty, 1943, p. 172). This was despite 'Fullagar' sailing successfully for 17 years before being sunk in a collision. After this time welding was used for certain parts of the ship only: "*Lloyd's Register of Shipping issued revised rules for the application of electric welding in 1932. In these rules it was contemplated that the improved electrodes could be used for welding parts of the vessel of primary importance*" (ibid. p. 172). The improved electrodes referred to in this quotation were the flux coated welding rods that would be recognisable today, prior to which welding had been achieved with bare wire and was less reliable. Buxton points out that at this time welding "*tended to be used where there were clear advantages such as oil tight bulkheads in tankers or oil fuel bunkers, where really oil tight riveting was difficult to achieve*" (Buxton, 2010). As well as technical reservations on the part of the classification society part of the problem limiting early adoption of the technique was that welding was significantly expensive. Labour unions sought additional pay for the skills needed and manufacturers of welding equipment tried to develop welding as a specialist subcontract, rather than promoting its use by shipyard workers.

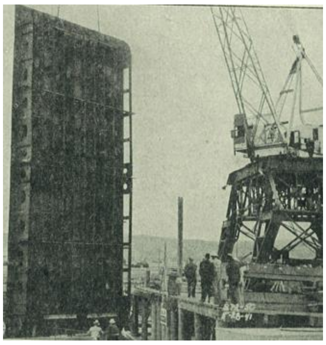
Swan Hunter & Wigham Richardson of Newcastle built an all welded Great Lakes tanker in 1933, preceding the first all welded ship in the United States, also a great lakes tanker, '*Poughkeepsie Socony'*, built in 1934. It was not until WWII, however, that welding became more common as a process for joining the structure of the ship. In 1940 a British shipbuilding delegation visited the United States to order "*about 60 vessels of the tramp type of about 10,000 tons deadweight"* (Thompson and Hunter, 1942). The delegation was ambivalent about welding but concluded: *"To suit USA practice, to ensure a good supply of labour, to facilitate production and to get the best value for money, it was decided that ships must be mainly welded"* with the extent of riveting varying by shipyard. The extensive *'Liberty Ship*' construction programme that followed US entry into the war saw fully welded ships become the norm in that country. The '*Liberty Ship'* was a standard 7,210 ton general cargo ship that was built as quickly and cheaply as possible to replace allied tonnage that was being lost at an alarming rate to enemy action: *"the..demands of WWII, when a capacity output of approximately four times that of normal peace time operations was mandatory"* (Fassett, 1948, p. 202). 2,468 *'Liberty Ships*' were built in total in United States shipyards between 1941 and 1945 and welding in place of riveting was one way of achieving the speed of construction needed. *"Since riveting had previously been the limiting factor in construction time, it was possible to decrease substantially the time necessary for all hull work"* (Fassett, 1948, p. 59). As Buxton puts it: *"Without welding, the US would not have been able to build the 5,000 ships the Maritime Commission produced between 1941 and 1945"* (Buxton, 2010).

The introduction of women into the workforce of the United States in WWII, when the men went off to war, also benefited from a less manually demanding joining process than the heavy work of riveting: *"One of the principal reasons for welding the vessels..was, of course, the shortage of skilled labour…It was recognised that much less time would be necessary to produce efficient welders than to train reliable riveters and caulkers. The present war time policy of the British Admiralty is to increase production by developing merchant ship construction along similar lines..That policy has to a very large extent been dictated by the same considerations which operated in America – namely, the insufficiency of proficient* *labour, and the necessity for the rapid training of dilutees, including women"* (Lords Commissioners of the Admiralty, 1943, p. 173). Thompson and Hunter noted in 1942, following their visit to the United States, that: *"It is much easier to train good welders than good riveters. Females can and do weld, but they cannot rivet. The average man would prefer to weld rather than rivet"* (Thompson and Hunter, 1942).

A further advantage of welding over riveting is that it permits pre-fabrication of sections of the vessel, something that could only be achieved for small parts using rivets. 'Traditional' shipbuilding involved the joining of individual pieces to form the structure of the ship at the final assembly site. Pre-fabrication of blocks of steel in covered workshops, prior to assembly on slipway or in dock, is an essential key to productivity in the modern industry. The origins of pre-fabrication were also seen in the United States in WWII: *"Mass production: In adopting these methods, wartime shipbuilders were following American industrial experience. Whenever it desired to turn out more identical units in a given time at reduced cost, the American mind inevitably devises mass production processes – whether it be for pins, automobiles or ships"* (Fassett, 1948, p. 226). *"The United States Emergency Shipyards have been specifically planned for mass production of standard welded merchant ships. As these yards are laid on vacant sites it has been practicable to provide extensive areas and depth of space above the head of the berths – essential for rapid production by pre-fabrication. Typical of these yards is the Todd California Shipbuilding Corporation in Richmond, near San Francisco. This yard laid down in 1941..the assembly and welding of large pre-constructed units, including double bottom structure, panels of the bottom shell.."* (Lords Commissioners of the Admiralty, 1943, pp. 142,143,146). Such pre-assembled units were actually very small by modern standards with assembly cranes of only 25 to 30 tons, compared to 1,000 tonnes plus for a modern final assembly crane. Photographs comparing 'traditional' piece by piece shipbuilding, WWII assemblies and modern block construction are shown in Figure 2.2.



1910



1941

2014

Table 2.1Construction of 'SS Olympic' 1910 (Rotha et al., 2011), a liberty ship 1941 (Lords Commissioners of the Admiralty, 1943, p. 144) and modern block construction 2014 (Hyundai Heavy Industries, 2014)

Pre-fabrication of standard products enabled substantial productivity of shipbuilding berths in the United States: *"the target of at least one ship per berth per month"* (Thompson and Hunter, 1942). It would be wrong, however, to suppose that the United States was alone in developing welding and pre-fabrication at this time. The same technology was undoubtedly also being developed in Germany, for example, in particular for submarine construction where dispersion of production, building '*U-boats'* at disparate locations to avoid allied bombing, required that block construction be developed, as illustrated in Figure 2.3.

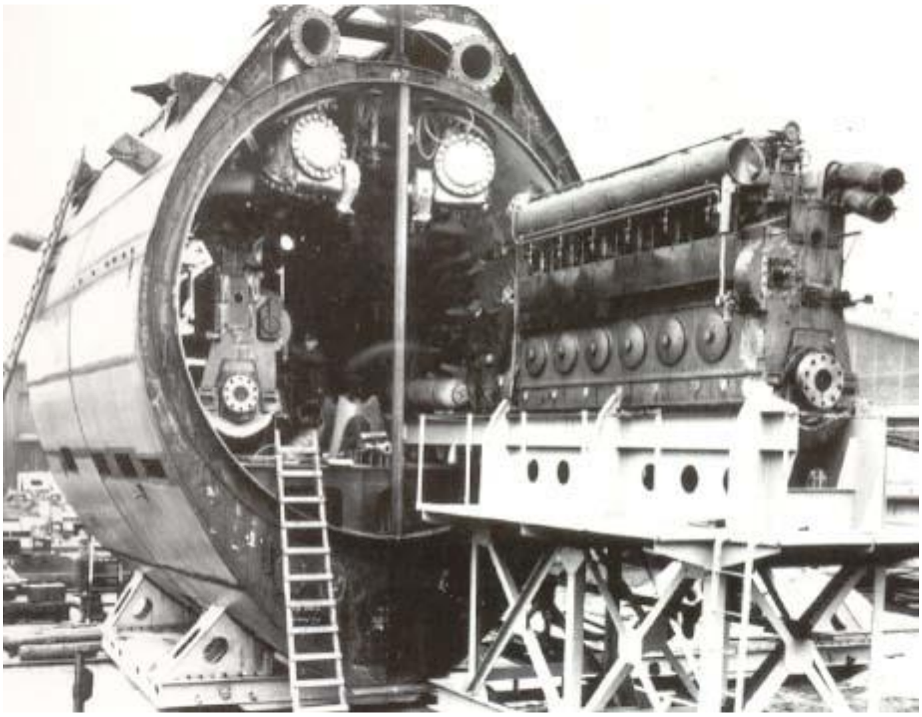


Figure 2.2 - U-Boat construction in WWII, showing advanced blocks being used (source: forum.axisindustry.com)

This photograph suggests that block building technology may have been more advanced in Germany than in the United States. The significance of US developments in this context, however, was that it was US technology that went on to be developed following WWII and which was therefore seminal in the development of the modern industry, even if more advanced technology had been developed elsewhere during the war years.

Modern joining methods, therefore, were established in WWII. The methodology of block or unit construction in commercial shipbuilding was then developed further in Japan in the 1950s. Shipbuilding, along with marine transportation, had been selected as a "*priority sector"* in what came to be known as Japan's 'economic miracle', that being the recovery of the economy that was decimated during WWII. Hardy and Tyrell note that the post-war recovery of the Japanese industry was *"aided largely by American capital, engineers, and production planning"* (Hardy and Tyrrell, 1964, p. 105). Under the influence of the United States (after 1948 under the "*great reverse"* following General McArthur's initial reform policies that were aimed at curtailing militarism (US Department of State Office of the Historian, 2014)) shipbuilding was selected as a priority industry, along with steel, coal mining, electricity generation, railways, chemical and others, for the rebuilding of the economy (Otsubo, 2007). The effectiveness of this policy was spectacular and by the mid-1960s Japan had established itself as a major industrial exporter. The industry developed in Japan at this time would be recognisable today as the modern commercial shipbuilding industry, establishing the build methods that would be used to develop industries in both South Korea and China, as well as most other modern shipbuilders. In this way, the development of the shipbuilding industry in Japan post WWII could be regarded as the birth of the modern commercial shipbuilding industry. Without doubt, Japanese shipbuilding would have learned about the production methods, mass production and pre-fabrication, developed in the United States in WWII but Japanese shipbuilders then developed the techniques further and eventually the situation reversed and the United States sought to learn from Japan. In a citation accompanying the award of the 'Solberg Award' by the American Society of Naval Engineers to Mr Louis D. Chirillo in 1985 it is stated: "*Under the auspices of the National Shipbuilding Research Program, he studied Japanese shipbuilding methods and through management of research projects with Japanese shipbuilders he gained a complete understanding of the logic and principles of their methods*" (American Society of Naval Engineers, 1985). Contributing to the strategic development of the industry in Japan was the appointment the head of the Japanese aircraft industry, which was industrially significantly more advanced than shipbuilding, to lead the development of the shipbuilding industry. *"Interestingly, the development of the modular construction system for shipbuilding which the Japanese developed came as a result of the now popular benchmarking concept of studying parallel industries. In this case, following World War II, the head of Japanese aircraft construction was appointed head of shipbuilding. In those days, the traditional method of building ships was to lay the keel and then build the ship from the bottom up. Aircraft construction was different; in this case, a modular construction method was used…This method required greater accuracy in the manufacture of units but overall it reduced construction times by a factor of ten. The same improvement resulted when the method was applied to ship construction"* (Hutchins, 2008, p. 46).

A final technical change in the industry in the second half of the twentieth century was the development of shipbuilding strategy and facilities to suit. Layout drawings of United States shipyards in WWII show that volume was achieved by building multiple slipways. The more slipways the more ships built, with the *'Liberty Ship'* possibly achieving the maximum possible of about 12 ships per slipway per year but more commonly a slipway would produce less than 2 ships per year (Fassett, 1948). The shipbuilding strategy involved completing the structure of the vessel and then installing outfit by trade; pipework, electrics, joinery, etc. Pre-fabrication enabled steelwork and outfit to start to be integrated, shortening the cycle time for the production of a ship and increasing the capacity of a slipway as a result. Figure 2.4 shows a typical layout of a high volume US shipyard of WWII vintage, showing the array of slipways (or 'shipways' as referred to in this drawing) needed for high capacity.

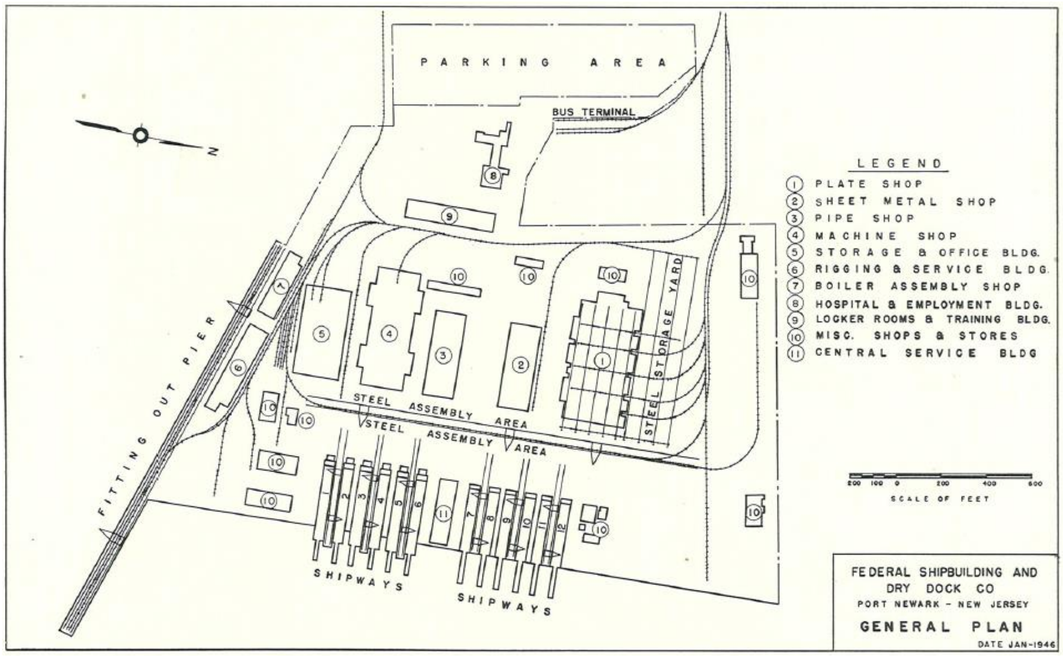


Figure 2.3 - Arrangement of a WWII US shipyard showing slipway arrangements needed for capacity (Fassett, 1948, p. 243)

As the slipway was the bottleneck, increasing the capacity of the slipway increased the capacity of the entire shipyard. The effect of advanced outfitting is shown in Figure 2.5. In the traditional sequential method the total cycle time *(T_t)* is equal to the sum of the steel work time (t_s) plus the outfitting time (t_o). If the start of outfitting is advanced by time δ_{ta} to overlap the steelworking process, rather than the traditional sequential approach that waited for steel to be complete before outfitting, then the total cycle time will be that much shorter than the original cycle time.

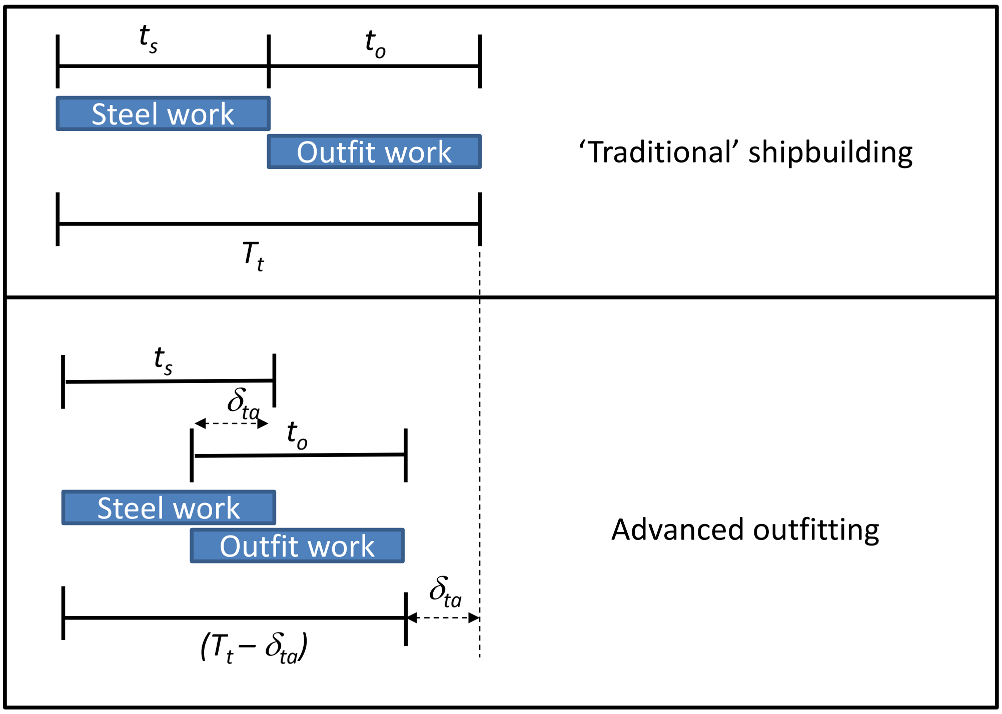


Figure 2.4 – The effect of advanced outfitting on cycle time

As blocks became bigger, further strategies emerged to enable slipway capacity to be increased. The most important strategy was called 'semi-tandem', which enabled the stern of a following ship, the stern normally containing a disproportionate amount of the total work due to machinery spaces, to be built alongside the previous ship and slid into place on the slipway following the launch of the first ship. The effect of semi-tandem construction on the capacity of a slipway is shown in Figure 2.6, considering the total cycle time for two ships. In this case the steel and outfit work of the second ship is advanced by a period δ_{tb} to proceed alongside the first ship.

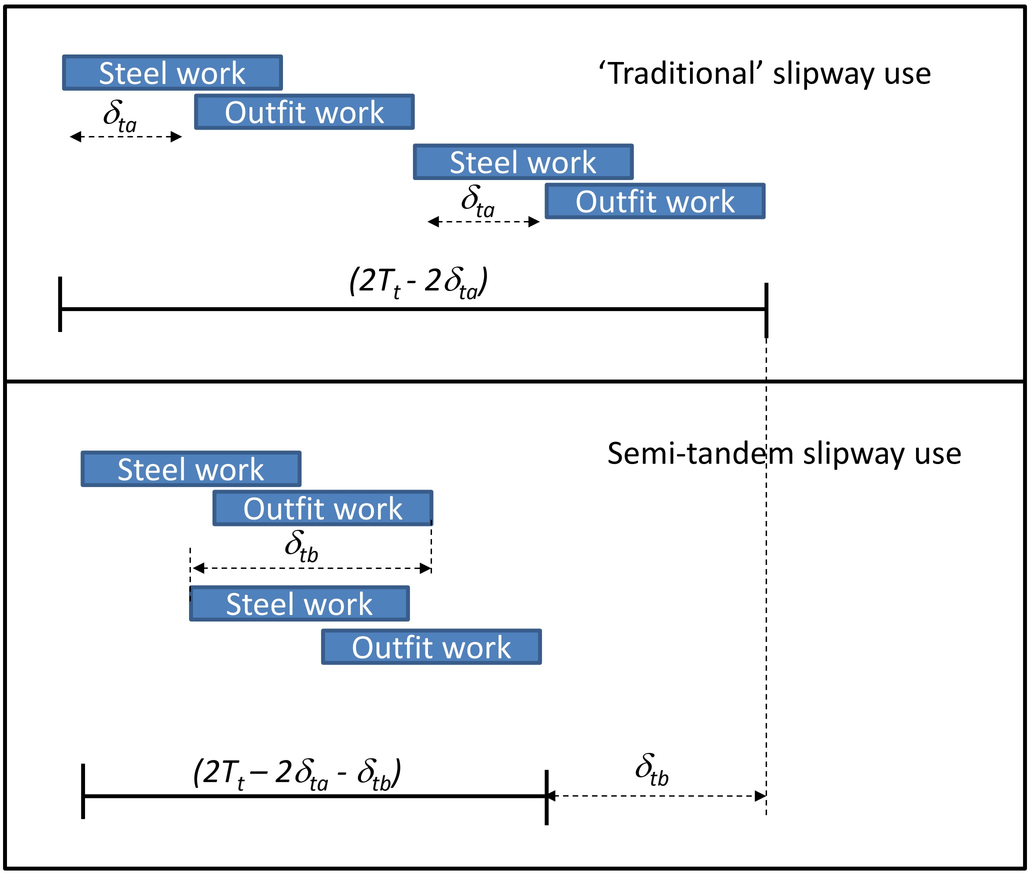


Figure 2.5 – The effect of semi-tandem construction on cycle time

Slipways are still commonly used in shipbuilding but the greatest capacity comes from the use of a flexible large building dock served by very large 'goliath' cranes, that is to say self-supporting gantry cranes. Hyundai Heavy's largest drydock, the no. 3 dock at Ulsan, has dimensions 672m x 92m and is served by three goliath cranes: one at 1,290 tonnes swl and two at 450 tonnes (Hyundai Heavy Industries, 2014). Cranes of this size would be largely impractical on an inclined slipway and are a key to higher productivity of a shipyard. This dock is shown in Figure 2.7, which can be compared to the slipway layout shown earlier for comparison.

Figure 2.6 – Flexible building docks at Hyundai Heavy Industries, Ulsan (Hyundai Heavy Industries, 2014)

The large cranes means that large (heavy) blocks can be fabricated in workshops for erection into the dock, maximising the integration of steel and outfit work on the block and undertaking this work in ideal conditions, not outside on an exposed slipway, which means that work can be undertaken at the ideal and therefore cheapest time. Integrated supporting workshops were designed specifically to support this strategy, defining the shape of a modern shipyard (Bruce and Eyres, 2012, p. 119 to 123). Commercial shipbuilding in drydocks, as opposed to on slipways, commenced in Germany in the late 1950s. In 1960 Kieler Howaldtswerke was using ship construction facilities that included 5 slipways and 4 drydocks, two of which were sometimes used for repair (information kindly provided by Verband Fur Schiffbau und Meerestechnik E.V. (German Shipbuilding and Ocean Industries Association)[1]). This is certainly an early commercial use of building docks, although

[1] Information provided for this work in email correspondence with the Association.

it has not been possible to confirm that this is the earliest adopter of this technology: Japanese shipyards were similarly building occasionally in repair docks (The Shipbuilders' Association of Japan, 1961). Dedicated newbuilding docks for commercial shipbuilding were first seen in the early 1960s in Europe. The ‘Patton Report’ into productivity in shipbuilding in 1962 noted 4 shipyards using drydocks for building in continental Europe. This included the purpose-built dock in Burmeister and Wain of Copenhagen, but output records for 1960 suggest that this particular dock was not in production in that year and a 1959 brochure for the company notes that the dock was due for completion in 1960. The report also notes the development of the large building dock at Gotaverken Arendal in Sweden, not yet open in 1962, which, along with the goliath cranes supporting the dock became a model for the modern generation of building docks (Patton J, 1962). This pattern of large shipyard was made ubiquitous, however, by British consulting company ‘A&P Appledore’, which designed and built Hyundai Heavy Industries in Ulsan in 1971 (Bruno and Tenold, 2011). The form and technology of that shipyard was exported to many shipyards globally, including the latest generation built in China.

The other great change in commercial shipbuilding in the 20th century was economic, that being the move away from empire towards globalisation, which was triggered by the Bretton Woods conference of 1944. Stopford argues that this was a key driving forces for the modern shipping industry. “*At the Bretton Woods conference in 1944 the US Secretary of the Treasury, Henry Morgenthau, outlined the objective of creating ‘a dynamic world economy in which the peoples of every nation will be able to realise their potentialities in peace and enjoy increasingly the fruits of material progress of an earth infinitely blessed with natural riches’. By the end of the meeting the World Bank and the International Monetary Fund had been founded and the groundwork had also been laid for the General Agreement on Tariffs and Trades (GATT). This policy had a profound effect on the maritime industry. By the end of the 1960s almost all of the European colonies had been given independence and they were encouraged to open their borders and transform their economies from self-sufficiency to export production ”* (Stopford, 2009, p. 37).

The ‘*profound effect’* on shipping had a knock-on profound effect on shipbuilding and it could be argued that the Bretton Woods conference in 1944 and the consequent globalisation that followed, was the trigger for the development of modern shipbuilding as much as it was the trigger for the development of modern shipping. The following changes in particular should be noted:

- Increased shipping demand required more ships and the volume of production increased. In 1950 the world's shipbuilding industry produced 3.2 million gross registered tons. In 1976 the industry reached a peak of 34 million tons and in 2010 reached a peak of 103 million GT, thirty two times the size of the industry post WWII.
- The types of vessels changed from the earlier ubiquitous general cargo ships, commonly termed 'freighters' that carried everything except oil, to dedicated carriers for different cargo types. The dry bulk carrier, for example, whilst it existed prior to WWII, particularly in the form of Great Lakes vessels, started to become more common in the late 1950s.
- The size of vessels increased in pursuit of economy of scale in shipping. Records (sourced from Sea-Web) for general cargo ship production in 1950, for example, show that the average size of ship built in that year was 2,868 deadweight tonnes and the largest was 13,632 tonnes. In the same year the largest tanker produced was 42,295 tonnes and the average was 13,984 tonnes. Shortly after this the first commercial[2] panamax vessel, the 70,000 dwt crude oil tanker '*W Alton Jones'*, was built by Newport News, Virginia, in 1954. This was a large vessel in its day but commercial ship size peaked with the development of Ultra Large Crude Carriers (ULCCs) in the 1970s, the largest having a deadweight of 555,000 tonnes (Stott, 2014). The first panamax tanker was followed by a panamax obo built by Mitsubishi in 1955 and the first panamax dry bulk carrier followed in 1959, the 58,000 dwt *'Pacific Maru'* built by Kawasaki. Shipyards clearly needed to be bigger to handle this step change in ship size.
- Another key development was the standardisation (or more correctly quasi-standardisation) of the products built, to suit the standardisation of shipping by class of vessel. Classes such as 'panamax' and 'VLCC' are recognisable in the modern industry. Prior to 1960, with the notable exception of the '*liberty*

[2] The first actual panamax ships were the USS 'Iowa' class battleships, of which four were completed in 1943 and 1944.

ship' and the *'T2'* tanker, built for the war effort, standards by and large did not exist.

The industry addressed in this dissertation, therefore, in terms of products, volume, producers, technology, materials and investment, emerged after WWII, was developed following a pattern originated in Japan and is the product of the process of globalization. How this may relate to the industry of the future is clearly uncertain and depends on how globalization now proceeds.

2.1.2 The evolution of cycles and volatility

This section looks at shipbuilding output since the late 19th Century, identifying how cycles and volatility have changed with the development of the modern industry. Figure 2.8 shows the output from global shipbuilding since 1892, clearly identifying periodic peaks. The peaks are shown on separate graphs because each subsequent peak masks the existence of the previous peaks by virtue of its size.

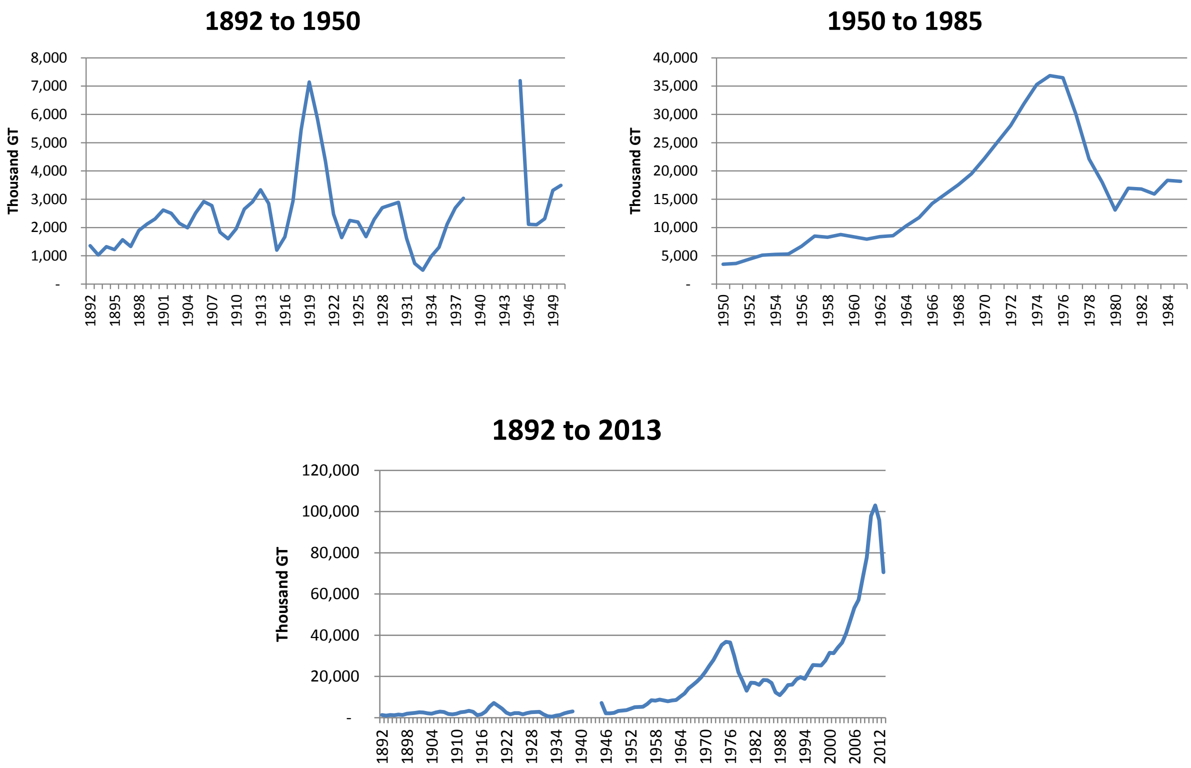


Figure 2.7 – Output from global shipbuilding at selected periods between 1892 and 2013 (compiled by the author from various sources: WWII output data not available)

It should be noted that the parameter evaluated here is output, not ordering, and the fall in output therefore lags the economic change that may have precipitated it. For example, the tail of very high WWII ordering can be seen as output in 1946, even though the post-war slump in ordering had already preceded this. (The significance of wars to shipbuilding output has long been recognised: *"Wars almost invariably inflated the industry and, usually temporarily, shipbuilding profits. Certainly, from the 17th Century, in the immediate aftermath of a war a substantial depression of trade followed"* (Clarke, 1997, p. 1)). Similarly the peak of output in the most recent cycle was seen in 2011, three years after the 2008 crash that precipitated a sharp decline in ordering.

Cyclical behaviour in the shipbuilding market, and all shipping markets, is expected by economic theory and anticipated by economists. It is not the intention of this dissertation to examine the causes of these cycles but the effect of one important progenitor is worth noting here: *reinvestment cycles*. This was a subject studied in the context of shipbuilding by Norwegian economist Johan Einarsen in the 1930s (Einarsen, 1938), who in turn refers to the work of Tinbergen (Tinbergen, 1931). The principal of reinvestment remains important in the forecasting of newbuilding demand in the modern era. Reinvestment suggests that capital expenditure has to be renewed periodically due to obsolescence of the prior investment, either because it is worn out or because newer and more productive technology is available. Einarsen referred to the cycles caused in this way as an *"echo phenomenon",* describing the 'waves' of demand that result from the phenomenon. Einarsen described reinvestment as follows: *"The production for capital goods – production instruments and long-lasting consumption goods – is also a cyclical one. A person who buys a machine today for his business will regularly some time in the future, when the machine is worn out or outmoded, be in need of a new machine to replace the old one"* (Einarsen, 1938, p. 35). He also notes that "*These cycles arise when the reinvestment takes place at the time when the capital instruments have reached their typical normal age for replacement"* (*ibid.,* p. 38).

Einarsen was seeking to examine Norwegian shipping as a case study to look at the general economic issue of reinvestment. Karl Marx in the 19th Century had postulated that reinvestment cycles are an important factor in the generation of the general business cycle, and had made an educated guess that the reinvestment cycle was typically 10 years in length. Einarsen was using Norwegian shipping to test the cycle length and did indeed concur with Marx's ten year hypothesis. This is clearly out of step with the life expectancy of a ship which, then as now, was typically around twenty to twenty five years. Einarsen therefore had to distinguish between *"reinvestment"* when a ship is scrapped and replaced and *"replacement"*, when the original purchaser sells the ship on and buys a new one, to take account of technical improvements and increasing maintenance costs and reduced efficiency of the original investment. He also noted that elasticity in the ultimate age of a ship leads to complexities in the working of the phenomenon and that the peak of expected reinvestment demand tends to lead ahead of a higher peak of shipbuilding demand in total, a feature that remains in current shipbuilding cycles.

Importantly, Einarsen noted that there has to be an original concentration of newbuilding to generate the future "*echoes"* or waves of demand. Factors that kick off the clustering of investment were proposed to include shocks such as wars: "*A war, for instance, will often result in a disproportionately strong expansion of those industries which produce goods previously imported from foreign countries. Further, wars often bring with them the destruction of capital goods to a great extent"*. Other generators include "*a new revolutionary invention, a sudden change in the trade policy, the opening up of new trade routes, etc., will influence the course of capital production*" (*ibid.,* pp 42,43). At Einarsen's time the Great War was seen as a progenitor of the shipbuilding cycle, at least in the context of Norwegian shipping: "*during the Great War, Norway (in spite of its being neutral) lost through the submarine campaign nearly half of its merchant fleet….This was re-established to a broad extent by the extraordinarily great number of new constructions in the years of 1920 and 1921. The Great War thus caused a pregnant concentration in the age distribution of ships" – which lead to a specific example to study the existence of the re-investment cycle*" (*ibid.,* p. 102). Based on this theory it would be expected that WWII would similarly have produced a concentration of demand leading to future "*echoes"*, along with the economic changes following Bretton Woods, as previously described.

Visual inspection of the graphs shown above suggests that there have been major cyclical peaks in 1919, 1946, 1975 and 2011, recurring at periods of 25 years, 29 years and 36 years respectively, an average of 30 years between major peaks. As well as these major cycles, however, there are many smaller cycles that can be seen in the period examined and the analysis of volatility has to take these into account.

To examine volatility the year-on-year change in output from this data has been analysed over the full period, with results presented in Figure 2.9. Certain key events of economic significance have been superimposed on this graph (with acknowledgement to Einarsen and Stopford for the techniques (Stopford, 2009, pp. 93-134)).

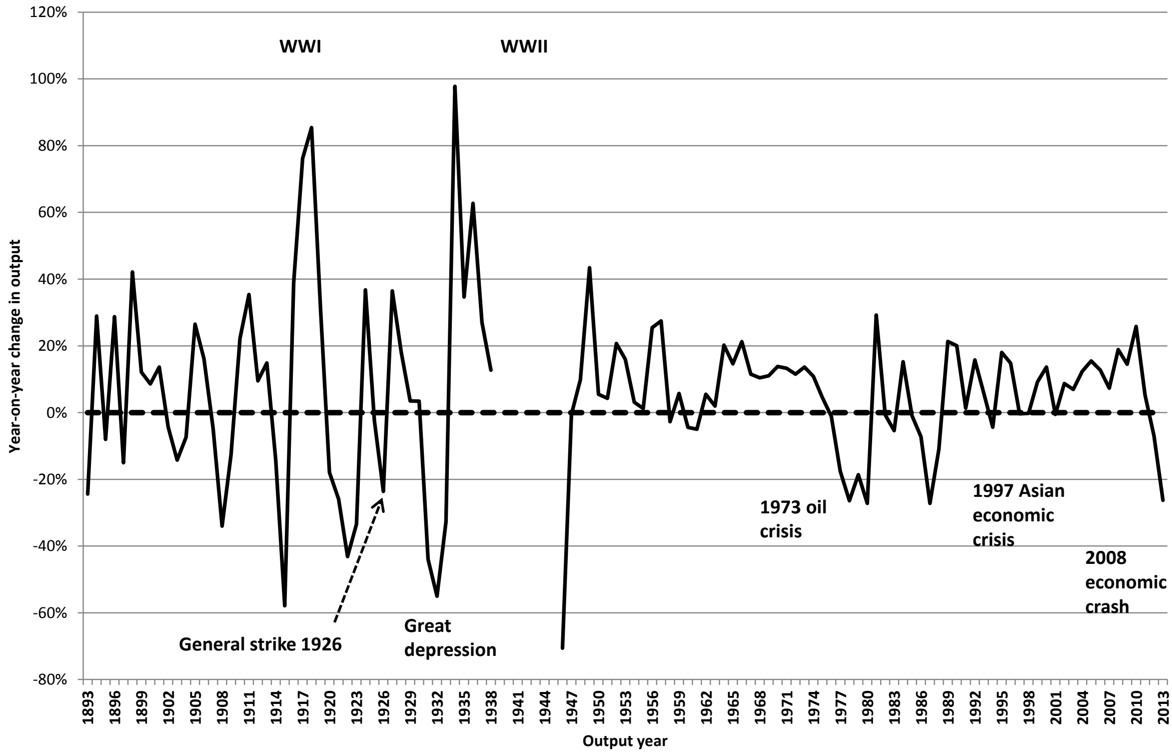


Figure 2.8 – Year-on year change in output from global shipbuilding

Based on this analysis and the evidence of literature on this subject presented earlier, cycles have been a constant feature of the shipbuilding industry since it began. This means that the economic difficulties caused by high fixed investment supported by volatile revenue, that is to say revenue that fluctuates and which is one of the major causes of subsidy, has also been a constant feature – even though industry personnel may still greet the problem with surprise every time it occurs.

It is clear from the figure, however, that whilst volatility is persistent its nature has changed over time. Volatility prior to WWII appears to have been significantly greater (higher growth and recession rates and more frequent changes in direction) than following the war. Three significant events in the 20th century had a particularly strong effect on the shipbuilding industry, however, causing very large swings in output. These were the two world wars and the great depression. If these are ignored the level of volatility of the two periods still appears different but the order of magnitude of growth and decline is more comparable.

The parameter used to investigate volatility is the coefficient of variance, that is to say the ratio of the variance to the mean. The larger the value the greater the relative variance and thereby the greater the volatility. Statistics comparing the periods before and after WWII are presented in Table 2.1.

	Prior to 1939	Post 1946
Mean annual growth	7.6%	5.2%
Variance	12.2%	2.8%
Coefficient of variance	1.62	0.53
Proportion of years in recession	43.5%	32.4%
Average recession yoy change	-23.8%	-12.1%
Average growth yoy change	31.7%	13.5%
Lowest recession yoy change	-57.9%	-70.6%
Highest growth yoy change	97.8%	43.4%

Table 2.2 – Comparison of statistics to compare volatility of output from global shipbuilding between 1893 and 2014

The reduced coefficient of variance confirms what can be seen in Figure 2.9, that volatility in the modern industry, post-WWII, is reduced compared to the UK-dominated colonial industry that preceded it. Whilst the average annual growth in the modern industry is lower than that preceding WWII the proportion of time spent in recession, that is in the down-swing of a cycle, is also less, suggesting more periods of sustained growth and longer cycles. The other statistics show that, with the exception of the very deep recession that immediately followed WWII, the cycles are less ‘sharp’, with longer periods and shallower growth or recession rates. These cycles are easier to see if a three-year moving average trend line is applied to the above chart, as depicted in Figure 2.10, although it should be kept in mind that the effect of such a trend line is generally to shift data to the right and the cycles revealed are therefore not precisely in the correct time alignment.

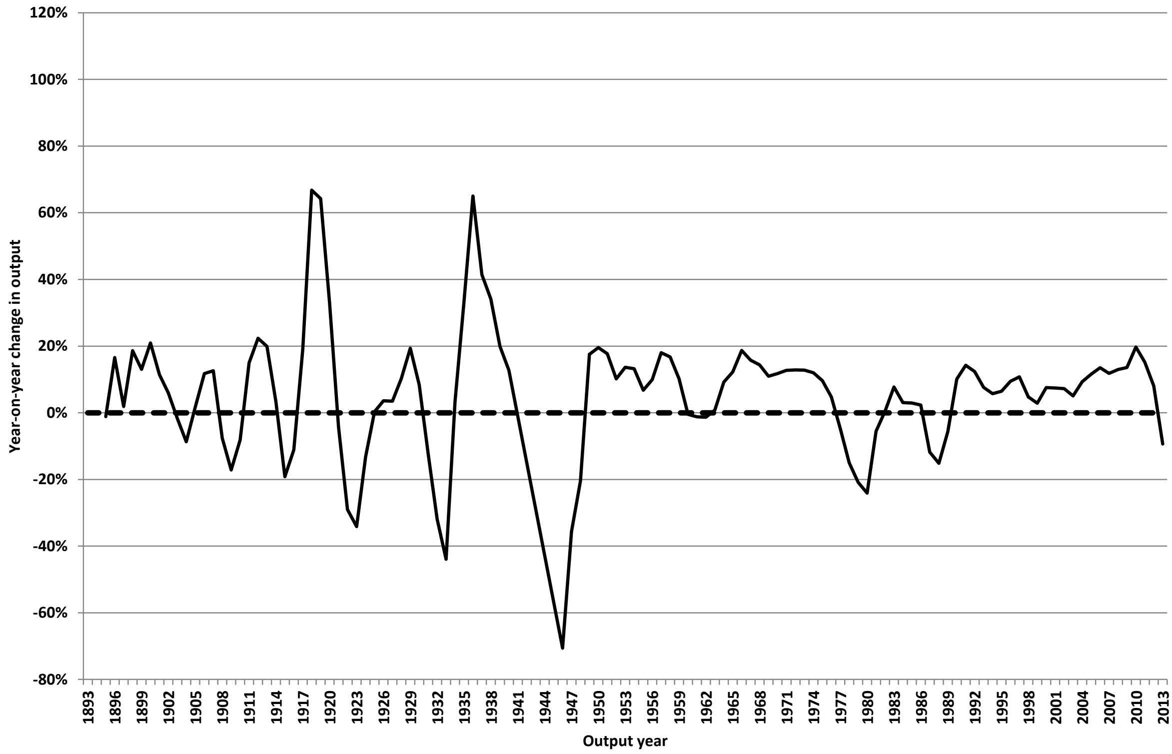


Figure 2.9 – Three year moving average trend line for year –on-year change in output, for greater clarity of the underlying cycles

The length of cycles, peak to peak, is analysed in Figure 2.11, showing the number of years between peaks for each major cycle identified in the data.

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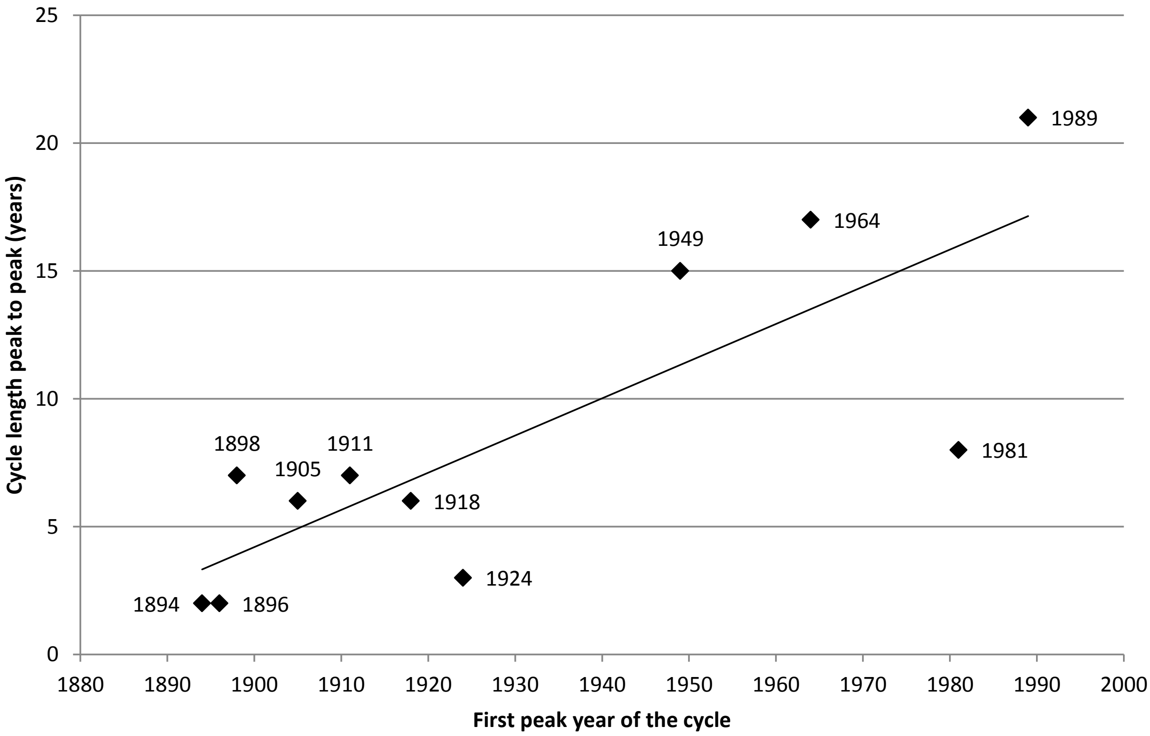

Figure 2.10 – Length of shipbuilding cycles 1893 to 2014

It can be seen that, unlike the average length of shipping cycles that appears to be reducing (Stopford, 2009, p. 107), the length of cycles in the modern shipbuilding industry has increased, with longer periods of sustained growth in the post-WWII period. The average length of cycle observed prior to WWII was 4.7 years, compared to 15.25 years post-WWII. The number of years of recession associated with each cycle has also increased as illustrated in Figure 2.12. This graph shows the number of years of negative growth associated with the recession phase of each cycle.

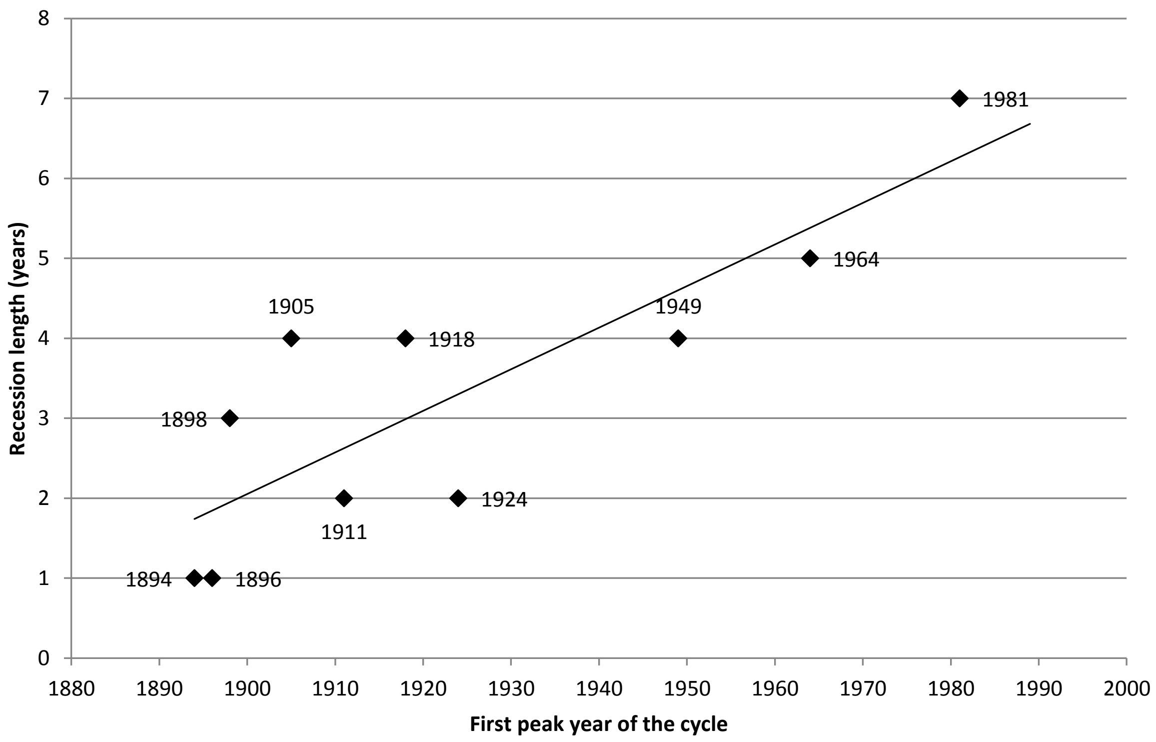

Figure 2.11 – Number of years of negative growth associated with the recession phase of each cycle

The average number of years of negative growth prior to WWII was 2.43 years per cycle whilst in the modern industry this has increased to 5.33 years per cycle on average, although the modern industry can clearly be seen to be on a rising trend.

In summary the volatility of the modern industry is lower than was experienced prior to WWII, with longer periods of sustained growth but accompanied also by longer periods of sustained recession. To some degree this change may be attributed to a combination of increasing capital intensity and changes in social attitudes. Prior to WWII shipbuilding was a skill-based industry, relying on skilled workers rather than capital investment. Without the capital burden it was easier to close shipyards and wait until the market picked up again, resuming work with new orders. It was also much easier in that period to lay off personnel to be re-hired when work was available, a practice common in many industries. Following WWII the capital intensive nature of the industry increased along with improved employee rights and social responsibility in corporate governance, reducing the potential for the use of temporary closures.

2.1.3 The evolution of global competition

The progress of market dominance in shipbuilding by successive nations might be termed a 'hegemony', that being the predominance or ascendency of one group to the exclusion of others (Oxford English Dictionary). For the long view, Hardy and Tyrell note: *"Before 1850 the Americans were supreme in shipbuilding, but in the second half of the nineteenth century Britain adopted the new techniques of the industrial revolution and overtook all other countries until she produced over 80 per cent of the world's ships. This triumph has been short lived; the same methods were adopted and improved upon elsewhere, so that by 1955 Japan had become the most prolific shipbuilding nation in the world, and by 1958 Britain produced less than 20 per cent of the tonnage launched outside the Communist bloc"* (Hardy and Tyrrell, 1964, p. 98). Whilst shipbuilding appears to be a shifting hegemony (Bruno and Tenold, 2011), and is sometimes referred to as such, the presence of a true hegemony is open to question. The only clear hegemony occurred in the late 19th Century when economic and technical dominance in steel shipbuilding meant that the United Kingdom took a market share of over 80%. Subsequent dominating shares have been very considerably lower than this value.

Figure 2.13 shows the progression of market share over time for market leaders, from UK to Japan and thence to South Korea and most recently China.

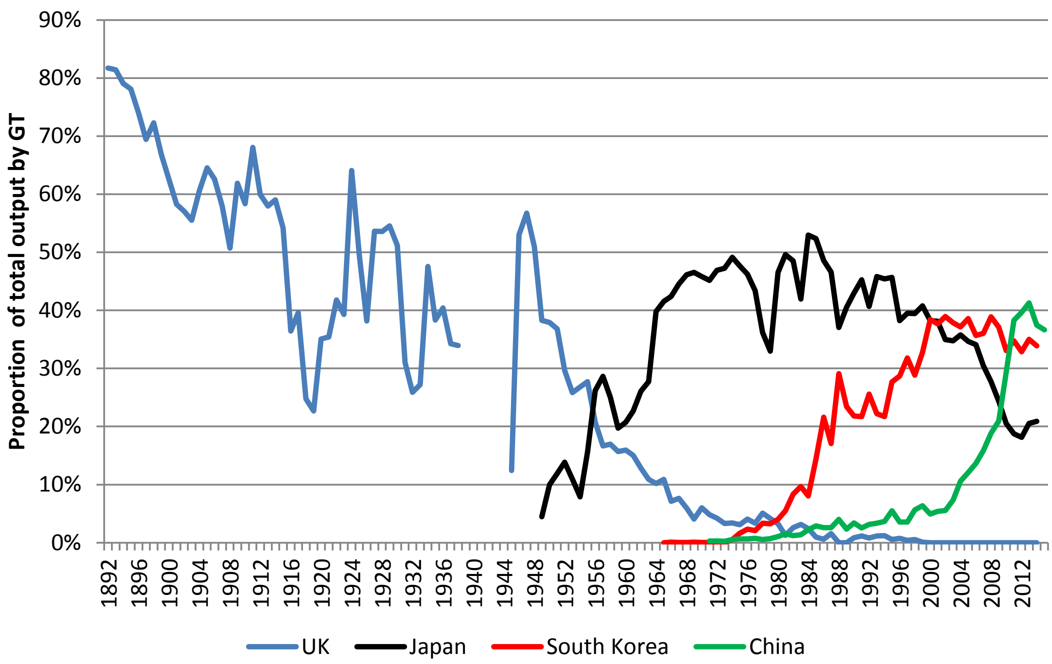

Figure 2.12 – Shipbuilding market share in global leading countries since 1892 (compiled from various sources)

The UK maintained its lead up to the early 1950s, but as can be seen failed to maintain its extreme dominance as the technical capability of other nations caught up and then over-ran the UK industry, and as markets moved from colonial trades prior to WWII to globalisation following WWII. It should be noted that the industry experienced loss of market share and not a reduction in output, which averaged around 1 million GT completed per year between the end of the great depression and the mid-1970s, only starting to decline after 1978. Numbers started to decline earlier, however, as ships became larger, the decline in numbers of ships completed being steady from about 1960 (Buxton *et al.*, 2015).

The gradual loss of market share caused much angst in the UK shipbuilding industry, the Government and trade unions from about 1925 until the industry effectively closed in the 1990s. A typical example of the angst is seen in the introduction to a 'Report of joint enquiry into foreign competition & conditions in the shipbuilding industry', published by a 'Joint Committee of shipbuilding Employers' Federation and Shipyard Trade Unions' in 1926: *"After the announcement early in March, 1925, that a British Shipowning firm – Messrs. Furness, Withy & Co. – had placed an order in Germany for five large Motor ships, …it is proposed that a Joint Conference should be held when the situation created by foreign competition and other cognate matters* *affecting the industry might be discussed.."* (Joint Committee of the Shipbuilding Employers' Federation and Shipyard Trade Unions, 1926, p. 5). The committee's terms of reference sought an exchange of views that would arrive at *"definite conclusions as to the best means which could be taken to re-establish the industry and enable it to retain its pre-eminent position in world shipbuilding"* (*ibid*., p. 6). This was one of many such reports by industry and government, a number of which are referenced in this dissertation, none of which found the means to swim against the tide of change that eventually engulfed the industry. Much has been made of the roles of poor management and restrictive practices in this process but the overwhelming causes stemmed from attempts to 'shoe-horn' the craft-based pre-war UK industry into the increasingly de-skilled and mechanised post-war global industry, the pursuit of volume that was beyond the scope of the investment inherent in ageing British shipyards and the market shift to much larger ships that were also beyond the scope of the UK industry in economic terms.

Japan took over the lead in the mid-1950s, for reasons relating to the economic miracle described earlier, and sustained a share between 40% and 50% for the next three decades. Korea took the lead in the early 2000s and then China around 2010. It can be seen that the period for which market dominance has been maintained has declined with each successive leader, as has the peak value achieved.

In the era of wooden sailing vessels up to the mid-1850s, and in particular for clipper ships, the leading producer was the United States. US builders benefited from a plentiful supply of North American softwood: *"before the Civil War the Americans, as well as the North American colonists, could build cheaper ships than the British, although it was widely held that Britain could build the better class of ship as cheaply as any other country in the world"* (Pollard and Robertson, 1979, p. 10). British shipbuilders lacked the supply of timber to compete with the USA and persisted in building better quality ships from hardwood. As Pollard and Robertson point out, however, Britain was: *"Favoured by an island position, sheltered ports, a large share of the world's trade, a relative abundance of capital, and technical skills second to none. Britain needed only an economical supply of the necessary raw materials to become the world's great shipbuilding centre"* (*ibid*, P. 9). Centres of shipbuilding clustered around the areas where the raw materials were plentiful (NE England and the River Clyde in Scotland) and where clusters of manufacturing were developed to supply the industries. This clustering mirrors the development of the modern industry, although clusters now tend to be national rather than regional – for example in South Korea, Japan and China.

Japan's ascent was founded in economic need and political motivation. South Korea's ascent in the 1980s benefited from a similar mix of motivations, the Government promoting heavy industry for economic growth whilst at the same time having an eye to domestic security and the need to build ships for defence (Bruno and Tenold, 2011). Bruno and Tenold suggest that the establishment of a significant shipbuilding industry in the modern era is virtually impossible without government support because of the level of capital needed, both fixed and working capital, and the economic nature of the industry, with volatile demand. Benefits accrue from the generation of economic wealth that the industry provides and history will almost undoubtedly show a similar mix of motivations and supporting factors in the development of the modern Chinese shipbuilding industry: *"Seeing Korean advantage as consisting in the melding of big shipyard practise with series production of large ships, they undertook to do likewise, inaugurating big yards in short order"* (Todd, 2011). Having said this, it is interesting to note that Bruno and Tenold's work shows the level of government support in the development of the UK industry in the 19th Century was much less significant than it has become in the modern era.

A number of themes emerge from this analysis, in particular:

- motivation for the development of the commercial shipbuilding industry stemming from shipbuilding's potential to confer economic benefits on a country;
- the strategic nature of the industry that stems from politics;
- the influence of military interests on the development of commercial shipbuilding.

It is apparent that development of a significant presence in the industry, at least, debatably, in the period post the British industry of the late 19th Century, requires more than pure commercial capital to be successful. Other attempts to gain a significant presence in the industry in the late 20th Century, notably in India, Vietnam and Brazil, have not yet succeeded.

It is common in market analysis of the shipbuilding industry for suppliers to be aggregated at the national level and this is justified by Strandenes as follows: *"We conclude that the newbuilding market has been characterised by competition between shipbuilding nations and not only by competition among shipbuilding firms"* (Strandenes, 2002). More significant than the national hegemony, however, is the level of 'concentration' in the market, which has increased in recent years. Concentration is described by Durlauf *et al* as: *"the degree to which the industry was* [sic] *dominated by a few large firms"* (Durlauf *et al.*, 2008). Shin and Lim go as far as to state that: *"A shipbuilding industry can be characterized as a typical oligopoly with quantity competition"* (Shin and Lim, 2013), although the analysis presented in their paper on shipbuilding competitiveness is aggregated at national and regional level, rather than between companies as one would expect when referring to an oligopoly, defined as: *"A state of limited competition, in which a market is dominated by a small number of producers or sellers"* (Oxford English Dictionary). The extent to which an oligopoly exists in shipbuilding is worthy of further study but the existence of concentration to a significant degree appears to be in little doubt, particularly when consolidation of shipyards into group companies in South Korea and China is taken into account. Data provider Clarkson Research Services monitors the concentration of the orderbook by group and reported the following concentrations in May 2011 and May 2014:

Proportion of orderbook (by CGT)	Number of groups May 2011	Number of groups May 2014	Change
Top 25%	4	4	0
Top 50%	17	14	-18%
Top 75%	48	35	-27%
Bottom 10%	364	279	-23%

Table 2.3 - Concentration of commercial shipbuilding orders by shipyard group (source: Clarkson World Shipyard Monitor)

The number of groups reporting orders has fallen by almost 25% in the three years shown, but it can be clearly seen that the likelihood of ceasing trading increases as group size reduces, with no reduction in market share for the four largest (Korean) shipbuilding groups, which together account for 25% of the global orderbook.

2.1.4 The persistence of subsidy

Cyclical downturns are one of the most significant causes of shipbuilding subsidies. They are not the only cause, however. For example, in the strongly growing market of the 1960s the British Government noted in a publication setting out the findings of the “Shipbuilding Inquiry Committee”, in rebutting calls for financial aid for the UK industry: *“the Government should first see whether it is possible to persuade foreign governments to get rid of some of their artificial aids to their own shipbuilding industries”* (Shipbuilding Inquiry Committee, 1966). Subsidy has been a general feature of the shipbuilding industry for as long as the industry has existed and has a wide range of causes and forms, many of which have been indirect, that is to say the subsidy may be given to the shipping industry to indirectly support home shipbuilders. For example:

- Clarke refers to 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 was imposed upon the foreign vessels over and above existing duties*” (Clarke, 1997, p. 5) . Such a tax in the modern era would be construed as an indirect subsidy to the shipbuilding industry that it seeks to support.
- Humphrey Jordan notes in the book ‘Mauretania’ that in the race for speed supremacy of passenger liners across the Atlantic: “*None of the companies were to escape the danger; sooner or later, in the struggle to own the fastest and the best ship upon the run, they all sought and obtained assistance from their governments*” (Jordan, 1936, p. 16). Such subsidies were often euphemistically termed ‘subventions’ or other vague terms to try to mask their existence. To receive the assistance these vessels had to be built in home shipyards and government assistance to shipowners thereby constitutes a shipbuilding subsidy and would, in the more open trading conditions of the

21st Century, be viewed as potentially distorting trade and damaging to foreign suppliers. The earliest subsidy mentioned in this context is four ships built for Collins Line in 1847, which received government assistance in their building (ibid., p. 15).

- Jones, in the book 'Shipbuilding in Britain' notes that: "*Shipbuilding is very sensitive to changing world conditions and is subject, more than any other industry, to political influences. At one time or another practically every maritime country in the world has either directly or indirectly assisted its shipbuilding industries*" (Jones, 1957, p. 6). The earliest state aid for shipping/shipbuilding cited in this work is in 1837, where subsidized ships were built to enable faster communication around the British Empire (ibid., p. 141). This type of subsidy was formalised in an act of Parliament in 1921, enabling the use of subsidy to promote national interests, known as 'mail subsidies', for vessels designed to carry mail around the British empire, where the government assisted the construction of ships against what was perceived to be unfair subsidized foreign competition. Jones goes on to note that by 1932 the need for subsidy had moved to a different and more general footing: "*the problem facing shipping was precisely that which confronted the shipbuilding industry – the need to rid the industry of redundant and obsolete capacity*" (ibid., p. 146). This comment was made in response to the Chamber of Shipping's proposal to government to introduce a "scrap and build" scheme that would, at the same time, reduce fleet capacity whilst providing work for under-utilised shipyards.
- In the modern era, the EU rules on state aid to shipbuilding, set out in the 'Framework on State Aid to Shipbuilding' permit "*specific provisions in relation to innovation aid and regional aid for shipbuilding, as well as provisions on export credits"* (European Commission, 2011). The concept of *"innovation aid"* recognises that prototyping in the development of innovative commercial ships is rarely an option: the prototype will be sold and as such the economic risk of technical innovation is high. The EU therefore permits limited subsidies for "*innovative products and processes, that is to say, technologically new or substantially improved products and processes when compared to the state of*

> *the art that exists in the shipbuilding industry within the Union, which carry a risk of technological or industrial failure"* (*ibid*.).

Subsidy has historically, therefore, been to some degree a permanent feature of the industry and is not solely a consequence of overcapacity. In studying the decline of shipbuilding in Western Europe following the peak of 1975, Strath refers to *"The Obscure Jungle of Subsidies"* in a chapter heading of the book '*The politics of de-industrialisation: the contraction of the West European shipbuilding industry*' (Strath, 1987, p. 13). Strath notes in relation to support for the industry: *"The wealth of subsidies that has supported shipbuilding is almost impossible to survey, at least if one is to try to calculate their size in real terms rather than simply detail the forms they take. The inventive power and ingenuity of politicians has been great when introducing new kinds of support for the failing industry, but the fact that it has been in the interest of every government to minimise the figure published has not made the survey easier"* (*ibid*.). Strath then goes on to list seven groups of types of shipbuilding subsidy recognised by the OECD, with 17 mechanisms listed only one of which is 'direct subsidy'. Zannetos also notes the ubiquity of subsidy: *"The number of tankers under construction may also be influenced by the domestic policies of various countries. Some governments take national pride in having vessels flying their flag, while others may attempt through legislation to encourage shipbuilding activities in their countries. Presumably such efforts by governments are intensified during periods of depressed market conditions and excess shipbuilding capacity"* (Zannetos, 1966, p. 75). Strandenes refers to the use of subsidies to preserve capacity in European shipbuilding as the industry has moved East in recent decades (Strandenes, 2002, p. 188). Strandenes also refers to the use of subsidy in the establishment of new shipbuilding industries: *"The result is a world-wide subsidy competition that presses prices and increases demand for new vessels"* (*ibid*., p. 195). In the same chapter Strandenes discusses the effects of subsidy on the shipbuilding industry and later in the same book Joon discusses the important place played by government policies in the development of the shipbuilding industry (Joon Soo Jon, 2002). Joon notes that *"Government policies in promoting shipbuilding industry are largely implemented through various types of financial assistance such as direct financial aid and or by guaranteeing loans"*.

The situation that first comes to mind for many, particularly in Europe, is where state aid is used as a support for mature industries that are struggling in the face of volatile demand and prices set against competition from lower cost producers. A variation on this is the provision of aid to ailing regions as has been used also in Europe (Joon Soo Jon, 2002, p. 535). Such aid is expensive. The declared average annual aid to shipbuilding in EU countries in the period 2001 to 2003, for example, was €840 million per annum (Commission of the European Communities, 2006). At the root of this problem is the persistence of shipbuilding capacity: capacity is not removed from the industry when on the basis of pure economics, because price has fallen below the cost of the producer, the capacity should close. The reasons for the persistence of capacity would form a valuable study in their own right. There is not space in this dissertation to review these in rigorous detail but the following are postulated as the root causes for persistent capacity:

1. Optimism: shipping is well known to be cyclical and there is a major cyclical element to shipbuilding also. Because of this governments may be persuaded that the under-utilisation of capacity is temporary and that an upswing will occur sooner rather than later and part of the cause of persistent capacity could be laid at the door of market research.
2. Politics: as a major industrial employer it is politically difficult to close a shipyard. There are knock-on consequences for votes for whichever political party is in power at the time. Politicians may therefore expediently listen to the optimism of market forecasts that predict that the downturn will be short lived and the industry will return to normal sooner rather than later.
3. High fixed capital investment means that shareholders are likely to be reluctant write capacity off. Mothballing appears to be a potential solution but is technically not straightforward and is likely to be expensive.
4. Loss of capability: the capacity of a shipyard is inherent not only in the physical assets but also in the skill and experience of the workforce. This takes a long time to develop and even if physical facilities could be mothballed the loss of the workforce would be difficult to recover for a future upturn.
5. Economic consequences: shipyards are major employers, not only in the shipyard itself but also for supplier industries. The utility of commercial shipbuilding in generating economic activity was demonstrated in the

Japanese ‘economic miracle’ of the 1950s and more recently in South Korea and China. Many jobs outside the shipyards are dependent on those shipyards remaining in trading. Closing a major shipyard, therefore, has a significant cost in terms of employment and economics outside the shipyard itself.

6. Being too large to fail: the closure of one of the very large shipyards of South Korea, for example, would have an economic impact at the national level that is best avoided where possible: *“The expeditious intervention of the Seoul government to buttress them* [the Korean shipyards] *through loans and guarantees speaks to their vital importance in the domestic economy”* (Todd, 2011). This is part of the advantage afforded by being part of a large industrial conglomerate. As Joon Soo Jon puts it: “*Conglomerates have political clout. These diversified, large companies command respect and influence in industrial, financial and political circles. This can mean easier access to capital markets and more sympathetic treatment by politicians, than could be expected by a dedicated shipbuilding company”* (Joon Soo Jon, 2002, p. 558).

As well as at the time of economic difficulties for mature industries, the role of state support in the start-up of shipbuilding companies can also be important and can also be very expensive. “*A supportive government is a major component in successfully establishing and maintaining a viable shipbuilding industry*” (Bruno and Tenold, 2011). Bruno and Tenold list the State Aid received by the fledgling South Korean industry as: “*In brief, 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*” (Bruno and Tenold, 2011). It is highly 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.

1. Firstly, the shipyard has to gain orders in competition with established shipbuilders that are likely to be more productive and have lower cost due to the established nature of the business. Even the best planned new shipyards

are likely to have a build-up period where supply chains and productivity are developed.

2. Throughput in early years is likely to be slow and the high cost of establishing the shipyard has to be supported by this low level of business. "..*high fixed costs make the establishment of shipbuilding capacity virtually impossible without government support*" (Bruno and Tenold, 2011).

The development of China's largest commercial shipyard provides a good example of the issues faced by large shipyards at an early stage of development. Shanghai Waigaoqiao Shipbuilding ltd[3], a division of China State Shipbuilding Corporation (CSSC) is conceived as a shipyard on the "Korean model" (Ludwig and Tholen, 2006), that is to say aimed at series production of standard large commercial ships. Exact information on Chinese shipyard development, operations and economics is hard to come by. Construction of the yard began in 1999 and operations started in 2001. The first ship was delivered in 2003. The total planned investment in the yard is not known precisely but was reported to be 3.2 billion Renminbi, around $390 million at the exchange rate of the time (Drewry Shipping Consultants, 2003) and tangible fixed assets reported in company accounts in 2010 was $545.7 million. Estimates of the intended capacity of the yard were initially put at between 1.8 and 2.8 million dwt per annum but this has already been well exceeded with deliveries of over 5.5 million dwt in 2012 and CSSC states the capacity of the yard as being over 7 million dwt per annum. The development of throughput at the yard is shown in figure 2.14.

[3] The author was lead consultant for the development of the strategic plan for this shipyard.

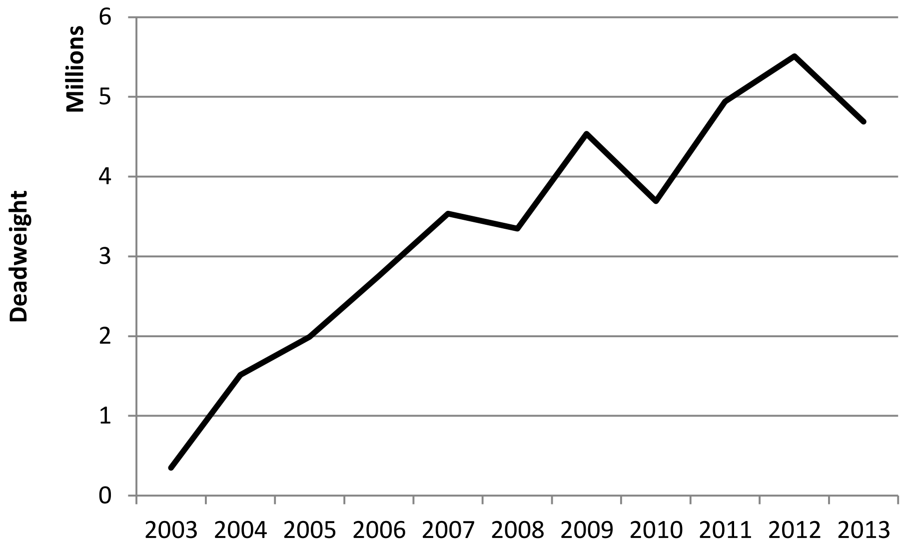

Figure 2.13 – Deliveries from Shanghai Waigaoqiao Shipyard (data sourced from Sea-Web)

It can be seen that the build-up of work took around seven to eight years from start-up and ten to eleven years from the start of construction of the shipyard. Note that because of the buoyant state of the market over this period this build-up could be regarded as an 'ideal': no better market conditions are likely to occur that could have reduced this build-up period. During this period the economic coverage of these assets will clearly be lower than is the case with the yard working at full capacity and it is tentatively estimated that the shortfall in value added at the shipyard, compared to output achieved in 2012, could have been between about \$3.5 billion and \$4 billion, greater than the cost of construction of the yard itself. This supports Bruno and Tenold's conclusion stated above that financial assistance is likely to be needed to fund a start-up period for a large shipyard and that this assistance may be beyond the means of private capital, particularly for a very large shipyard.

Such a lengthy start-up is not unique to Waigaoqiao but is likely to be faced by any new major shipyard. Figure 2.15 shows the build-up of output from HHI Ulsan as another example, from its opening in 1972 to 1985.

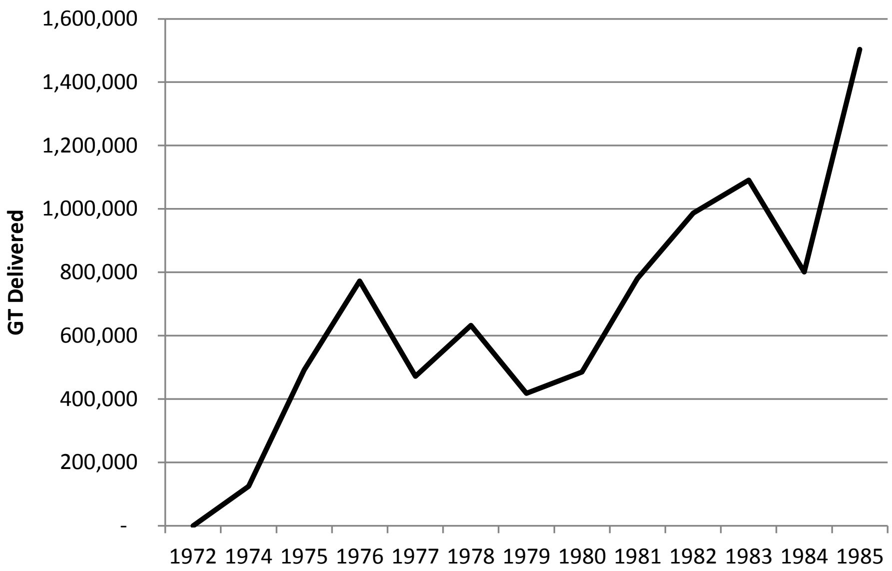

Figure 2.14 – Build-up of output at HHI Ulsan (data sourced from Sea-Web)

In addition to a build-up period for volume there will also be a build-up period for efficiency. Statistics presented for South Korean productivity development in Section 6.1.4.2 suggest a long term average performance improvement of 6% to 7% per annum, referring to what Craggs *et al* call '*shipyard learning'* (Craggs *et al.*, 2004) to differentiate this from productivity gains made on series' of ships, although significantly greater gains can be made in the early stages of development. In 2004 Waigaoqiao reportedly had a permanent workforce of 3,900 persons (Ludwig and Tholen, 2006) but this did not include temporary labour, used extensively, so an estimate of the yard's productivity for comparison in precise terms is not possible. Benchmarking of shipbuilders main assets has been recommended as a possible measure of efficiency of a shipbuilder (Colin and Pinto, 2009), and is relevant in this situation. In particular one of the most significant investments made in a new shipyard is that in the building docks and the efficiency of this asset can be compared to competitors. The development of performance in terms of CGT produced per square meter of building dock available is presented in Figure 2.16.

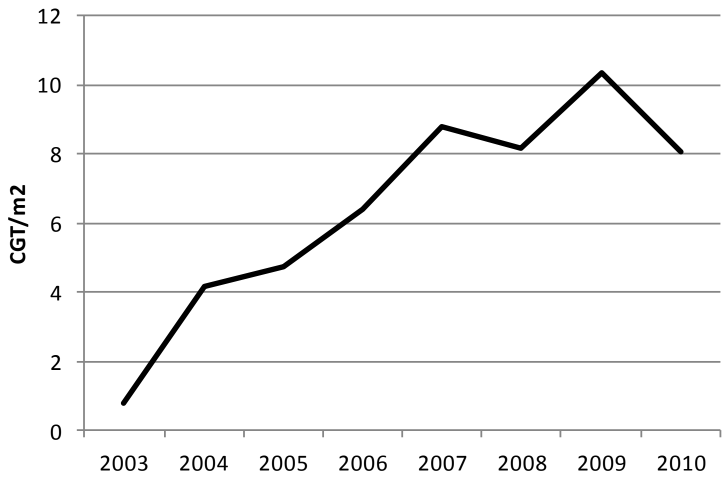

Figure 2.15 – CGT produced per annum per square metre of building dock at Shanghai Waigaoqiao

Clearly the development of performance shown in this chart follows the output development shown in Figure 2.15. For benchmarking the performance of the South Korean industry in 2005 was estimated by Colin and Pinto to be around 13 CGT/m^2 and rising sharply. This suggests that whilst there has been significant improvement in performance at the shipyard over the past ten years it has not yet approached the level of performance achieved in South Korea in the mid-2000s and proceeded through a significant build-up period during which productivity was relatively low. The cost penalty resulting from this performance build-up will have to be funded by the yard's shareholder: in this case ultimately the Chinese Government.

2.2 The economic and regulatory context

2.2.1 Shipbuilding in the context of WTO

A summary of the World Trade Organization (WTO) and its legislative instruments is given in Appendix 3 to this dissertation.

Following a period of consultation between the shipbuilding industries of South Korea and the European Union, during which no resolution could be found, on 11th June 2003 the EU requested the establishment of a panel at the World Trade Organization to examine a complaint relating to unfair subsidies to the shipbuilding industry on the part of the Government of the Republic of Korea. The panel met over the subsequent year to hear the dispute and finally reported findings on 7th March 2005 (World Trade Organization, 2005). The complaint was made according to the procedures of the WTO's "Agreement on Subsidies and Countervailing Measures" (hereinafter the "SCM agreement"). The author of this dissertation was a participant in this process, as technical expert advising the European Communities and appeared at the tribunal in this capacity. The case is referred to as "*Korea – Measures Affecting Trade in Commercial Vessels"* (hereinafter referred to as *Korea – commercial vessels*[4]) and has the WTO case number DS273.

There is not sufficient space in this work to delve into the specific aspects of the complaint brought by the EC but succinct summaries can be found in Glen (2006) and on the WTO website (World Trade Organization, 2016). The outcome is summarised by Glen as follows: *"..the EU, despite winning its case in a number of specific issues, has lost the fight to establish that there was significant price suppression of ships as a consequence"* (Glen, 2006). The failure to demonstrate price suppression and thereby harm to the industries of other nations raises a fundamental question about the WTO's ability to rule on disputes relating to shipbuilding. This is a serious issue given that the WTO's "*main function is to ensure that trade flows as smoothly, predictably and freely as possible*"(World Trade Organization), that shipbuilding is a global industry and that the WTO is the only recourse for complaint in the case of unfair practices of other nations. It raises the potential that WTO may not be able to accommodate complaints relating to commercial shipbuilding and thereby shipbuilding is potentially outside the international regulation mechanisms established for trade disputes. This is the conclusion reached by the European Commission following the failure of the case against South Korea. Scepticism on the part of the EC was shown in a communication to the European Parliament in 2003 relating to the establishment of a policy framework to support the industry in Europe at the time that the WTO panel was initiated. The EC stated: "*Commercial shipbuilding and ship repair operate in a truly global market. This comprehensive exposure to world-wide competition and the fact that WTO trade disciplines are not in all cases suitable for application to this sector, make shipbuilding substantially different from most other manufacturing industries"*(Commission of the European Communities, 2003). Following the failure of the WTO dispute the EC, in a working document from 2007 that evaluates the

[4] This follows the normal referencing of cases in WTO law and this form will be used throughout this thesis.

progress made in supporting competitiveness in European shipbuilding, stated: "*The shipbuilding industry is truly global and ship owners can buy vessels anywhere in the world without significant technical, commercial or legal restrictions. However, the global trade rules governing the sector are often unequal, incomplete or inapplicable. Regrettably, no tangible results can yet be seen in this domain despite the best efforts of all concerned in the OECD and other arenas and the determination shown in prosecuting the WTO case against Korea. This case underscored the limitation of current trade rules with regard to shipbuilding where the concept of import and export effectively does not exist and where subsidisation is often related to the producer rather than the product. Thus, the ruling on this case offered little help to European shipbuilding"* (Commission of the European Communities, 2007).

One of the requirements of the SCM agreement is that the complainant is required to demonstrate "*serious prejudice*", or in other words the complainant must show that significant harm is done to their own industry by the action of the other. There are several definitions within the agreement of what may constitute serious prejudice, with the definition claimed by the EC in relation to shipbuilding defined as "*the effect of the subsidy is a significant price undercutting by the subsidized product as compared with the price of a like product of another Member in the same market or significant price suppression, price depression or lost sales in the same market*"*(World Trade Organization).* The panel accepted on an uncertain basis that such a market exists in commercial shipbuilding but ruled that the EC had not adequately established a link between pricing behaviour of specific shipyards in South Korea and the behaviour of market prices in general. The arguments centred around two specific issues that were discussed at length in the panel hearings:

1. What are the bounds of '*like product*' in the commercial shipbuilding industry? For example, what is the relevance of pricing of LNG tankers in South Korea when the majority of shipyards in Europe were building either cruise ships or container ships at the time of the complaint? These products are not inter-changeable from the point of view of their use and it is difficult to see what their relationship is to each other – how are they 'like'?
2. EC did not show "cross price elasticity" between different product types in the shipbuilding market, thereby failing to establish that the products are economically part of the *'same market'*. The South Korean shipbuilding

> industry was engaged at the time in construction of large tankers and container ships. Can it be shown that pricing behaviour in these specific sectors affect the market, for example, for shipbuilders building smaller container vessels?

South Korea additionally argued that there was no such thing as a "shipbuilding market" and that all contracts were decided on an individual and un-connected basis. Certainly at one time this opinion could have been argued strongly. In 1966, for example, Zannetos, in examining the market for tankers, concluded: *"In shipbuilding..agreements are reached through private negotiations and often the terms of contracts are not readily available, thus causing market* imperfections" (Zannetos, 1966, p. 95). Zannetos noted lack of transparency of information on market prices and lack of consistency between products as, inter alia, particular problems with the notion of a shipbuilding market in the economic sense. Since that time, however, standardisation of products and widely available price information have changed the nature of the market, not to mention the widespread adoption of standard shipbuilding contracts as the basis for contractual relationships between buyer and builder. The Panel were prepared to accept the EC argument that the shipbuilding market does exist as a coherent entity in order to progress the hearing, although without defining in any specific way how the market is constituted, but found that the pricing mechanism between countries and between products was not sufficiently established.

2.2.2 Shipbuilding in the context of maritime economics research

The research presented in this dissertation is fundamentally about one of the four shipping markets as identified by Stopford, namely the "*newbuilding market"* (Stopford, 2009, p. 175), these four (including additionally the "*freight market"*, the "*sale and purchase market"* and the "*demolition market"*) forming the core of maritime economics. A summary of the development of research in maritime economics is presented in Appendix 2.

The field of maritime economics, as described by Heaver, *"remains diverse"* (Heaver, 2012, p. 28), but research specifically in the field of the newbuilding market constitutes a minority in the discipline. The summary of research subjects given by Heaver shows that by far the most active sector of the field remains port studies, measured by the proportion of papers on the subject published in the two principal journals (Maritime Policy and Management and Maritime Economics and Logistics), accounting for 27.3% of papers published between 2000 and 2009, although this had reduced from around one third of all papers published between 1982 and 1991 (*ibid*, p. 26). The economics of shipping markets, taking liner and bulk together, accounted for 17.2% of all papers between 2000 and 2009, only slightly up from 16.9% in the period 1982 to 1991. Woo *et al* reach a slightly different conclusion to Heaver, based on the analysis of content of *Maritime Policy and Management* alone, in a retrospective covering the first forty years of publication. In this review shipping market studies feature ahead of the ports sector in terms of number of publications (Woo *et al.*, 2013).

The proportion of papers on shipbuilding identified by Woo *et al* decreased from 7.5% in the period 1989 to 1991 to only 1.7% (8 papers in total) in the period 2000 to 2009 and it is possible that this decline reflects the European-centric nature of maritime economics. Woo *et al* provide information that reveals that 68% of papers published since the 1970s have been from European institutions and the decline in interest in the economics of shipbuilding could be correlated with the decline in European shipbuilding over that period.

No specific shipbuilding themes are identified either in Heaver's analysis, the sector being referred to as generating "*a variety of subjects*" (Heaver, 2012, p. 28), or in Woo *et al*, where the comment is made: *"Although this area presented a consistent appearance, the number of papers remains relatively small"* (Woo *et al.*, 2013). A review of 11 papers published in Maritime Policy & Management between 1999 and 2013 that contain 'shipbuilding' in the key words, undertaken as part of the research for this dissertation, reveals the following subjects included:

Subject	Number of papers	Overview
Price	1	Price formation of Chinese-built bulk carriers
Management	1	China's shipbuilding management challenges in the 1980s
Competition	3	The WTO dispute, modelling of global competition and Taiwanese competitive strategy
Policy	6	Various policy studies and recommendations for the shipbuilding sector

Table 2.4 – Review of shipbuilding papers published in Maritime Policy & Management, 1999 to 2013

This dissertation is related to the two most numerous sectors, competition and policy, but 11 papers in over a decade would still be counted as a low level of output. It is interesting to speculate why this low level of research in the economics of shipbuilding might be. It certainly cannot be because the sector is without economic interest, nor that all economic issues have been solved. The evidence for this is that both Talley and Woo *et al* include shipbuilding as an element of the subject in their reviews, although one that is not significantly addressed. It is more likely to be related to the technical nature of the subject, study of which is normally the realm of engineers rather than economists. Woo *et al* state: *"The shipbuilding industry takes responsibility for the supply side of the shipping market and may be considered as a part of the shipping market sector. However, this study regards 'shipbuilding' as a separate research area since this industry as a manufacturing industry, has different forms of market structure, policy and regulatory frameworks, industrial practices and so on"* (Woo et al., 2013). Various statements and reviews clearly ground shipbuilding in maritime economics, although from a very different direction when compared to shipping. Shipbuilding does not appear in a list of five suggestions for new directions in maritime economics research.

The lack of publishing on the economics of shipbuilding extends to text books as well as to papers. Stopford is almost alone in dedicating a chapter to the subject (Stopford, 2009, pp. 613 - 654). Talley's widely respected text book 'The Blackwell Companion to Maritime Economics', on the other hand includes virtually no references to shipbuilding and its economics (Talley, 2012). Grammenos includes a chapter on the role of government policy in shipbuilding, although this is fairly general (Grammenos, 2010, pp. 557 - 576). Similarly, shipbuilding textbooks, such as they are, consider solely the design and production aspects of the subject, without reference to economics. Whilst there are occasional exceptions (Strandenes, 1986), where the economics of shipbuilding is considered it is normally a snapshot of market share, demand and price development that is given, without elucidation of the underlying economic principles. A good example is the 1960 book: 'The Economics of Shipbuilding in the United Kingdom' , where *"the emphasis has been placed on the current position of the industry as revealed by an examination of the current facts"* (Parkinson, 1960, p. x), although Parkinson does include an interesting section on the relationship between shipping cycles and shipbuilding cycles. Such 'snapshots' inevitably have a 'shelf life' because the global shipbuilding industry is constantly in a state of flux with changes in the major players and competitive conditions. Such publications are therefore of limited use in the long run, except perhaps to historians. The conclusion drawn from this is that this dissertation presents an opportunity to add a new dimension to the area of maritime economics research by addressing what is thus far a relatively neglected sector, but is one that is of significant importance to the totality of the subject.

The lack of publishing on the subject has added a dimension to this work that had not been envisioned at the start. Because publications on the economics of shipbuilding are scarce it has been necessary to extend the literature review historically, a process afforded by the 'Marine Technology Special Collection' at Newcastle University. As established earlier, the economic issues currently faced by the global industry are substantially the same as those faced a century and more ago, and publications over this extended period have therefore been able to provide a vital reference source for this work.

Finally, it is perhaps worth noting that this dissertation is written from the point of view of the shipbuilder, which is unusual in economic analysis of the industry. In doing this it is hoped it will contribute to a need identified by Dikos in modelling newbuilding prices, where he concluded: *"In order to understand fully the formation of the demand and supply functions for new vessels, we need to employ models of competitive exchange. This task lies ahead for future research and will hopefully shed some light on the question of the nature of the behaviour (strategic or not) of the builders of new vessels" (Dikos, 2004)*.

3. Objectives and research questions

3.1 Research objective

It is the objective of this research to propose solutions to problems raised by specific barriers encountered in the application of the WTO's subsidy and countervailing measures dispute process, identified in *Korea – Commercial Vessels,* so that the WTO's mechanisms may be better available when such disputes arise in the future. This requires that the underlying difficulties of identifying 'like products' and 'cross price elasticity' between those products are addressed and, to enable this to happen, the precise nature of the 'commercial shipbuilding market' must first be established.

Additionally, the dissertation uses this specific problem to examine the fundamentals of the sector and to contribute to the *"deeper understanding"* sought by the OECD, as discussed in Section 1. The research seeks to improve the understanding of the nature of the business of shipbuilding and links between its investment and operations, products, markets and economics, which will hopefully stimulate further research into the complex economics of this fascinating industry.

3.2 Research questions

In the following list, the designation 'H' refers to hypothesis and 'R' to research question. The overlying thesis is as follows:

- H: The international commercial shipbuilding industry is not fundamentally different to other industry sectors in that it can be defined and analysed to make it governable by WTO instruments that aim to regulate competition.

In order to support this thesis it is necessary to address the fundamental questions that arose in *Korea – commercial vessels*, as described above in Section 2, and this requirement leads to the identification of the hypotheses *"each of which will be tested for its adequacy"* (Phillips and Pugh, 2010, p. 49). The fundamental questions that arose in *Korea – commercial vessels* are summarised as: does the commercial shipbuilding market exist, what are the characteristics of 'like products' in that market and can cross price elasticity be demonstrated between those products, which would be an indicator of a competitive market situation? Three hypotheses resulting from these questions are:

- H1: The commercial shipbuilding market exists;
- H2: Like products exist in the commercial shipbuilding market;
- H3: Cross price elasticity exists between like products in the commercial shipbuilding market.

Underlying all sections of the work is the requirement to understand the meaning of ‘like product’ in its legal sense in WTO regulations and the first question that needs to be asked, therefore is:

- R1: What is the legal definition of ‘like product’ in the context of WTO?

To investigate **H1** two questions must be addressed:

- R2: Does the functioning of the international commercial shipbuilding market correspond to the accepted definitions of what constitutes a market in the economic sense?
- R3: What are the boundaries of the market and how is it constituted in terms of products and their characteristics?

To investigate **H2** it has to be shown that likeness can satisfy the definitions required by WTO and, as will be seen in the answer to R1, this is essentially about competitiveness. To investigate H2, therefore, two questions must be addressed:

- R4: How do shipyards compete and what determines competitiveness between shipyards and between products?
- R5: How can ‘like products’ be characterised based on the answers to R1 and R4?

To investigate **H3** two questions must be addressed:

- R6: How is price determined in commercial shipbuilding?
- R7: Can cross price elasticity be demonstrated across different products?

The structure of the theses and questions is shown in Table 3.1.

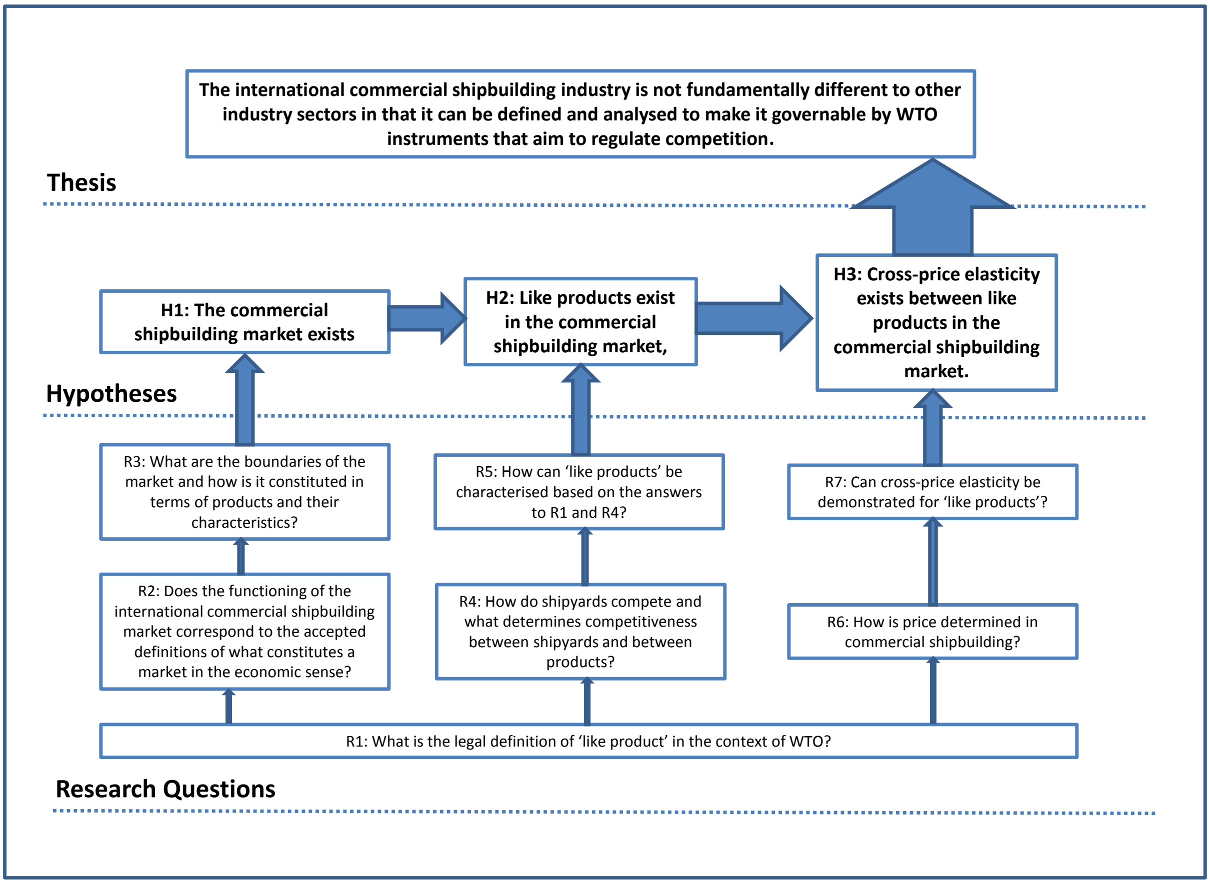

Table 3.1 – Structure of Thesis, hypotheses and research questions

4. R1 – What is the legal definition of 'like product' in the context of WTO?

Establishing 'likeness' between products is a vital element in identifying violations in WTO law: "*the 'likeness' element can offer more than just a comparison that provides the first step in the analysis. It can also be the key to the provision*" (Lester et al., 2012, p. 272). The general term 'like product', along with similar terms such as '*directly competitive or substitutable products'* (Lang, 2011, p. 261) appear many times in WTO and GATT instruments but generally without guidance or interpretation or meaning. Bossche lists 10 uses of the term 'like product' in GATT 1994 but notes that "Nevertheless, the concept of 'like products' is not defined.." (Bossche, 2013, p. 325). Outside the GATT agreement itself, however, the Agreement on Subsidies and Countervailing Measures, the specific agreement that was at the root of *Korea – Commercial Vessels*, does provide some guidance on the meaning of the term, which is defined in the agreement as: "*a product which is identical, i.e. alike in all respects to the product under consideration, or in the absence of such a product, another product which, although not alike in all respects, has characteristics closely resembling those of the product under consideration*"(World Trade Organization, 1994). This is clearly a wide and rather vague definition. What characteristics of a product can be considered, for example, and what are the bounds of "closely resembling"? Thus, even where guidance is given the concept of 'like product' is complex and gives a wide scope for interpretation. Even if the narrowest possible view of the term were to be taken, that is to say where two products appear to be identical, the ambiguity persists. Lester et al point out that "*two individual products could never be exactly the same in all respects. They could share common features such as physical characteristics or end use, but would differ in others*" (Lester et al., 2012, p. 316). A good example to illustrate this would be the difference between a genuine and a counterfeit Rolex wrist watch. Even if the counterfeit were to be a perfect copy in every respect it would not be 'like' the genuine article.

This vagueness may seem strange to non-legal readers or persons new to the WTO system, but there is a good reason for it and von Moltke notes that this ambiguity was intentionally introduced into the original draft of the GATT's immediate predecessor in 1948, the 'Havana Charter', to reflect problems in the real world

(Moltke, 1998). Lang argues that in drafting the original GATT agreement "*there was an alternative view of the role of law… which saw legal ambiguity as a potentially constructive force"* (Lang, 2011, p. 200), because it requires the context of a trade measure to be taken into account through interpretation, rather than simply proscribing an absolute and firm rule. Lang points out that this view was developed during the negotiation of the 'Havana Charter' following a memorandum submitted by the UK during negotiations, which stated:

"…*there are numerous provisions in the charter which require the discretion and economic judgement rather than precise interpretation of the terms of the charter…In almost every conceivable case arising under the Charter the issues will of their nature involve the element of economic appraisal and assessment and will not be purely legal in character, and it will be impossible to say where the economic judgement ends and the legal judgement begins*" (Ibid.).

Thus, whilst the lack of a definition or even precision of language with respect to 'like product' may seem like an oversight on the part of the drafters of the WTO legal documents, it is in fact an important and intentional feature. To quote further from Lang who, in turn, is quoting from another author (Robert. E Hudec): *"..the issue was not just to ensure that dispute settlement was guided by economic (not just legal) forms of expertise, and controlled by 'pragmatic' economic experts whose judgement was not cluttered by legalistic ritual'*[5]*"* (*Ibid*.). In other words, the law is trying to avoid clear rules and thereby avoid '*predictable behaviour'* (*ibid*.). Naval Architects will recognise the features of this type of predictable behaviour in the development of 'paragraph ships', common terminology for specific design features introduced to circumvent what are seen as disadvantageous proscriptive rules. Blocksidge notes that the first known rule for tonnage calculation resulted from a 1694 Act of Parliament that proscribed a simple formula for calculating the tonnage of ships carrying coal. He goes on to state that: *"From this date onwards there have been frequent changes to deal with evasions, anomalies, and alterations in the design of ships"* (Blocksidge, 1933, p. 124). In any situation, therefore, proscribed firm limitations and rules are likely to be seen as a challenge, rather than a restriction. It is only in the current century that ship design is finally getting to grips with this,

[5] From Hudec (1970): The GATT Legal System: A Diplomat's Jurisprudence.

through the introduction of goal-based rather than rule-based design methodologies, directly analogous to the WTO's legal approach to the meaning of 'like product'.

The lack of an explanatory definition of the meaning of the term 'likeness' in most instances of its use means that it has been up to case law to develop its interpretation, and it remains one of the most hotly debated features of WTO law. As Lang puts it: *"These rules of the game can be thought of as 'customary norms'… The GATT's legal system relied on the existence of this underlying and evolving substratum of informal norms, without which it simply could not function effectively" (Lang, 2011, p. 203).*

Consideration of the meaning of the term 'like product' is specific to the particular paragraph of the WTO agreements in which the term appears and thus there can be no single or general definition. Strictly speaking, therefore, an overall meaning cannot be given, nor inferred between contexts. Notwithstanding this, to gain the widest view of possible interpretations the following section looks at the definition of 'like product' in all contexts, to gain an insight into the potential breadth and depth of meaning that could be inferred under the SCM agreement definition. This is consistent with case law relating to the SCM agreement, which has found that assessment of likeness under this agreement should be similar to that for assessment under GATT in general. The Panel in *Indonesia – Autos (1998)* ruled:

"*Although we are required in this dispute to interpret the term 'like product' in conformity with the specific definition provided in the SCM agreement, we believe that useful guidance can nevertheless be derived from prior analysis of 'like product' issues under other provisions of the WTO Agreement*".

A good history of the development of term through legal rulings going back to the original 1947 GATT agreement is given in Cottier *et al* (2000). Certainly the simplistic notion that products should be substitutes for each other in a functional sense is far too narrow to define what constitutes a like product within the ambit of WTO agreements, and early attempts to define the concept using dictionary definitions were therefore found to be too narrow. The WTO's Appellate Body (the organisation that deals with appeals following Panel rulings) in the case of *Canada-Aircraft* in 2000 ruled that "*dictionary meanings leave many interpretive questions open"* and thus the meaning of 'like product' has to be interpreted on a case by case basis. The case of *Japan – Alcoholic Beverages II* in 1996 further concluded on appeal that the concept of 'like product' is not constant and products that are like in one situation may be considered to be not so in another, indicating that the features that determine 'likeness' are not simple or straightforward. These rulings reflect the findings of an influential Working Party on Border Taxes from 1968, which considered the meaning of 'like product' and which concluded that such a case by case approach is necessary.

The Working Party's concept of likeness has subsequently been used, to varying degrees, in virtually all Panel and Appellate Body considerations of 'likeness', establishing the four primary considerations of the concept of 'likeness':

In considering likeness "*a panel examines on a case by case basis all relevant criteria or factors including: (1) the products' properties, nature and quality, i.e. their physical characteristics; (2) the products' end-uses; (3) consumers' tastes and habits, also referred to as consumers' perceptions and behaviour, in respect of the products; and (4) the products' tariff classification*"(Bossche, 2013, p. 363).

Consideration of the tariff classification of products provides a relatively simple approach to defining likeness and Bossche notes that *"tariff classification has been used as a criterion for determining 'like products' in several panel reports"* (Bossche, 2008, P.353). The most appropriate classification would be the SITC system, that is to say the United Nations' Standard International Trade Classification system (United Nations Statistics Division, 2013). Under the taxonomy of this system the classification of ships can be found in:

- *Section 7 – Machinery and transport equipment*
- *Division 79 – Other transport equipment*
- *Group 793 – Ships, boats (including hovercraft) and floating structures*

This group is sub-divided into the following sub-groups:

- *793.1 - Yachts and other vessels for pleasure or sports; rowing-boats and canoes*
- *793.2 - Ships, boats and other vessels (other than pleasure craft, tugs, pusher craft, special-purpose vessels and vessels for breaking up)*

- *793.3 - Vessels and other floating structures for breaking up*
- *793.5 - Light vessels, fire-floats, dredgers, floating cranes, and other vessels the navigability of which is subsidiary to their main function; floating docks; floating or submersible drilling or production platforms*
- *793.7 - Tugs and pusher craft*
- *793.9 - Other floating structures (e.g., rafts, tanks, coffer-dams, landing-stages, buoys and beacons)*

Clearly sub-group 793.2 is relevant as a potential context for likeness in commercial shipbuilding. Sub-group 793.2 is further subdivided into the following 'basic headings':

- *793.22 - Tankers of all kinds*
- *793.24 - Fishing vessels; factory ships and other vessels for processing or preserving fishery products*
- *793.26 - Refrigerated vessels (other than tankers)*
- *793.27 - Other vessels for the transport of goods (including vessels for the transport of both passengers and goods)*
- *793.28 - Cruise ships, excursion boats and similar vessels principally designed for the transport of persons; ferry-boats of all kinds*
- *793.29 - Other vessels (including warships and lifeboats other than rowing-boats*)

These 'basic headings' collectively sufficiently describe the vessels included in the market definition derived later in this dissertation but include two headings that are not appropriate to commercial vessels (as included in *Korea – Commercial Vessels*): 793.24, fishing, and 793.29, other (including warships). Heading 793.27 provides a possible classification for many commercial vessels and this group would confirm that container ships and bulk carriers, for example, are to some degree 'like' because they would be both within the ambit of this definition. Where this approach breaks down, however, is that tankers and refrigerated vessels are included in separate categories and this approach therefore is inconsistent. The demarcations in the system are evidently orientated to the trade in goods rather than the ships themselves as products, reflecting the most common use of this system in the classification of trade and tariffs. This is not appropriate in the definition of like product in the shipbuilding context. This approach is therefore inadequate, except in that it establishes the principle that two apparently dissimilar vessels, for example a small feeder container ship and a large capesize bulk carrier, or a North Sea ferry and a general cargo vessel, may be considered as like at least in this context. This reinforces the view that products that are like do not have to be substitutes for each other in a functional sense, counter to what was argued by Korea in the panel hearing of *Korea – Commercial Vessels*. This also reflects the Appellate Body's conclusions in the case of *Japan – Alcoholic Beverages II,* where the Body *"cautioned against the use of tariff bindings"*. The definition of likeness clearly has to be approached from another direction.

Following interpretation of the term 'like product' on a dictionary or tariff-boundary approach, a more analytical market-based approach was developed and this is essentially the approach used today, which *"looks to the consumer and the market… to make distinctions between products"*. It is worth noting that an alternative coherent approach for interpretation developed along the way was termed 'regulatory intent', normally referred to as the "*aim and effects test"* (Cottier *et al.*, 2000; Lang, 2011; Bossche, 2013) whereby the consideration of likeness should take into account not the attributes of the product but what is the aim of the measure that is the subject of the complaint (the support of the commercial shipbuilding industry in South Korea in the case of *Korea – Commercial Vessels*) and what is the effect of the measure on the complainant (loss of business for EC shipyards in the case of *Korea – Commercial Vessels*). This approach appears to have merit but was rejected as unworkable in 1996 by the Panel in *Japan – Alcoholic Beverages II*, primarily because governmental intent is virtually impossible to deduce from analysis, and is now discredited and abandoned in the consideration of likeness in the WTO. This was essentially the underlying approach taken in the arguments of the EC in *Korea – Commercial Vessels* and as outlined in the Panel ruling the case for likeness was rejected as unproven.

Cottier et al note that: "*For most purposes, however, meaningful comparisons of 'like product' definitions requires specifying the criteria by which likeness can be measured. One must describe the individual criteria with some care, and after that it is possible to talk about degrees of likeness within the boundaries of those criteria or* *characteristics*". The flexibility of the term 'like product' has led to it being described in terms of an accordion, which can stretch and squeeze depending on the situation and the specific agreement concerned. Bossche notes that "*It is generally accepted that the concept of 'like products' has a different scope or 'width' in the different contexts in which it is used*" (Bossche, 2013, p. 326) and goes on to list a framework of three questions that need to be resolved in considering the interpretation of the concept, based on the rulings on another case: EC-Asbestos in 2001. The questions are:

1. "*which characteristics or qualities are important in assessing 'likeness';*
2. *to what degree or extent must products share qualities or characteristics in order to be 'like products'; and*
3. *from whose perspective likeness should be judged*".

In considering these questions it is important to state that whilst similarity of physical characteristics may be the first consideration of likeness it is not necessary that such similarity exists for likeness to exist. Conversely, products that share even apparently identical physical characteristics may not be 'like' within the context of WTO laws. Konrad von Moltke points out that when the GATT agreements were drafted, those drafting the texts must have known that the English word 'like' in this context has no perfect counterpart in either French or Spanish, the other two designated languages for legal texts in the WTO (Moltke, 1998). He points out that the French version of GATT speaks of 'equivalent' as the translation for 'like' and notes that:

"*Some products are equivalent but not like (for example, whisky and sake). Some products are like but not equivalent (for example, wild caught salmon and the ranched version). In the modern trading system, some products are identical but not alike (for example, generic and branded pharmaceuticals*)".

The author points out that some generic and branded pharmaceuticals may be produced on the same machines but may not be 'like products' under the terms of the 'TRIPS' agreement, that is to say the WTO agreement on intellectual property rights. The issue under discussion in Moltke's paper is related to fishing methods for Tuna, where the author argues that dolphin-friendly methods for catching the fish must be distinguishable in trade law from non-dolphin friendly, but in determining likeness in the WTO context the consideration of the production method, or process and production methods (ppm) as it is known, is not permitted: harvesting or production methods that do not alter the end product cannot make a product ‘less alike’. Bossche notes that this aspect of likeness is increasingly being put under pressure on the basis of competitiveness of environmentally friendly and un-friendly means of production. As a general rule, however, *“two similar products cannot become unlike on the basis of their method of production or process”* and developing countries in particular argue against the use of production methods in determination of likeness (the so-called *“ppm debate”)* (Bethlehem, 2009, p. 546). This is important in determining likeness between two units of shipbuilding capacity. A unit of capacity in a modern shipyard building in a drydock, for example, cannot be seen as being dissimilar to a unit at a yard building on a slipway.

Cottier et al point out that “as soon as any difference of physical characteristics is found, however, one has to resort to other criteria to determine whether the difference is relevant to the question of ‘like’ treatment”. The example of a non-physical characteristic that may be taken into account in this source is ‘commercial interchangeability’ and it is this concept, within the framework of questions listed above, that provides the basis of likeness in commercial shipbuilding proposed in this dissertation. This reflects the generally held view that “‘*likeness’ is essentially a determination of the competitive relationship between two products*” (Bethlehem, 2009, p. 547). Lester et al put it as follows, with reference to key Panel and Appellate Body rulings: “*With these statements, the appellate body has seemingly issued a clear and determinative statement that ‘likeness’ is about the economic competitiveness of products”* (Lester et al., 2012, p. 271). Cottier et al point out that substituting the words ‘competing products’ for ‘like products’ possibly gives a far more meaningful indication of the intent of the wording although with its own set or problems in the definition. The authors go on to provide the basis of a test for likeness, additional to Bossche’s three questions listed above, in the following terms:

“*Many of the criteria of likeness that have been offered in GATT legal discussions of the ‘like product’ concept can be viewed as overlapping variations on the idea of competitiveness. First there is substitutability – the extent to which consumers perceive two products as functionally equivalent, measured by the consumer’s willingness to substitute one for the other, a willingness which in turn is usually* *measured by the extent to which relatively small changes in price affect consumer preferences for one or the other. Next, there is concept of functional likeness, the extent to which the two products do in fact perform the same function, like sweeping dirt. Finally, although the producer-orientated provisions sometimes do employ 'likeness' criteria that do not, strictly speaking, relate to the competitiveness of the goods in question – e.g., the extent to which two products are made from the same raw materials, in the same establishments, by the same capital goods, or by the same workers – the competitiveness criteria are still the first and most important factor in the 'like product' decisions in those areas as well*".

Bossche states, on the basis of the ruling of the Appellate Body in relation to EC – Asbestos (2001): "*It is clear that an internal regulation can only afford protection of domestic production if the internal regulation addresses domestic and imported products that are in a competitive relationship*" and this clearly places the issue of competitiveness in the evaluation of like product within the context of the SCM agreement. The Appellate Body in question stated: "*determination of likeness under* [GATT] *Article III:4 is, fundamentally, a determination about the nature and extent of a competitive relationship between and among products*"(Bossche, 2013, p. 388). It is also pointed out that the ruling requires that both the nature and extent of the relationship is examined and this means that the determination of likeness is a matter of judgement and not just economic analysis.

To summarise these factors in terms that can be used to judge likeness in the following analysis, likeness has to show:

1. Substitutability – consumers have to be willing to substitute one for the other;
2. Functionality – the two products have to perform the same function; and
3. Competitiveness – the two products have to actually be competing for the same opportunities.

In general, therefore, both competitive factors and physical characteristics have to be taken into account in determining likeness. Even products with physically similar characteristics may not be 'like' if their "*competitiveness of substitutability is low"(Bossche, 2013, p. 388).* A good example here that has been tested in the WTO is the comparison of luxury cars with cheaper more utilitarian vehicles. The end use of the two cars is the same, the physical properties are more or less the same (they are both cars) but consumer tastes and habits in the purchase of the two are very different and the two are therefore not competing or substitutable and are not considered to be ‘like’.

These three factors will be used, along with Bossche’s four questions outlined earlier, in the analysis that follows to test the issues of likeness in commercial shipbuilding against the definition given in the SCM agreement.

Finally it should be noted that the definition of ‘like product’ needs to take into account the intent of the context within which it is used. The importance of context is central to the interpretation of the term: *“the Appellate Body in Japan – Alcoholic Beverages II did not hesitate to observe that the term ‘like products’ has different meaning in the various contexts in which it appears throughout the WTO agreements” (Bethlehem, 2009, p. 612).* In the case of the SCM agreement this intent is not specifically stated in the agreement per se, but it is clear from the agreement that the intent is to prevent the use of government financial support to favour domestic industry against foreign competition in the global trading arena. The WTO’s own explanation of the intent of the agreement, published on the WTO web site, is as follows:

“*This agreement does two things: it disciplines the use of subsidies, and it regulates the actions countries can take to counter the effects of subsidies. It says a country can use the WTO’s dispute settlement procedure to seek the withdrawal of the subsidy or the removal of its adverse effects. Or the country can launch its own investigation and ultimately charge extra duty (known as “countervailing duty”) on subsidized imports that are found to be hurting domestic producers*”. (World Trade Organization, 2013a)

This intent will be taken into account in the following analysis of like product in commercial shipbuilding, taking into account also the tests for ‘likeness discussed above’ and that the concept of likeness necessarily has to consider the competitive relationship between products from the point of view of shipbuilders and their customers, not in relation to the functional use of the ship.

5. H1 - The commercial shipbuilding market exists

5.1 R2 – Does the functioning of the international commercial shipbuilding market correspond to the accepted definitions of what constitutes a market in the economic sense?

5.1.1 Empirical acceptance of the existence of the market

Wijnolst and Wergeland in 1996 considered the question *"Is it relevant to talk about one world market for the building of ships"* (Wijnolst and Wergeland, 1996, p. 183) and concluded statistically that a single market exists: *"The conclusion is that it seems relevant to talk about one, global market for the building of ships. The price correlation is very high for most segments, so prices adjust quickly to either regional or ship type differences. The technological diffusion process is also very rapid, making it difficult, if not impossible, to protect a new innovation or design from strong competition"* (*ibid*., p. 186)[6]. This was done in part by reviewing price correlations between market sectors, which were shown to be substantially positive. Even without positive statistical proof, however, it is widely accepted by industry practitioners that a commercial shipbuilding market exists and it is widely discussed as such in key texts and books. A small number of the wide uses of the term are as follows:

- The "*newbuilding market*" is identified by Stopford as one of "*shipping's four market places*" (Stopford, 2009, p.177) and Stopford uses two 19th Century economists' definitions to define what a market is, the essence being that traders are in "*close communication with each other*" and as a result "*the prices of the same goods tend to equality easily and quickly*".
- Strandenes talks about the economic concepts of the shipbuilding market in another standard work on the shipping markets commonly referred to in maritime economics (Grammenos, 2002, p. 186 to 202). In other work, Strandenes classifies newbuilding along with the spot freight markets as *"'real' markets with market clearance between supply and demand for transportation services and vessels, respectively. The time charter markets and markets for*

[6] In drawing this conclusion the authors appear to be quoting from a paper: *"One shipbuilding market?"*, SNF-Working Paper 30/96, Bergen SNF, Haddal, R., and Knudsen, K, (1996)

second hand vessels, on the other hand, are 'auxiliary' markets. In these markets shipowners may spread their risk or get information as to the view of the future held by the 'market'. This implies that both the time charter and the second hand market reflect the economic agents' expectations of the future development of the spot freight rate" (Strandenes, 1984).

- In discussing the key themes in shipping economics research, Cullinane notes: *"the importance of analysing the shipbuilding, ship sale and purchase (S&P) and scrap markets"* (Cullinane, 2005, p. 2) and goes on to list a range of data providers and consultants that provide information and analysis in the market.
- In the Institute of Chartered Shipbrokers guide for trainee ship brokers it states that trainees must: "*understand what factors influence the state of the S&P [sale and purchase] market generally and what factors influence each of these markets particularly*" and in defining the scope of this market the trainees must "*thoroughly understand the differences and relationships between the markets for newbuildings, second hand tonnage and demolition*" (Institute of Chartered Shipbrokers., 2012b).
- The widely regarded 'Platou Report', published annually for over 30 years by Norwegian ship broker R.S. Platou, is similar to many brokers' state of the market reports in including a section specifically titled "*The Shipbuilding Market"* (R.S. Platou a.s., 2014, pp. 12-15). Other published brokers reports similarly contain sections referencing the 'shipbuilding market' or the 'newbuilding market' (Clarkson Research, 2014; Fearnleys, 2014).
- The OECD has a working party on shipbuilding: "*Since its creation in 1966, the OECD's Council Working Party on Shipbuilding (WP6) has addressed factors that distort normal competitive conditions in the shipbuilding industry in accordance with its mandate*" (OECD Working Party 6, 2012a). WP6's background paper on market distorting factors in 2012 and its supporting documentation extensively discuss an entity specifically titled the "*shipbuilding market*" (ibid.).

Notwithstanding the widely accepted existence of an entity called, interchangeably, the "shipbuilding" or "newbuilding" market its existence was questioned at the WTO hearing (World Trade Organization, 2005)**.** In preliminary hearings the Korean side argued that there is no entity that could be termed the 'shipbuilding market' and that each contract for a new vessel had to be considered as a separate entity in its own right. The panel rejected this notion, not least because the Korean technical expert themselves were engaged in publishing reports analysing an entity called the *"shipbuilding market"* (Drewry Shipping Consultants, 2001). Later discussions included in the report of the panel centred on the definition as to what constituted such a market. The European submission claimed the existence of a general "*world market" or "global market"* where new ships are bought and sold on a global basis and with the existence of "*market prices"* within that market. The Korean submission denied the existence of such a market, arguing that "*some markets are reserved for national producers (citing LNGs, and the US cabotage market, as particular examples). Korea further argues, as described above, that price suppression/price depression must be established in relation to (a) particular national market(s). Korea seems to imply that therefore a case based on a world market must fail on this basis alone"* (World Trade Organization, 2005).   The "*US Cabotage"* market referred to here is the protected 'Jones Act' market, whereby ships involved in cabotage trades in US waters are restricted by law, inter alia, to being built in US shipyards. Clearly this is an example of shipbuilding trade that could not be included within the definition of a world market. The LNG example cited is rather confused, due to an apparent misunderstanding by the Panel. The building of LNG tankers is not reserved nationally in any protected way, unlike contracts that fall within the terms of the Jones Act, but it is concentrated in a small number of specialised builders and there are significant barriers to entry in that sector that may be argued preclude it from any discussion of a *"global market"* in a general sense. It must be concluded, given these two exceptions, that the Korean argument correctly recognises that there may not exist a single homogeneous entity called a 'shipbuilding market' but this does not preclude that a group of more or less discrete sub-markets may exist, nor the possibility of linkages that connect pricing mechanisms between these markets[7].

There is clearly merit in both sides of this argument. The panel accepted the existence of a world market for "*commercial vessels*" in its ruling but key aspects and the nature of this market remain ill-defined. What are the boundaries of the market

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[7] In reality, cross price analysis presented later in this dissertation suggests that LNG tankers are like other ships, despite the barriers to entry, and the distinction proposed by Korea is found to be false.

in terms of products, that is to say what could be considered as 'like product' in such a market, and is there any meaningful concept that could be called a 'market price', for which cross price-elasticity within the bounds of like products must be shown?

5.1.2 Benchmarking commercial shipbuilding against definitions of the economic concepts of a 'market'

In defining the market it is helpful to return to basic economic principles and examine underlying definitions of what constitutes a market. The shipbuilding market can then be tested against these definitions.

The Oxford English Dictionary's (OED) basic definition is "*A place at which trade is conducted"*, with first use noted as being in the Anglo Saxon Chronicles in the year 963 AD. The concept of a market being constituted in a physical place persisted until relatively recently, up to the 1980s, with the Baltic Exchange and the London Stock Exchange being good examples of places where trade was done physically in a specified locality. Such physical places persist in many forms, for example in food and other retail markets, but the development of electronic trading means that the physical place is no longer necessary for the transaction of intangible items or what has historically been termed the trade in 'paper'. Such intangible items may be linked to tangible products, for example relating to a contract for production of a new ship.

Subsequent OED definitions come closer to what may be referred to as the 'shipbuilding market' under discussion here. Definition 4 refers to: "*The action or business of buying and selling; a commercial transaction, a purchase or sale; a (good or bad) bargain"*, and definition 5 to: "*The rate of purchase and sale of a commodity. Now usually (chiefly in Stock Market): the market price or the market value"*. These represent the modern economic definition of a market, as an economic construct rather than a physical place, although surprisingly are only marginally younger in terms of first use than the first definition (the years 1340 and 1592 for definitions 4 and 5 respectively). Based on these definitions the underlying concept of a market can be seen to include:

1. facilitation of economic transactions (buying and selling);
2. a mechanism for setting of price.

This ‘classical’ definition concurs with that discussed by Stopford in relation to the newbuilding market, discussed above. To expand this, four further definitions from economics reference sources have been examined. These are outlined below, with comments on the situation described in the WTO panel ruling.

Definition 1: Routledge dictionary of economics (Rutherford and Ebooks Corporation., 2002)

"*A medium for exchanges between buyers and sellers...markets for goods and services are termed 'product markets' and for labour and capital are determined 'factor markets’. There is a linkage between product and factor markets in that the demand for a factor is derived from the demand for its product. Dealers in a market seek to create an equilibrium between demand and supply at a particular price*”.

Essentially the European view expressed in the panel ruling takes a ‘factor market’ approach, with the factor traded being shipbuilding capacity. The Korean view, on the other hand, takes the ‘product market’ approach, suggesting that trades are specific to the particular contract and thereby to the specific product involved in a particular trade. As suggested by this definition, however, the two approaches are not mutually exclusive but are linked. In a very real sense shipyards do, of course, sell ships. At the time of contract, when the sale is made, however, the ship, except in rare circumstances, does not exist and what is actually being traded is a commitment to provide capacity to build that ship at a future time. Brokers commonly refer to this future capacity as a ‘slot’ in the shipyard’s build programme. It is demonstrated later in this dissertation that not only is commercial shipbuilding capacity flexible in terms of the products that it can economically produce, it is essential to competitiveness that this flexibility exists due to the fluctuating nature of demand. One-product shipyards have existed in the past and to some extent current examples could possibly be postulated, for example dedicated cruise ship builders, but in the long run pure one-off shipbuilders have been unable to survive without adaptation of their capacity for other purposes. The forward capacity that is sold when an order is placed, therefore, could be booked for a range of product types and it is therefore capacity that is being traded, a factor of production, as well as the product. The sale is directed to the product and purchaser that offer the best economic prospect to the shipbuilder at that particular time and the nature of this trade will vary depending on shifting market conditions.

The length of time from contract before which capacity is actually utilised can be significant, depending on market conditions and the shipyard's backlog of work at the time of taking the order. For example, records in Sea-Web show that 12 large container ships (over 10,000 TEU) ordered from Hyundai Heavy Industries (HHI) of South Korea in 2006 did not see keel lay for 32.5 months on average after the orders were placed, with the longest waiting 39 months for keel lay. If the order were to be cancelled before production commences the capacity 'slot' would wherever possible be re-sold but the subsequent contract would not necessarily be for the same product. Thus, whilst in product terms a ship itself is not substitutable for another ship type when in operation, for example an LNG tanker could not carry containers, the factor of production that is traded, capacity, is substitutable at least to some extent between products. This characteristic of shipbuilding capacity was noted by Adland *et al* in studying the nature of 'asset bubbles' in shipping: *"It is worth emphasising that the different types of ships will compete for the same slots"* (Adland et al., 2006). Of course the proposed ship has to be compatible with the factor of production, taking into account both the size and technical characteristics of the vessel, which have to be within the shipyard's capability, the shipyard's strategy with respect to product mix and access to factors of competitive advantage that the shipyard holds. As an example, HHI has in the recent past used the same units of capacity to build VLCCs, capesize bulk carriers, large container ships and LNG tankers.

The question that arises is how flexible is a unit of shipbuilding capacity between products and what determines the limits of this flexibility? This could be stated in terms of what products could the capacity be competing for and this is central to the issue of like product that is also addressed later in this dissertation.

The attributes of both factor and product are taken into account in the theory of price for new ships. Haralambides *et al*, in conducting a review of ship price research and publications, conclude that: *"In addition to market expectations, the price of new ships depends on shipbuilding costs and shipyard capacity"* (Haralambides et al., 2005). This recognises that price is determined both by the attributes of the product (a cruise ship, for example, with sophisticated public spaces and systems, will self-evidently be more expensive than a bulk carrier which contains a limited amount of outfit, or a small bulk carrier will self-evidently cost less to build than a large bulk carrier) and the attributes of the availability of capacity, with prices likely to be higher when the supply of capacity is limited (i.e. when shipyards are relatively full of work with long backlogs) and lower when orders are scarce.

In the context of this definition there remains the question about the existence of a mechanism that can account for the determination of a 'market price'. This is discussed further below.

Definition 2: Dictionary of economic terms (Gilpin, 1977)

"*An area, however large or small, where buyers and sellers are in sufficiently close contact with each other to ensure that the price of a commodity tends to be the same in all parts of the market*".

This definition addresses the key question of the identification of a mechanism for pricing and the issue of cross price elasticity between differing products, which are competing for the same units of capacity. It is necessary, therefore, to consider the existence of a potential mechanism for this "*close contact"*, to confirm the existence of a market within this definition and conforming to the basic OED definition given at the start of this section and also discussed by Stopford.

It is proposed that this mechanism can be shown to exist as a combination of two elements. The first element stems from the common practise of the use of agents, in the form of 'sale and purchase' (S&P) brokers, to negotiate between buyer and seller in the fixing of newbuilding contracts. The role of S&P brokers is summarised as follows by Branch in a widely used shipping textbook: *"The sale and purchase of vessels is a very specialized activity and is undertaken by a sale and purchase broker. He (*sic) *normally acts either for the buyer or seller of a ship"*. (Branch, 2007, p. 332) The Institute of Chartered Shipbrokers (ICS) outlines the role of an S&P broker as: "*S&P brokers tend to specialise, some dealing exclusively in new ships where a close knowledge of the prices yards are quoting and the availability of building berths is needed"* (Institute of Chartered Shipbrokers., 2012a, p. 64). Thus, the use of ship brokers appears to fulfil the criteria in the above definition that, whilst there is no sophisticated mechanised exchange for new ships such as in the stock markets, there is a mechanism providing *"sufficiently close contact"* to justify the claim that a pricing mechanism may exist in the market. The ICS further classifies brokers into *"bulk carrier (dry and tanker) general purpose and small ships ...small also includes such craft as fishing vessels, barges, tugs and other specialised vessels.. Passenger and ferry"* (*ibid*.) and this demarcation may give some clues to the boundaries of like product, to be discussed further. It should also be noted that many shipbrokers span more than one market classification, thereby offering a potential route for cross price mechanisms.

The second element demonstrating 'close contact' relates to the statement quoted above from the ICS that part of the job of the broker is to have a "*close knowledge of the prices yards are quoting"*. This close knowledge will come partly from direct contacts with shipyards and with fellow brokers within the same firm and between firms. Additionally, however, as with any sector of the shipping market, there are a range of sources available that track shipbuilding prices and publish information on the generality and, in some cases, specifics of contracts. Perhaps the most widely used general source in this respect is *Clarkson's World Shipyard Monitor*, which publishes both guide prices for specific products and a market index for prices in general, but there are many other publications and broker's reports available to advise on prices. Prices are reported in generality, for example, in *Lloyd's Shipping Economist* and *Fairplay*, and specific contract prices in journals including *Lloyd's List* and *Tradewinds*.

In this way it is proposed that *prima facie* the mechanisms for price setting that are part of the definition of a market exist in general terms and as such supports the contention that a market can be said to exist, although no doubt there will be exceptions. A good example is the cruise ship sector, where negotiations tend to be direct between shipyard and owner, rather than through an S&P broker. The purchase of smaller and specialised vessels, for example tugs, may also be outside the scope of the S&P broking sector, with direct negotiation between buyer and seller. The Dutch tug producer Damen, for example, has sufficient brand presence such that sales can be made directly without the need for brokers.

Definition 3: Collins Internet-linked dictionary of economics (Pass *et al.*, 2005)

"*An exchange mechanism that brings together sellers and buyers of a product, factor of production or financial security... Economists generally define a market as a group of products that consumers view as being substitutes for one another (that is, they have a high cross elasticity of demand). This market may not correspond exactly with industrial classifications, which group products into industries in terms of their technical and production characteristics rather than consumer substitutability. .... In the absence of reliable cross elasticity of demand data, economists are often forced to fall back on industrial classifications as a best approximation of markets in empirical analysis. .. From the point of view of applying competition policy, however, a dis-aggregation of such groupings into sub-markets is necessary*".

This definition provides good justification for the decision of the WTO Panel to accept the existence of a market, even though the detail was uncertain at the time and the industrial classifications proposed by the EC submission were therefore accepted to enable the case to be heard. This definition opens up the option that a market may exist even where its parameters are 'fuzzy', without very specific definition of the boundaries.

Definition 4: The penguin dictionary of economics (Bannock *et al.*, 2003)

"*A collection of homogeneous transactions. ... In traditional economics a market is characterised by a single prevailing price for commodities of uniform quality. This is not necessarily the same as the business view - the market is a collection of selling opportunities; or the legal view; where the market is a trading zone free of artificial restrictions on transactions*".

This definition is useful in considering the Korean claim that no market exists, simply individual transactions. Even this is hard to argue as not constituting a market, however, under the *"business view"* given in this definition. In supporting the EC contention of the existence of a "*world market"* it would be impossible to conclude that all newbuilding contracts are homogeneous: the setting of the price of a cruise ship or a standard tug as a direct negotiation between shipyard and owner, for example, lead to the conclusion that at best a series of markets exists, bounded by the limits of ‘like product’. In terms of price, the existence of a single prevailing price can only be demonstrated using cross price elasticity within those sectors.

5.2 R3 – What are the boundaries of the market and how is it constituted in terms of products and their characteristics?

5.2.1 The broad definition of the ‘commercial market’

It is clear, without further need for justification, that a 10m GRP pleasure yacht has little in common with a VLCC and it would be ludicrous to include them within the same definition of a market. It would be very difficult to propose a framework in which they could be considered as ‘like products’ and they certainly do not compete for the same factor of production (capacity). The problem lies in the identification of the precise nature of the boundaries between the two and identifying precise definitions that specify the extent of the boundaries. A 150m steel mega-yacht, for example, could make a case for inclusion in the same market as a VLCC and shares more of the characteristics of the VLCC and its production than it does if compared to the off-the-shelf plastic product from the ‘production-yacht’ sector. Clearly there are issues of both materials and scale in the production-yacht analogy, but what about a 20m aluminium workboat? This broadly shares the same production process as steel vessels, albeit with specific requirements within those processes, but can this be compared to the steel sector and how far does the issue of scale extend?

The WTO case is titled “*Korea – measures affecting trade in commercial vessels*”(World Trade Organization, 2005) and this gives a starting point for defining the market, but what is meant by “*commercial”* and what is meant by “*vessel”* in this context? Interestingly, the word “*commercial*” appears 123 times in the WTO Panel ruling, both in the general sense of the word and the specific use in naming a market for “*commercial vessels”*, but nowhere in the document is its meaning defined. EC provide the only specific definition in the ruling relating to part of the market as follows: “*7.518 - The EC also has clarified that the focus of its price suppression/depression claim is three particular types of commercial vessels: container ships, product/chemical tankers (that is, tankers that can be used for either petroleum products or chemicals, rather than tankers dedicated exclusively to one or the other), and liquefied natural gas carriers, or "LNGs"*” (*ibid*.). This clearly relates to parts of the sector of large steel ocean-going cargo vessels, but no further guidance is given. It should also be noted that this was a clarification of the EU position when pressed to be specific about which products were the subject of price suppression that affected EU shipbuilders. In retrospect the factor approach being developed in this dissertation may have been a more appropriate response.

In the absence of a specific definition it has to be concluded that the term "*commercial vessels"* is used in a generally accepted form that would be recognised by operators in the industries to which it relates. In a general sense this would suggest that the market includes vessels involved in commercial, that is to say trading, activity, the OED definition of commercial being: *"Engaged in commerce; trading"*. As such it specifically excludes military vessels and pleasure craft. The former exclusion is appropriate in that the decisions relating to the builder of a warship are predominantly taken on the basis of political policy and such vessels rarely compete for general shipbuilding capacity, but the latter exclusion requires further thought. There are examples of shipyards (including Damen of Holland and Babcock Marine Appledore of UK), where large luxury yachts compete for shipyard capacity with commercial tonnage, both types having been built in recent years by the same capacity. The word "*vessel*" in this context would further suggest that non-propelled structures, such as topside modules or jackets for offshore energy extraction, should also be excluded. It is not possible to exclude all offshore products, however, and stick to a definition of purely cargo and passenger vessels, as many offshore types, including FPSO and OSV, compete with cargo ship types for shipyard capacity and therefore should correctly be included within the market definition.

Clearly, any such broad definitions are insufficiently precise to form the basis of legal discussion and a more detailed definition is needed to provide this precision.

5.2.2 Legislative and industry definitions

Two definitions of the commercial shipbuilding market exist within the context of legislative instruments, both in relation to measures that seek to limit government economic assistance to shipyards. The first is from the EC and the second the OECD. Whilst these two definitions contribute to the understanding of the nature of the market, neither is adequate to define the market in the context of like product evaluation. This is because of the predominant concentration on function and end use of the ship rather than the capacity and activities of the shipbuilder.

Details of these definitions along with discussion of relevance are presented in Appendix 4.

Further clues as to what constitutes the commercial market can be found by examining information published by shipping data providers. Details of these definitions along with discussion of relevance are presented in Appendix 5.

Using these definitions it is possible to specify a set of data to be examined which is proposed for this dissertation to constitute the "*commercial market"*. This is summarised as follows:

All ship structures that:

- Are greater than 100 Gross Tons or 365kW in the case of tugs
- Excluding military vessels

This definition includes fishing and other service craft, inland waterway vessels and any other ship structure that competes for shipbuilding capacity.

This simple definition will be used in the evaluation of 'like product' characteristics to follow but, before doing that, it is necessary to consider whether this is a single market or may be constituted by more than one market on the basis of construction material or size of vessel. This question in particular is raised by the classification of ship brokers by the Chartered Institute of Shipbrokers discussed earlier in the section, where it was identified that brokers are classified both by ship type and by a category designated "*small"* vessels.

Having concluded that a market exists, therefore, the following Sections consider the nature of this market in terms of product, whether the market is split in terms of size or materials and, if so, at what size and what the characteristics of the split are.

5.2.3 Material demarcation

At first sight it may be considered possible to exclude vessels constructed from wood or GRP (and other composite materials) from the market definition, on the basis that they will not be competing with steel shipyards for capacity and thereby fail the general test of a market. Having said this there are always exceptions, such as VT Shipbuilding in the UK which has constructed vessels in both GRP and steel. Aluminium differs from GRP in that aluminium vessels could be manufactured in steel facilities and vice versa, both being welded. In practice there are practical considerations that make this less straightforward than it may first appear, but it is nevertheless a viable proposition.

Having said this, there is no exact demarcation of materials, in particular for builders of yachts and smaller specialised vessels. This was tested against a dataset of 20,438 vessels built in the five years at the recent peak of the market between 2008 and 2012. The results are shown in Figure 5.1, identifying the number of builders crossing boundaries between materials.

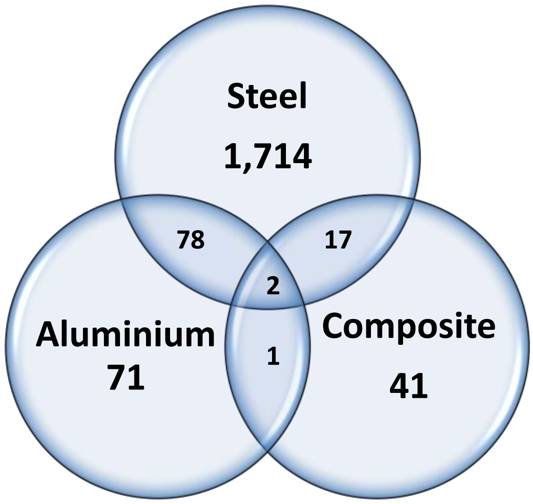


Figure 5.1 – Number of shipbuilders delivering vessels 2008 to 2012 by material of construction[8]

It can be seen from this charts that steel shipbuilding dominates, with 90% of shipbuilders building in steel only. Aluminium is second in importance but only around half of the shipyards constructing in aluminium restricted products to aluminium only, the other half constructing both aluminium and steel vessels. As would be expected composite materials was third in importance but there was a significant overlap with other materials, in particular with shipyards building in steel. Because of these overlaps, which suggest competition for capacity, and for the sake of completeness, it is concluded that the definition of a commercial shipbuilding

[8] Graphs in this section are compiled from data sourced from Sea-Web.

market cannot strictly be restricted to any specific material. Having said that, aluminium and GRP are a feature of small ships and for larger seagoing vessels the products will impose a restriction to steel only by their design.

5.2.4 Size demarcation

The maximum size of vessel is limited by the market itself and no upper bound is necessary. But what about a lower bound? It would seem appropriate to include some lower bound to separate industries commonly referred to as shipbuilding from boat building/workboat building. The question then has to be asked as to whether the market above this lower bound is constituted by a single market or are there further boundaries that have to be taken into account? Are the industry sources cited in Appendix 5 correct to concentrate on larger steel vessels only in the consideration of the commercial market?

It is clear that the shipbuilding market must be demarcated by size. Taking two extreme examples, a tug and a VLCC cannot be considered to be within the same market because it is not credible to conjecture that they might compete for the same capacity. For a tug builder the restriction is obvious: the shipyard's facilities are unlikely to be able to physically cope with a vessel that is typically 330m in length. From the opposite direction a VLCC yard could clearly build a tug but the question has to be asked whether this would be a proposition that the yard would ever consider in competitive terms? The question needs to be viewed in terms of work content. A VLCC is equivalent in terms of work content to around twenty six, 40m tugs. 26 tug orders would be required to replace just one order for the VLCC builder, not taking into account the gross under-utilisation of assets, in particular a large building dock served by very large goliath cranes, which such a transition would represent. It makes no sense at all for the VLCC builder to compete for small ship types. The question remains, therefore, as to where the boundaries should be drawn in terms of size?

Figure 5.2 presents an analysis of the distribution of number of ships and work content (CGT) by ship size (GT) for vessels over 100 GT built in the five years 2008 to 2012 (sample size 20,438 vessels).

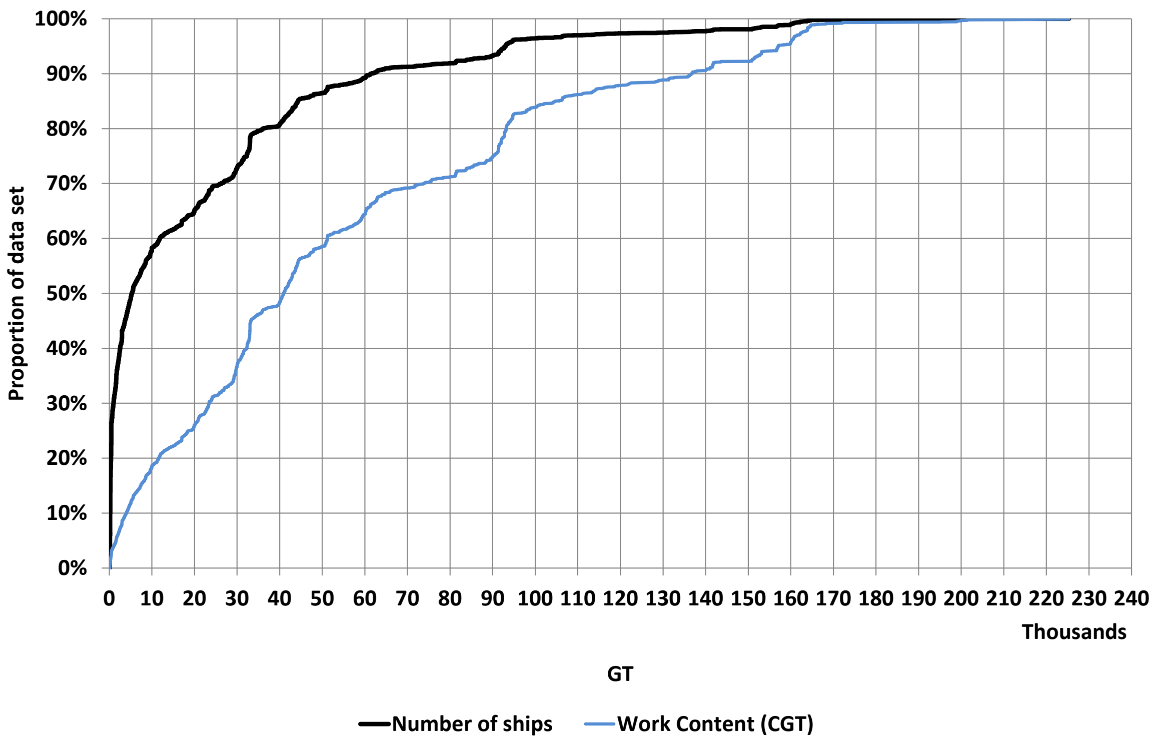


Figure 5.2 – Distribution of number of ships and work content of all vessels over 100GT built 2008 to 2012 by vessel size (GT)

It can be seen from this figure that there is a very steep rise in number of vessels built below 5,000 GT, with a gradual slackening of the gradient thereafter, whilst the proportion of work content rises only slowly in this size range. The rise in number of ships can be seen to be particularly steep up to about 500 GT.

To examine the divergence between number of ships and work content further, the difference in proportions between the two has been examined as presented in Figure 5.3.

Figure 5.3 – Difference between proportion of number of ships and work content built between 2008 and 2012, by vessel size (GT)

It can be seen that the divergence increases very rapidly up to about 500 GT and the increase remains rapid up to about 5,000 GT. After that point the rate of increase in divergence slows and peaks at 10,000 GT, after which the two parameters start to converge.

The differences between proportions of ships and work content at 500 and 5,000 GT are shown in Table 5.1.

Sector	Proportion by number of vessels	Proportion by work content (CGT)
Below 500 GT	26%	3%
Below 5,000 GT	49%	12%

Table 5.1 – Proportion of vessels over 100GT built 2008 to 2012 by number of ships and work content

In rough terms it could be said that the smallest one quarter of the vessels built over this period accounted for only about 3% of the total shipbuilding work undertaken and about 90% of the work undertaken was accounted for by larger vessels over about 5,000 GT. This distribution is shown graphically in the following two figures.

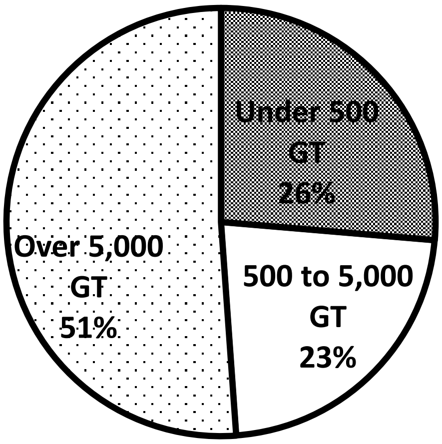


Figure 5.4 – Distribution of market size in each sector by number of ships

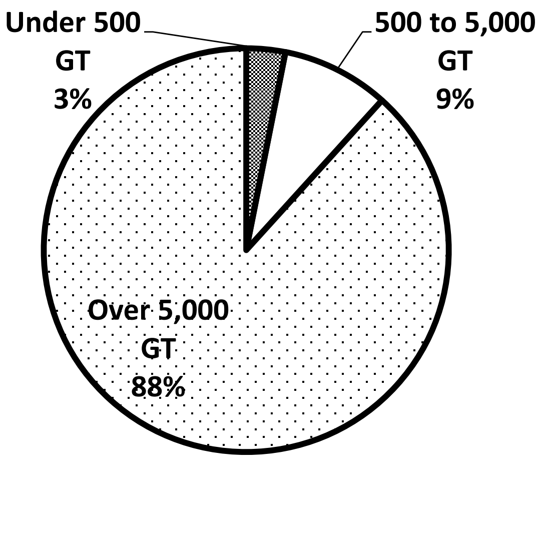


Figure 5.5 - Distribution of market size in each sector by work content (CGT)

This provides a justification for the limitations imposed by commercial data providers, as discussed above and in Appendix 5.

A further significant factor in the distribution of shipbuilding by ship size is a shift from the construction of workboats, which predominate at the small end of the market, to payload-carrying vessels which predominate at the larger end of the market. This is summarised in the following chart, which shows the distribution between the three sectors.

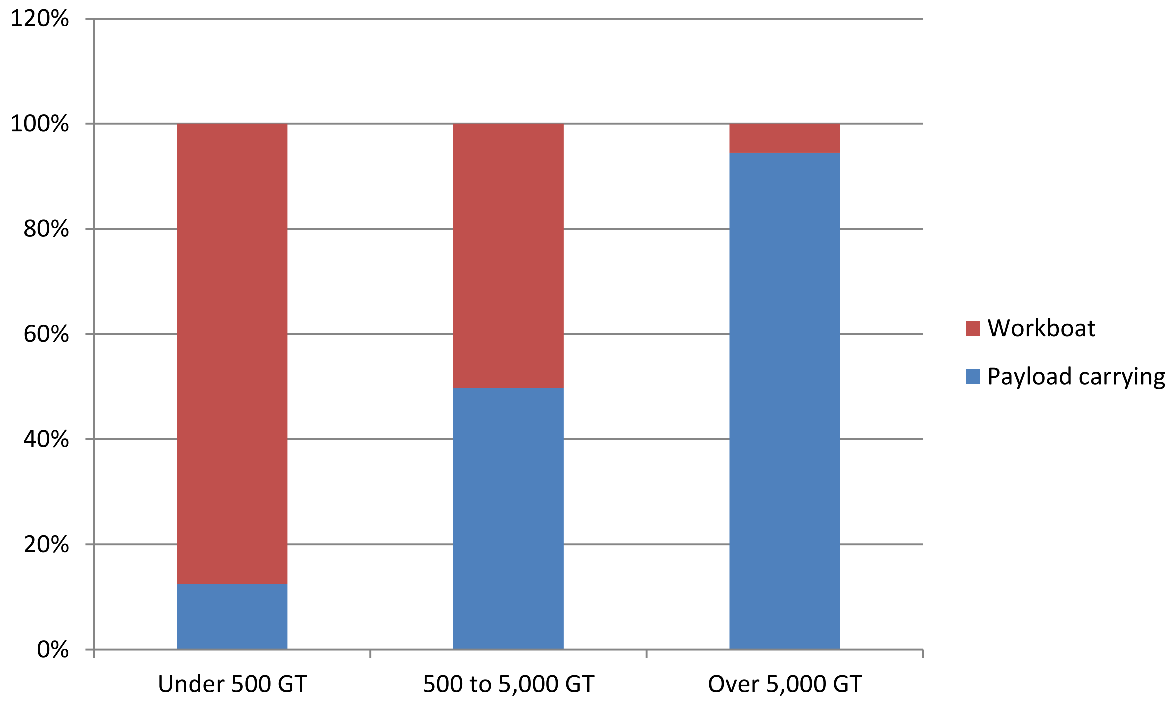


Figure 5.6 – Proportion of workboats and payload carrying vessels by number of ships built 2008 to 2012, by ship size

It can be seen that below 500 GT workboats are dominant and above 5,000 GT payload-carrying vessels predominate.

It is concluded from this analysis that in terms of products the shipbuilding market is not homogeneous at least in the split between workboats and payload-carrying vessels. The characteristics of the markets are analysed further below, using cut-off points at 500 and 5,000 GT. The selection of these two points has been made on a pragmatic basis. Further analysis revealed no significantly more appropriate cut-off between 3,000 and 5,000 GT and there is no absolute cut-off that the market provides that could be used: the split can only be made on the basis of judgement.

These sectors of the market have been analysed against the following characteristics:

- How do the products vary between sectors by ship type and materials?

- How ‘global’ is competition in each sector, evaluated by examining the incidence of domestic and regional purchasing?
- How volatile is demand in each sector, evaluated using analysis of variance, bearing in mind that volatility of demand and its effect on capacity utilisation and price is at least in part at the root of the market distortion issues examined in this dissertation.

5.2.5 Product types and materials

Figure 5.7 shows how the product mixes vary between the three market sectors, by work content (CGT).

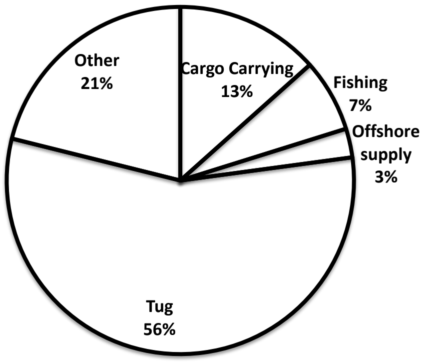
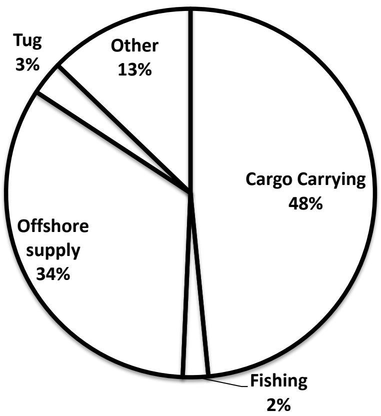
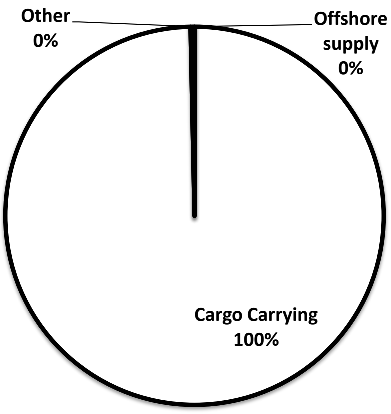
Sector	Product mix by CGT
Under 500 GT	
500 to 5000 GT	
Over 5000 GT	

Figure 5.7 – Variation of product mix by size category (by CGT)

It can be seen that the split by size is not perfect with types leaking to some degree between sectors (for example the largest tugs and fishing vessels appearing in the mid-sized sector whilst predominantly being a feature of the smallest-sized sector of the market). The product mixes are characterised as follows:

- **Under 500 GT:** tugs and fishing vessels predominate, accounting for two thirds of the sector. Other workboats ('other' in the diagram) take this total up to around 90% of the sector, the remaining 10% being made up by small cargo carrying vessels, including inland waterway. In general, however, it can be seen that in the smallest sector the market is predominantly comprised of workboats of different types.
- **500 to 5,000 GT:** a shift can be seen in this sector from workboats towards cargo carrying vessels, the two split roughly 50% each. Offshore supply vessels make up the most important workboat sector, accounting for around one third of the total of the sector as a whole and about two thirds of the workboat sector specifically.
- **Over 5,000 GT:** the largest sector is predominantly payload-carrying vessels (including passenger) but with a small proportion of large workboats included in addition. These include larger OSV and specialist offshore vessels.

Given the split between workboats and cargo carrying vessels by size category, as well as the technical and cost difficulties arising from building larger vessels out of other than steel, it is no surprise to reveal that the use of aluminium as a hull material is predominantly for vessels below 500 GT, and for GRP virtually all vessels are below 500GT.

In summary there is some logic in using these three sectors to demarcate the market by product type and material.

5.2.6 Variation in market cycles and volatility

As discussed in Section 2 the modern (i.e. post-WWII) industry experienced two long cycles of about 30 years each, with more localised variability between the two. The most recent two major cycles can be clearly seen in Figure 5.7, showing shipbuilding output in the fifty five years from 1960 to 2015. Due to the unprecedented volume of the recent peak it is difficult to see in this Figure that the previous peak in the 1970s was similarly dramatic. For this reason the graph also shows the ratio of output in GT to the size of the fleet in the same year, which demonstrates that the two peaks were relatively equivalent in magnitude.

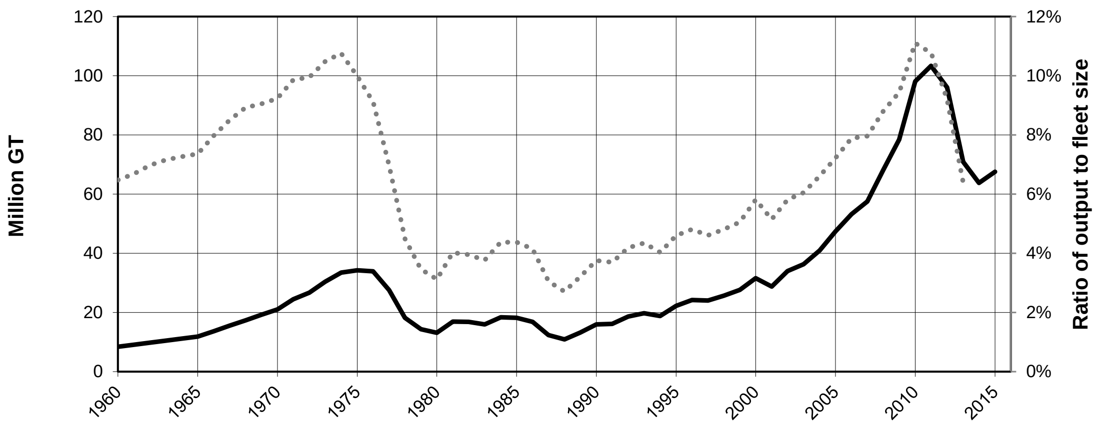


Figure 5.8 – Commercial shipbuilding output 1960 to 2015 (left hand scale) and ratio of output to existing fleet size (right hand scale)

The question arises as to whether this high volatility was manifested in each of the three sectors of the market? The output for the three individual sectors of the commercial market for the period 1963 to 2012 is shown in Figure 5.8.

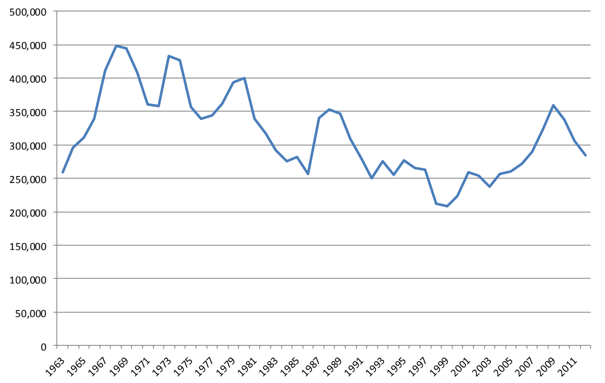
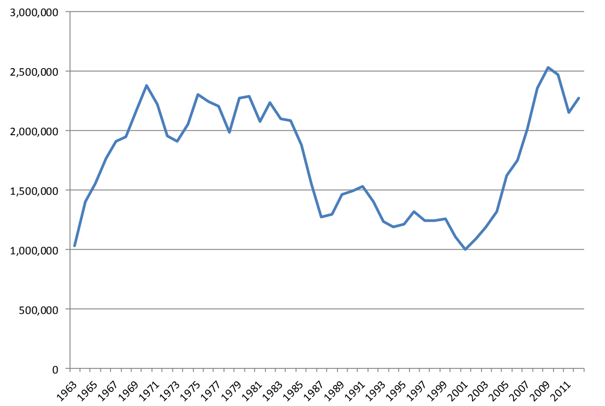
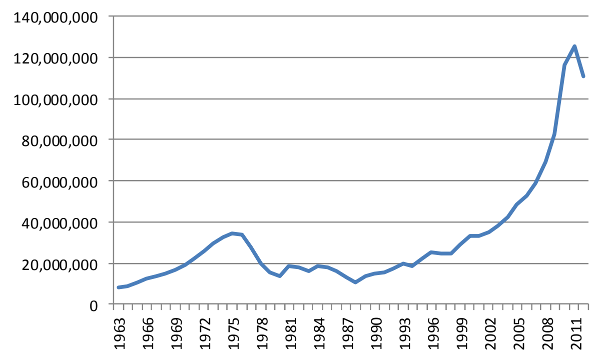
Sector	Output (GT) 1963 to 2012
Under 500 GT	
500 to 5000 GT	
Over 5000 GT	

Figure 5.9 – Comparison of output from the three main commercial market sectors 1963 to 2012

It can be seen from the comparison of the sectors in Figure 5.8 that the large cyclical variation in the markets over the period shown was driven overwhelmingly by the largest sector over 5,000 GT. In particular the most recent very large peak that dominates output from all previous years has little parallel in the two smaller market sectors. A peak can be seen in the sector between 500 and 5,000 GT but is no larger than the volume of the sector output at the previous peak.

It is concluded from this that the two smaller sectors were not directly affected by the 'superheated' levels of demand that occurred in the period 2008 to 2012, notwithstanding that market conditions were good in both the smaller sectors at the time, but production volumes were not unprecedented in either sector.

The coefficients of variance for each sector are as follows:

Sector	Coefficient of variance
100 to 500 GT	19.67
500 to 5,000 GT	26.02
Over 5,000 GT	86.01

Table 5.2 – Coefficient of variance by sector

It is evident from the statistics presented in this table that the larger the sector the greater the amount of variability, or lower the stability of the market.

The question then arises as to how the variability has changed over time. This is examined by reviewing the change of coefficient of variance by decade over the fifty years from 1963 to 2012. The results are presented in Figure 5.10.

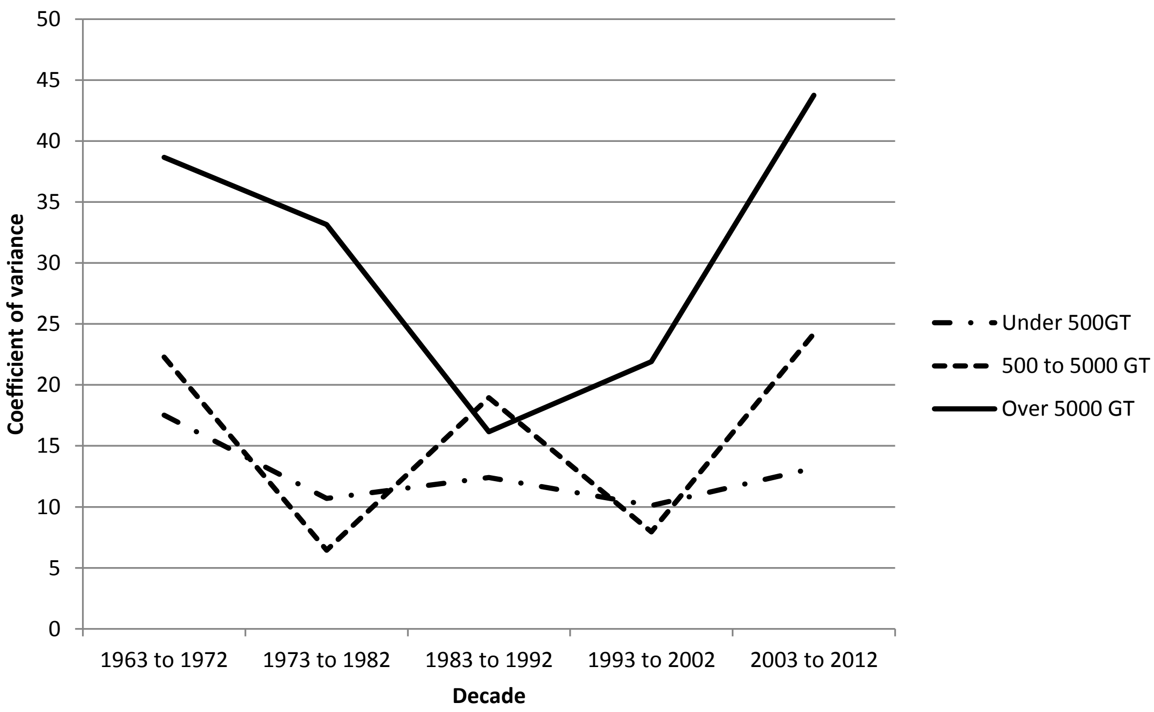


Figure 5.10 – Change in coefficient of variance by decade and summary of output by sector between 1963 and 2012

It can be seen that the smallest sector shows a relatively steady level of variability over each decade, suggesting limited volatility over the long term trend. The mid-sector shows a greater level of variability reflecting the two peaks that characterise the time series shown, but within relatively narrow bounds. The large vessel sector shows much higher variability.

It is concluded that the smaller market sectors, below 5,000 GT, are more stable than the large ship sector over 5,000 GT and that as a consequence the trading conditions likely to lead to trade disputes are more common in the large sector. In the context of defining the commercial shipbuilding market of relevance to the WTO's ability to rule on trade disputes, the market above 5,000 GT is the most relevant.

5.2.7 Local and regional purchasing

Shipbuilding is a highly international industry. For the purchaser of a large vessel it could be regarded as normal practice that the buyer will source globally and will accept the cost of building a vessel possibly across the other side of the world. Where domestic ordering is possible, however, that is to say where domestic shipbuilders present a competitive option, the greater ease (due to cultural and language factors) and lower transaction cost in ordering domestically are likely to see a preference for domestic orders. There are also instances where government policy might dictate an obligation for domestic ordering, the most overt example being the Jones Act in the United States. Other examples include domestic content requirements in some sectors of shipbuilding in both Brazil and Canada. As vessel size reduces the relative cost of transactions to order the vessel, supervise construction and to deliver the vessel on completion, compared to the cost of the vessel, increase and it would therefore be expected that the incidence of domestic ordering will increase as vessel size reduces.

The feasibility of a domestic order clearly depends on the availability of suitable competitive shipbuilding capacity to take the order. In the absence of suitable domestic capacity it would be assumed, based on previous statements, that if no domestic capacity is available then a suitable (i.e. competitive) regional supplier would be chosen where available, before taking the decision to order from a supplier at a greater distance. Region is defined in the following analysis by geographical location, with countries being divided between twelve regions as follows:

Africa	Mediterranean Europe
Central America	North America
Central Asia	North Europe
East Europe	Oceania
Far East	South America
Middle East	SE Asia

Table 5.3 – Regions used for geographical analysis

The pattern of ordering postulated is confirmed in Figure 5.11, which shows the proportion of deliveries of domestic and regional orders over the peak period (2008 to 2012) in each market sector.

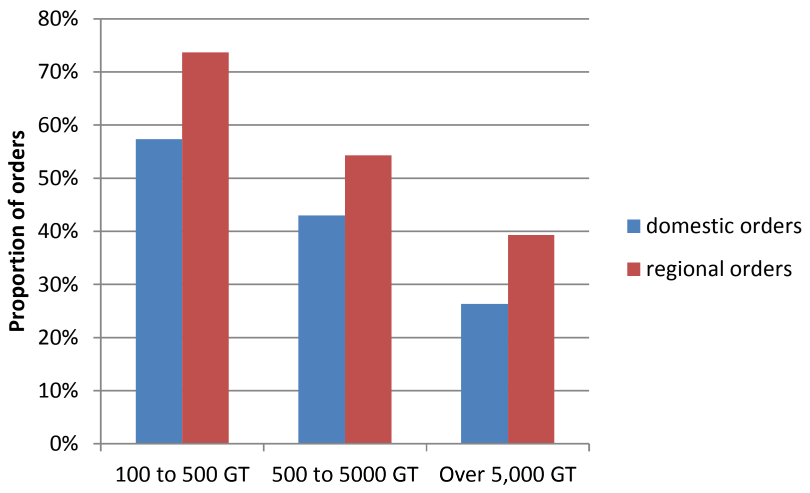


Figure 5.11 – Proportion of domestic and regional (including domestic) orders in vessels delivered 2008 to 2012

Almost three quarters of the smallest category were ordered domestically or regionally, compared to around half of the 500 to 5,000 GT category and about 40% of the largest category.

5.3 Conclusions for Hypothesis H1: The commercial shipbuilding market exists

In reviewing the general definitions given above it is possible to say that the WTO Panel was correct in accepting that a shipbuilding market exists. Apart from the pressure of supporting opinion from those in industry and academia:

- the existence of "*economic transations (buying and selling)"* (OED) between shipyards and buyers is not in question (both EC and South Korea accepted this);
- the use of S&P brokers and market intelligence sources on shipbuilding prices provide a mechanism for the "*sufficiently close contact"* to exist in the determination of price;
- the commercial shipbuilding market has attributes relating both to the products and, more importantly, to a factor of production: capacity. Capacity is flexible, within limits yet to be determined, and ship pricing mechanisms relate to the elements of both the factor market and the product market.
- the concept of a market can be relatively loosely defined and may be made up of a series of sub-markets. Clear exceptions in shipbuilding demonstrate that

sub-markets must exist: there can not be a single entity called a ‘shipbuilding market’;

It has not been possible to conclude that a single entity that could be termed the *“commercial market”* in shipbuilding exists that could cover all commercial vessels. It has been possible to conclude that three market sectors exist, which demonstrate characteristics that define the economic concept of a market, demarcated by size, with the largest of these accounting for around 90% of all work done in the commercial shipbuilding industry. The characteristics of the three sectors vary in a number of ways, including in terms of the products, the geographic nature of competing shipyards and the nature of demand, specifically its variability. The characteristics are summarised in table 5.4.

Ship size range	Market designation	Main products	Geographic nature of competition	Nature of demand
<100 GT	Boatbuilding	Not within the scope of this dissertation		
100 to 500 GT	Workboat market	Tugs, fishing vessels and other workboats, inland waterway and very small payload carrying vessels	75% Local and regional	Variable but without very large shifts in demand
500 to 5,000 GT	Large workboat/small ship market	OSV, small payload carrying and miscellaneous larger workboats	50% Local and regional	Variable but without very large shifts in demand
>5,000 GT	International commercial shipbuilding market	Large payload carrying vessels	40% Local and regional	Volatile with periodic very large shifts in demand

Table 5.4 – Summary of derived market sectors

The products included in *Korea – commercial vessels* were from the dominating sector above 5,000 GT. The remainder of this dissertation concentrates on that sector in isolation to evaluate the parameters of the sub-market as they relate to trade regulation and like product and cross price elasticity. Importantly, however, links between sectors have been shown by virtue of shipyards operating across the boundaries between sectors. This is important in that it establishes potential channels for a mechanism for factor and price linkages between the sectors and the potential for disputes in smaller sectors triggered by the volatility of the largest sector. This is recommended for further study, following the analysis of the main larger sector in this dissertation.

6. H2 – Like products exist in the commercial shipbuilding market

6.1 R4 – How do shipyards compete and what determines competitiveness between shipyards and between products?

6.1.1 Overview of commercial shipbuilding competitiveness

As established in Section 4, the issue of 'likeness' is essentially about competitiveness. In general the discussion of shipbuilding competitiveness in literature in the past has been heavily orientated towards technical aspects of the industry, published in technical journals such as *Ship Production*, with fewer researchers looking at the overall economic aspects of competitiveness (Jiang and Strandenes, 2012; Jiang *et al.*, 2013). Such technical research tends to be introspective, concentrating on factors within the control of the firm and being focused primarily on productivity. This approach therefore may miss the essential elements of competitiveness that relate to location and the shipyard's context.

In the seminal book 'Competition in Global Industries', edited by Michael Porter of Harvard Business School, shipbuilding is examined as a specific case. Porter notes that: *"In shipbuilding, the competitive advantage tends to be more location-specific than firm-specific"* and uses this observation to validate the aggregation of firms at the national level for strategic and market analysis in shipbuilding (Porter, 1986, p. 542)[9]. The key determinants of competitiveness are summarised by Porter as follows: *"Shipbuilding is labor-intensive, depending mostly in semi-skilled workers. The domestic availability of steel and ship component industries influences the competitiveness of shipbuilding firms in that country. Shipbuilding contract invariably involves a substantial amount of financing to a ship buyer. A well-established local finance market (often influenced by government) is a key to the competitive position of a shipbuilding firm"* (*ibid*.). Porter goes on to note that *"three production –related factors (procurement of input materials, labor efficiency, and economies of scale in operations) are the major determinants of cost position"* (*ibid*., p, 548).

Whilst costs may normally be regarded as the main determinant of competitiveness there may be exceptions where other factors predominate. Parkinson, for example,

[9] Note that this is contrary to the stance taken by South Korea in '*Korea – commercial vessels'*, where the validity of such potential aggregation was denied.

proposed a slightly wider view: *"In the last resort what determines where ships are produced is where costs are lowest, or where orders can be attracted by favour, custom or subvention* [i.e. subsidy] *, or where delivery can be made speedily to take advantage of a transient situation"* (Parkinson, 1960, p. 198). More recently, Bruno and Tenold list the factors of success in the development of the industry in South Korea as: "*government support, low labour costs and the repression of labour, favourable access to international and domestic funds, and assistance in technology transfer"* (Bruno and Tenold, 2011).

Despite this range of competitive factors it is often assumed intuitively, in particular by those in industry facing the challenge of lower labour cost competitors, that low labour cost is not only *a* contributing factor to competitiveness in shipbuilding but also is a (or even *the*) *key* factor. This view harks back to an era when the labour portion of shipbuilding costs was significantly greater than it is in modern times: *"The inability of the American yards to compete with those of Great Britain and the Continent during the late 'sixties* [1860s] *and 'seventies* [1870s] *was a cause of considerable surprise and disappointment both within and without the industry. Much was said about foreign subsidies, foreign naval construction as a supporting influence, and the failure of owners to appreciate the American-built iron ships, but apart from these considerations, the cost structure was heavily weighted against American builders for normal economic reasons. Probably the primary difficulty was to be found in the high cost of labour"* (Fassett, 1948, p. 45). The view of the role of labour costs in determining competiveness has prevailed in much of the industry since the time of this quotation and before, even though cost structures have changed. A perception of the dominating significance of cheap labour in shipbuilding competitiveness continues, at least in the general perception of the industry, up to the present time. The UK Government's advice to exporters of marine equipment to Vietnam, for example, states that: "*Concerted efforts of the Government and enterprises have transformed Vietnam in to a fast growing shipbuilding country, mainly on the basis of its low cost labour sources*" (UK T&I, 2012). Such a view is common. Vietnam has yet to fulfil its promise, with the main State yards becoming insolvent and output has remained limited. KPMG in their 2008 assessment of the prospects for Indian shipbuilding proposed a similar view of competitiveness: "*Given the inherent labor intensive nature of the shipbuilding industry, India has a natural* *advantage by virtue of its lower cost of labor and availability of skills*"(KPMG, 2008). The same report in comparing the Indian shipbuilding industry with China, states that "*China's biggest economic advantage is low labour cost*" although later on goes on to acknowledge that the lower cost that enables competitiveness "*comes from inherent economic advantages (e.g. cheap labour) and enabling Government support*". India has never achieved the anticipated increase in market share of commercial shipbuilding that was deemed achievable, based on the advantages of low labour cost as outlined in this report, despite significant capital investment in shipyard development, and this suggests that low labour cost may be less effective as a determinant of competitiveness than many in the industry believe.

The notion that labour cost is less powerful than it may at first appear is not new to economists: "*Indeed, advocates of what is branded 'technological determinism' do not scruple to put the 'technology factor' ahead of other 'factors of production' considerations, including that of labour, when it comes to accounting for industrial development*" (Todd, 2011). So, what 'technology factors' or 'factors of production' do give competitive advantage in commercial shipbuilding? A number have already been mentioned in the quotations from Porter and Bruno and Tenold above and Alderton notes the importance of *"economies of scale – a trained workforce and an established market with secure outlets"* (Bruno and Tenold, 2011) as the key features of comparative advantage for South Korea in addressing the question *"what can give a group a comparative advantage"* (Alderton, 2011, p. 119). What else contributes to competitiveness and what is the relative power of each element in the goal of competing in the global market?

The following sections consider this question by reviewing the structure of ship costs and examining the competitive potential of each element of the structure. Before doing that, however, it is important to review seminal developments in the structure of both the industry and its products, which have taken place in the post-war period and which have had an overriding influence on competitiveness. These are the pursuit of volume and standardisation of the product. These two factors have led to economy of scale that has had a strong influence on the ability of market-leading shipbuilders to reduce material costs through volume purchasing, in addition to economic benefits that accrue within the firm.

6.1.2 The development of economy of scale in commercial shipbuilding in the fifty years 1960 to 2010

Over the past fifty years, developments in automation, equipment and supporting systems have self-evidently contributed to the development of productivity and thereby competitiveness in commercial shipbuilding. Key technological developments have included: direct links between design and production (eliminating traditional lofting), automated panel production, the integration of outfitting and steelwork (facilitated by improved planning and larger cranes), sophisticated planning and logistic control systems, automated cutting and marking, improved welding processes to increase productivity and reduce heat input and distortion, quality assurance to reduce rework, the maximisation of block size prior to final erection and the use of high volume building docks rather than slipways, to name the most significant developments. In addition to these technological advancements there have been two key shifts in the nature of the commercial shipbuilding business that have been fundamental to the development of competitiveness, these being the pursuit of volume and standardisation of the product. These two factors, which essentially together relate to economy of scale, play a key role in the understanding of the economic development of competitiveness in the industry.

The introduction of more automated processes into shipbuilding and the application of machinery in place of skilled craftsmen were given a boost in WWII by the need to produce cheap standard ships in large numbers as discussed previously in this dissertation. By the 1960s the general applicability of mass production methods was understood in shipbuilding but introduction was problematic. This was discussed by Hardy and Tyrell in 1964 as follows: "*There has been another and even more important change in methods of ship construction. Since Henry Ford first made the Model T by mass-production methods, steady material flow – taking the job to the man and his tools – has become the accepted basis for increasing productivity and reducing costs in engineering. The application of flow production to shipbuilding has not been easy because of the large size and weight of the ship…coupled to the complexity and variety.."* (Hardy and Tyrrell, 1964, p. 2). Part of the problem was the lack of standardisation of the product (the preponderance of *"variety"* referred to in this quote), the authors of this book noting that: "*The advantages of standardization are obvious, but difficult to achieve in practise".* The authors further note that two key reasons for this difficulty are "*the relatively small capacity of most yards"* and "*Shipbuilders tend to regard each ship as individual, and ship-owners all have their own ideas of what a ship should be like"* (Hardy and Tyrrell, 1964, pp. 1-15).

The move to a globalised economy post-WWII and the consequent explosion in seaborne trade has led to the standardisation of ship types (if not to the absolute standardisation of ships, for which reason this could be better termed 'quasi-standardisation') to suit commodities and parcel sizes (in the application of economies of scale to the shipping industry), moving away from the idiosyncratic cargo liners and tramp ships that served the 'empire trades' up to the 1960s, which led to Hardy and Tyrell's difficulty with automation and economy of scale in shipbuilding. The pursuit of volume and the standardisation of products therefore go hand in hand. The market leading shipyard in 2010 produced twenty eight times the gross tonnage of the market leader in 1960 and five times as many ships. The level of volume achieved presents a significant opportunity to develop the supply chain and reduce material costs. Details of the development of volume and product standardisation are presented in Appendix 6.

The development of economies of scale in shipbuilding has direct analogies in the automobile industry, with progression from early bespoke craft-based production through automation and absolute limitation of product variety to lean production. Womack in the book "*The Machine that Changed the World*" produced a framework, within which the elements of economy of scale can be analysed (Womack *et al.*, 1990). The horizontal axis presents the number of different products sold by a company and the vertical axis presents the average number of units of each product being sold. The product of both axes (number of products x volume per product) equals number of units sold. Clearly the higher the volume per product the greater the standardisation, as described in the context of this analysis, and the higher the number of products and the volume per product the greater the volume of production of the business. Volume of production can be increased both by increasing the volume per product offered and by increasing the number of products offered.

It is possible to use the chart proposed by Womack to place the global shipbuilding market leaders. In this analysis a 'product' is regarded as a coherent series of similar ships, irrespective of the number of ships in the series built over the year. It is acknowledged that variation in design between sister ships is common so ships within a product group do not need to be identical. As described by Packard in the book 'Sale and Purchase', in the modern industry shipyards are "*constructing standard vessels, their basic concept being varied only marginally in accordance with the purchaser's wishes*" (Packard, 2006). The criteria applied to define acceptable variation are that they are of the same ship type, the hull form is similar, with L and B being within 5% of each other, and that capacity is similar, with GT and dwt being within 10% of each other. Where a clear standard has developed over the year, for example with increasing dwt within a very similar hull form, as was the case with the development of VLCCs at Mitsubishi in 1975, these are regarded as a single product. Analysis has been undertaken for the industry in 1960 and then around the two peaks in output since that time, in 1975 and 2010.

The results are shown in Figure 6.1, tracing the development of the shipbuilding industry over the peaks of output over the past fifty years. The resulting chart is similar to that shown for automobiles by Womack, showing a similar path of increasing volume with reducing then expanding variety.

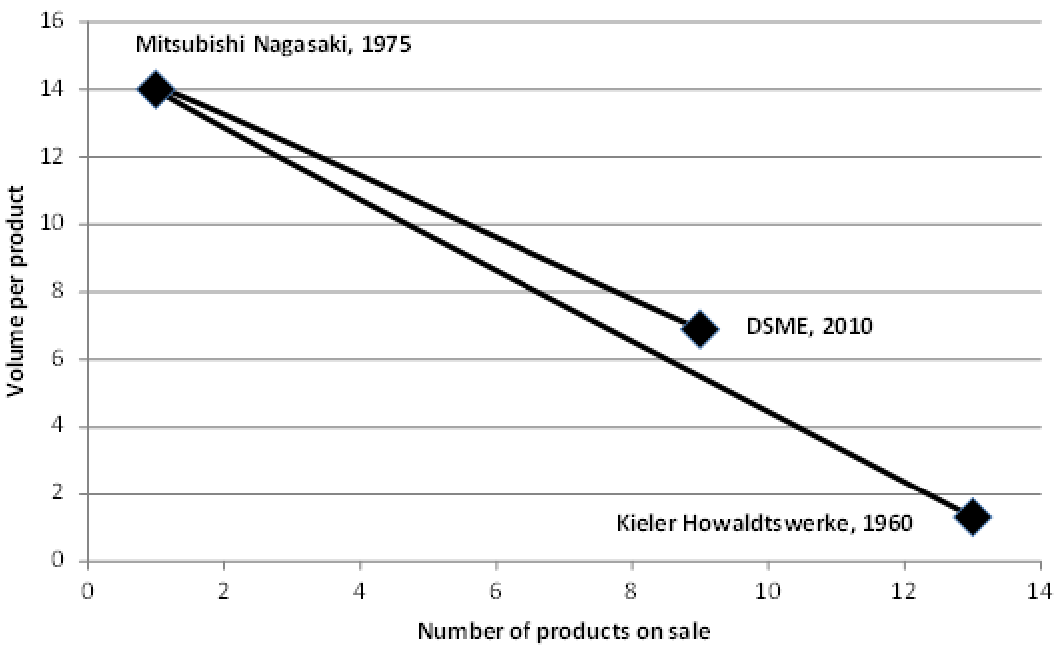


Figure 6.1 – Progression of product variety and production volume in the shipbuilding industry market leaders

The progression of commercial shipbuilding shown in this chart is as follows:

- In 1960 Kieler Howaldtswerke was essentially a 'bespoke' shipyard and a unit of capacity was almost completely flexible, capable of building almost any type of ship. Each product was either one-off or built in a very short series with a small number of sister ships. Reliance on craft skill of the workers was high.
- In 1975 Mitsubishi Nagasaki had progressed to complete standardisation with a single product (VLCCs), replacing craft skill with automation as far as was possible. Volume per product was high. The concentration on a single product was found to be unsustainable due to market shifts, however, as discussed in Appendix 6, and the yard had to subsequently introduce a product mix to survive[10].
- In 2010 DSME's volume per product was about half that achieved by Mitsubishi in 1975 but the number of products offered was nine times greater, leading to significantly greater volume produced.

The chart misses the influence of Liberty ships, which would not fit on the scale, but it is argued that these were something of a unique situation in shipbuilding for their time, a response to a specific crisis, although as discussed they were highly influential in the development of the modernised industry. This chart also addresses only the market leaders to show the track of the development of the industry and, as was the case with the original Womack diagram quoted above, is therefore something of an 'idealisation'. Positioning on both the horizontal and vertical scales, for example, is partially a function of capacity and is therefore likely to reflect the level of capital investment. Analysis of smaller competitors using this framework, however, confirms in general that the trend has been present throughout the industry. The increase in concentration of the industry in large groups, discussed in Section 2, should also be taken into account, with capacity increasingly being concentrated in high volume shipyards.

The resulting economies of scale and standardisation lead to significant opportunities to reduce material costs, something that until relatively recently was

[10] Note that this experience demonstrates that flexibility of capacity to produce a range of compatible (or like) products is an imperative in shipbuilding, due to shifts in demand.

regarded as largely outside the control of the shipyard. The assumption that material costs cannot generally be addressed to improve competiveness is summed up in an influential report prepared by consultants for the UK DTI[11] in 1973, in a discussion relating to how competitiveness in the industry in the UK could be improved. The report states: "*Because of the cost structure of shipbuilding, significant cost reductions can only be achieved through capital investment designed to increase productivity…..It is assumed that material costs could be reduced only marginally by the shipbuilders, although some savings could be made by marine equipment manufacturers, if volume increases could be achieved"* (Booz-Allen and Hamilton International BV, 1973, p. 235). This statement has proven to be incorrect in the long term.

It would follow that the larger the shipyard the greater the competitive advantage that could be gained from economy of scale, provided that sufficient work can be maintained to utilise the expensive capacity developed. This caveat identifies what might be regarded as a 'double-edged sword' characteristic of the strategy of pursuit of economy of scale, given the variable nature of demand in the largest sector of the market. The vulnerability of this strategy relates to the difficulty (or, probably, more correctly impossibility) of keeping capacity occupied in a market downturn such as that prevailing at the time this dissertation is being written. It is possible that the model of ultra-large shipyard developed at the start of the twenty first century is not the optimum in the long term, despite very high efficiency at the peak of the market, due to the cyclical nature of demand. Efficiencies at the peak will be countered by inefficiencies due to low demand in the trough and such large capacity yards will be very difficult to manage over the full cycle. This is recommended for further study, including consideration of the bounds of flexibility of capacity to minimise the downside economic effects of cyclical demand whilst at the same time facilitating access to economies of scale and increased business in times of peak demand.

6.1.3 The structure of costs in commercial shipbuilding

Examination of the structure of ships costs provides a framework for analysis of elements of competitiveness. There is a long-established rule of thumb in

[11] Department for Trade and Industry, the ministerial division of the government responsible for industry at that time.

shipbuilding that the cost of building a ship splits roughly 60% materials and 40% labour and overhead. The 'Booz-Alan' report on British Shipbuilding published in 1973 reflected this generality, showing that the average split of costs between six merchant shipbuilders at that time was 59.5% materials, 25.6% labour and 14.9% overheads. (Booz-Allen and Hamilton International BV, 1973). Interestingly, this split is different to that reported in the construction of ships in the United States around the end of WWII, where the proportions were reported to be 40% materials, 35% labour and 25% overhead (Fassett, 1948, p. 11). This reflects the more labour-intensive work in the shipbuilding process at that time and the lower outfit content in ships that were inherently simpler than modern tonnage. Comparison of these two sources also suggests that the generality will change over time and across ship types. Porter in his value chain analysis for shipbuilding in 1986 noted that *"the major portion (63 to 70 percent) of the total cost of a ship consists of inputs such as steel, engines and other components. The second biggest item is cumulative labor costs (12 to 30 percent), which vary by country of shipbuilding and the type of vessel. Then comes infrastructure costs (1 to 11 percent), which include interest expense and depreciation"* (Porter, 1986, p. 548).

A more detailed "rough breakdown" of the elements of shipbuilding costs is presented in the text book '*Maritime Economics'* and is summarised in Table 6.1:

Sector	Element	Proportion of total cost	Total proportion
Labour and overhead	Overheads	27%	(47%)
	Direct Labour	17%	
Materials	Other	7%	(53%)
	Major purchases	20%	
	Main Engine	16%	
	Steel	13%	

Table 6.1- Cost Structure of merchant ship (developed from Stopford, 2009, p. 639)

Whilst rather general, this information confirms the broad guidance that the cost of material purchases predominates in a commercial shipbuilding contract. It can also be seen that the sphere of influence on which low labour cost can act on the costs of a shipyard is therefore relatively limited. The influence is greater than the specific 17% indicated for direct labour in the above table because overhead and material costs are also influenced by labour costs. The extent to which low labour cost in a country can contribute to the reduction of material costs depends on the extent of the availability of domestic sources of steel and marine equipment. Clearly if domestic suppliers are plentiful and also take advantage of low labour costs, and are acceptable to buyers, then this will be of significant benefit to the shipyard's competitiveness. The labour cost influence within the shipyard also extends to both direct labour and overheads because a part of the overhead cost in shipbuilding, or any business, will typically be related to overhead labour costs and it may be inferred that a low labour cost base in relation to a company's production workforce is likely to confer a similar benefit to the same company's overhead workers. For example Table 6.2 presents the breakdown of "*Selling, General and Administrative Expenses*" for Hanjin Heavy Industries of South Korea in the first six months of 2010 (Hanjin Heavy Industries & Construction Co., 2010):

Cost category	**million Won**	
Salaries	19,442	25%
Provisions for severance benefits	2,068	3%
Employee benefits	3,971	5%
Taxes and dues	888	1%
Advertising expense	1,574	2%
Bad debts expense	14,671	19%
Service fees	5,967	8%
Service contract expense	6,919	9%
Warranty expense	10,050	13%
Others	11,240	15%
Total	76,790	100%

Table 6.2- Selling, General & administrative expenses at Hanjin Heavy 2010 (Source: published company accounts)

It can be seen that the first three categories of this table relate to labour costs and it can be inferred from this that around 1/3 of the overhead cost is labour-related and will respond to the influence of unit labour cost. Using this information and the simple model proposed in Table 6.1 the relative power of reduction in unit labour cost, including reduction in direct labour and overhead categories, is compared to that of materials costs in Figure 6.2, assuming this labour-related overhead cost proportion to be typical and holding all other cost factors constant.

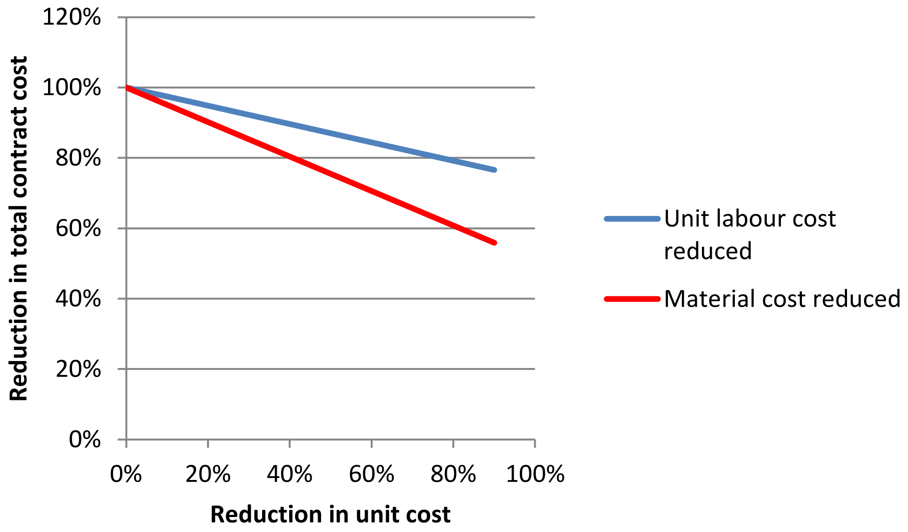


Figure 6.2- Change in total contract cost per reduction in unit labour or material cost

The gradient of the labour line shown in Figure 6.2 is 26%, that is to say that the advantage conferred on a total contract cost by a lower labour cost is little more than one quarter of the absolute labour cost advantage, all other things being equal. The gradient of the material line is 62% or in other words, almost two thirds of any reduction in material costs achieved is felt directly on the bottom line.

The above analysis is simplified and idealised. In reality the structure of cost varies over time, between shipyards and between ship types. The reasons for variation are summarised as follows:

- Wage costs change and this is compounded by the effect of exchange rates, bearing in mind that commercial ships are normally traded in $US.
- The material cost proportion will vary by ship type. For example the material and equipment cost of a cruise ship is likely to be proportionately higher than the material and equipment cost for a bulk carrier.
- The direct labour proportion will depend on the combination of both labour cost and the efficiency/productivity of the shipbuilder.
- The level of overhead will depend on the efficiency of the company. Companies with low overhead structures or those that achieve economy of scale, spreading the overhead over a large throughput, will achieve a lower overhead proportion.

- The material cost will vary according to the market price of steel and major equipment, the buying power of the shipyard and the nature of the marine equipment supply industry in the country in which the shipyard is located. Exchange rates will also have an influence as, for example, main engines are often traded in $US.

Any analysis of cost breakdown structure can only be a ‘snapshot’ therefore and will be subject to change over time and between producers. Given this limitation, however, it is possible to obtain an indication of the variation of cost structure between ship types by analysing work undertaken for the EC, DG Enterprise, in preparation for the WTO dispute. Significant effort, over six years, was put into establishing cost estimates for market leading shipyards in South Korea, with the results published in a series of cost reports[12] (First Marine International Limited, 1999 to 2005). Using information published in these reports as base data, Figure 6.3 presents an estimate of how the elements of cost vary by ship type for a large and efficient (high throughput and good efficiency) Far East builder, based on a steel cost (Grade A plate) of $645 per tonne, total labour cost (wage and additional costs) of $15.40 per hour and an exchange rate of 1,000 Won to the $US, being representative of a competitive level of cost at the time of writing. This has been achieved by looking at the relative values published across the reports to compare proportions of cost. The Figure also includes a measure of the relatively complexity of the build process for the different products using the CGT system (OECD, 2007). Complexity is represented by the ratio of the Compensated Gross Tonnage value of the ship to its Gross Tonnage, or what in previous incarnations of the CGT system was known as the ‘CGT Factor’. The products shown are ordered with increasing complexity from left to right. The CGT factor effectively measures the relative amount of shipbuilding work content per GT. It is also important to note that the cost structure shown is at the operating level and does not include depreciation or, in cash terms, interest costs relating to the investment in the shipyard or the servicing of general company debt.

[12] The author of this thesis was lead consultant for this work.

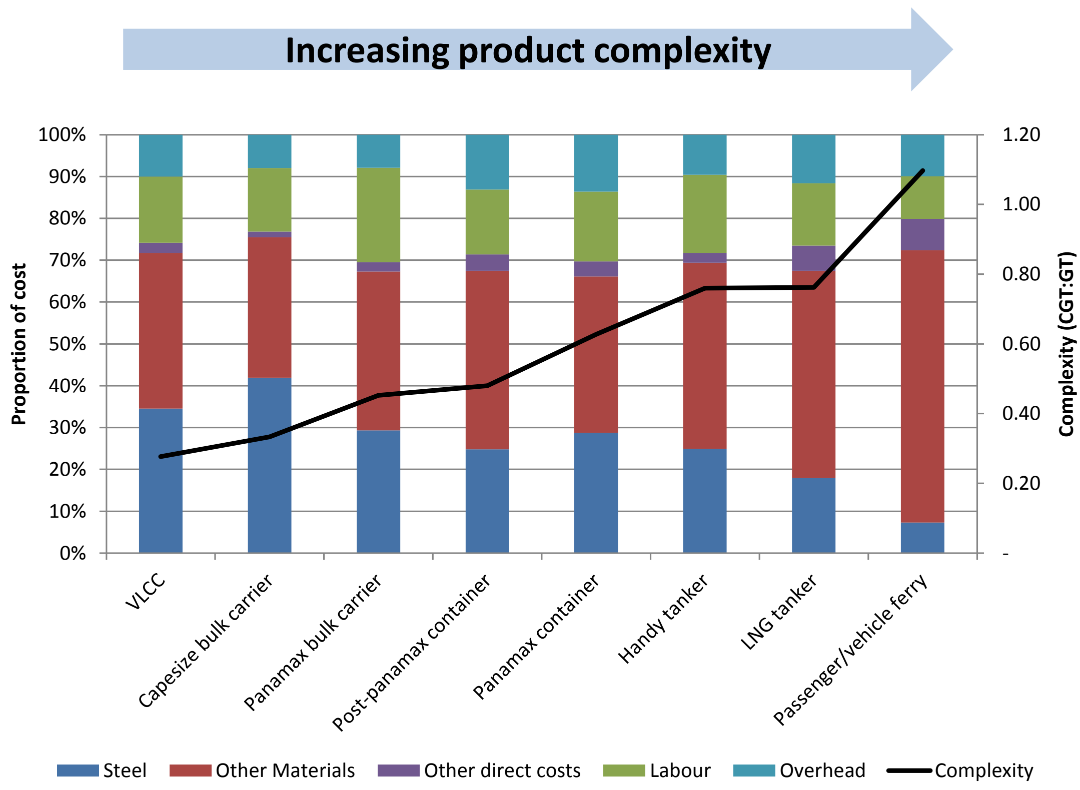


Figure 6.3– Variation in cost breakdown by ship type

The definitions of the cost categories shown in this chart are as presented in Table 6.3.

Cost category	Definitions
Steel	Structural steel of all grades, including primarily plate and rolled sections.
Other materials	All other materials (other than steel) and subcontractors (other than labour subcontracts), including propulsion and main engines, auxiliary engines and generators, cargo handling equipment, cargo containment equipment, deck equipment and all other equipment and materials.
Other direct costs	Design licenses, classification and surveys, warranty reserve, builders risk insurance, and any other costs that may be required depending on the ship type and design.
Labour	Cost of direct labour in all areas of the shipyard and including subcontracted labour.
Overhead	Provision for selling, general and administrative overheads and all overhead labour.

Table 6.3– Definitions of cost categories (First Marine International Limited, 1999 to 2005)

It can immediately be seen that the split of material to labour and overhead costs in this series is 70:30, not 60:40 as assumed in commonly held rules of thumb. This reflects the high volume efficiency of the builders represented in this chart, with overhead spread over a large throughput and high productivity achieved.

The proportion of steel cost decreases from left to right, as the complexity of the product increases. Conversely the proportion of other materials increases as does the proportion of other direct costs such as working capital finance, classification, licenses and so on. In aggregate, however, the total proportion spent outside the shipyard (steel plus other materials plus other direct costs) is remarkably consistent at around 70%.

Figure 6.4 shows how the product mix (proportion of output of the main commercial ship types) developed at Hyundai Heavy Industries Ulsan shipyard between 1980 and 2009 and Figure 6.5 shows how the average size of ship constructed over that period developed. These graphs illustrate the progression that shipbuilders in South Korea and more recently in China have pursued as their capability and labour cost increase, moving from less to more complex products over time and moving from smaller to larger ships.

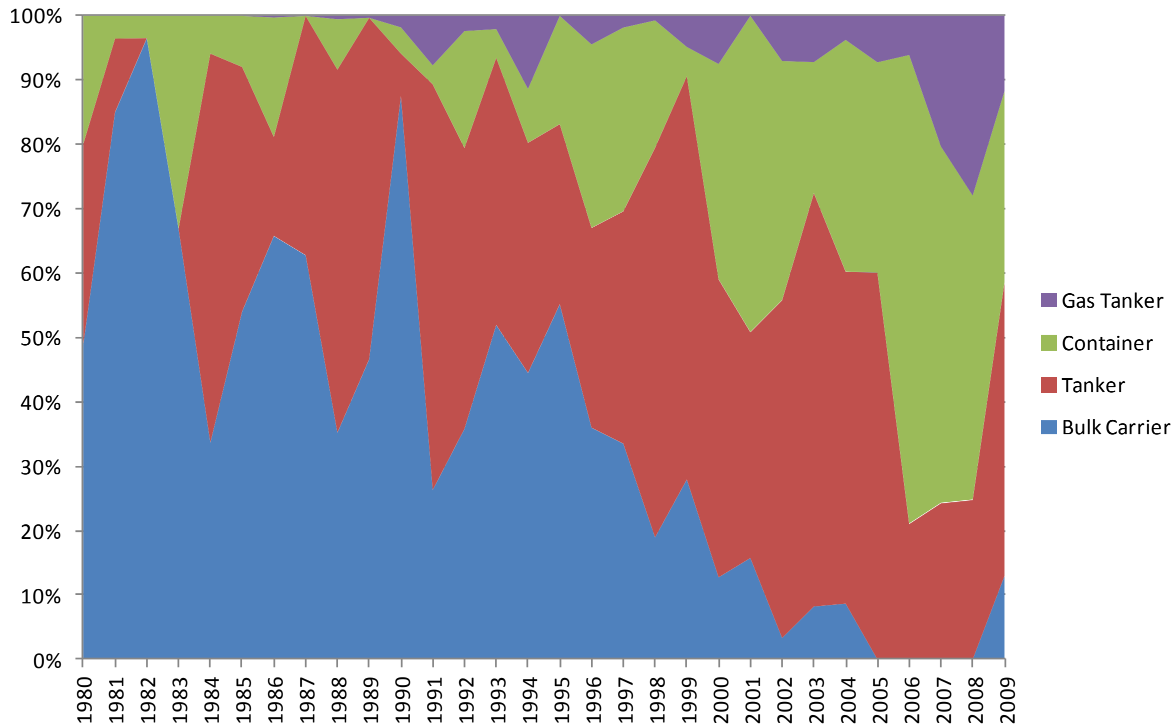


Figure 6.4– Development of product mix (proportion of GT delivered) at HHI Ulsan shipyard (data sourced from Sea-Web)

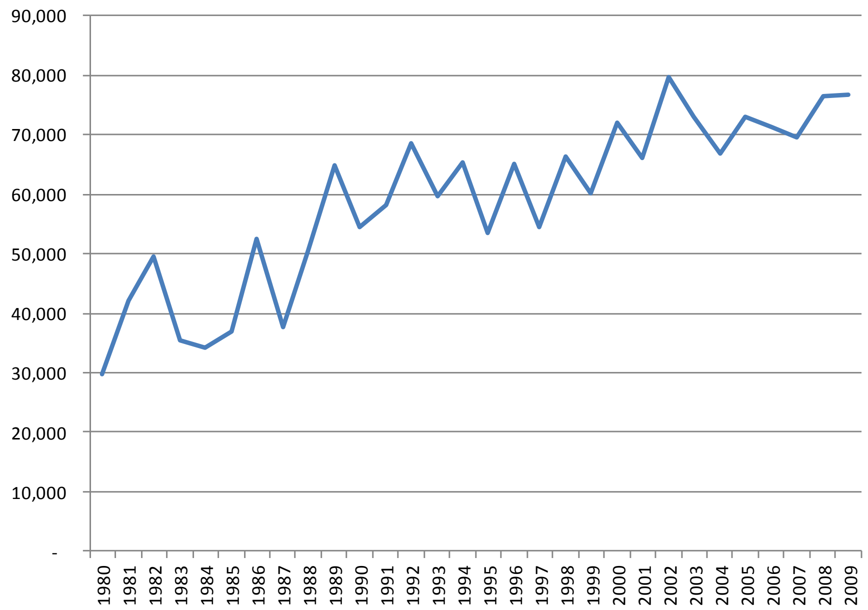


Figure 6.5 – Average GT produced at HHI Ulsan shipyard (main commercial ship types only – data sourced from Sea-Web)

This progression is based on the assumption that more complexity and larger size is linked to greater value of work. The validity of this assumption can be reviewed by looking at the influence of labour costs on specific ship types. The level of influence of labour cost on the total contract cost for each ship type, comparable to the general 26% ratio discussed above, is shown in Figure 6.6.

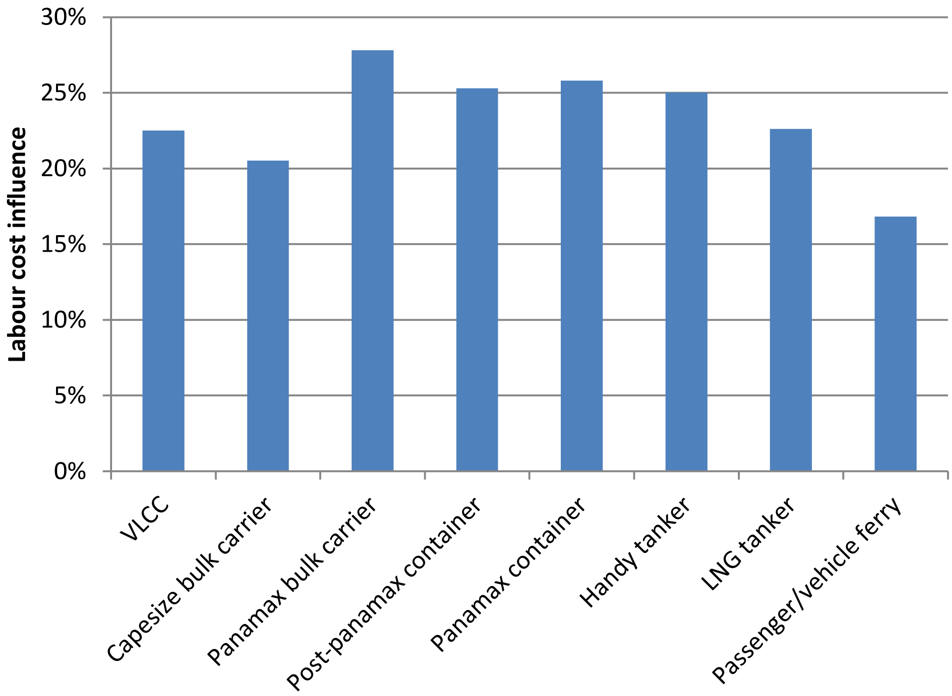


Figure 6.6 – Variation in the influence of labour cost on total cost

A number of conclusions can be drawn from this analysis:

- In moving from smaller to larger products in the same ship type (for example from panamax to capesize bulk carriers) the influence of labour cost reduces. This suggests that shipyards with higher labour costs should pursue the larger ship sizes whilst those with low labour cost should pursue smaller ships, where their advantage has the greatest effect.
- Counter-intuitively, the data suggests that the progression from simple to more complex products, the strategy generally pursued by shipbuilders as their labour cost rises, may result in some cases in a detrimental increase in the influence of labour cost. In other words labour cost influence is greater in a large container ship than a VLCC and the VLCC shows a greater labour cost influence than the capesize bulk carrier. The LNG tanker, the next product logically in this progression, shows significantly less labour cost influence than the large container ship, and thereby is an improvement for a higher labour cost producer, but is no better in this respect than a VLCC and is worse than a capesize bulk carrier.
- The product experiencing the least influence from labour cost in the data shown is the passenger ship and this may explain to some extent why this

has provided the 'last refuge' for high labour cost large European shipyards and why Far East builders are so keen to try to break into this sector.

Finally, it should further be noted that there is no provision in the cost breakdown used so far for servicing of debt or depreciation of the facilities. In other words this breakdown of costs does not provide for payment for the shipyard itself and this can be substantial. The difference between the total contract costs and the contract price should be regarded as contribution, rather than profit. In cash terms the surplus provides contribution to the payment of interest and servicing of debt for capital and working capital finance before profit is truly recognised. For the efficient high throughput builder referred to above it was estimated by the EC's cost modelling exercise that this may add around an additional 5% on average to the total contract cost. Any profit included in the price would then be additional to this total amount.

6.1.4 Determinants of competitive advantage

6.1.4.1 Labour cost

Because of the difficulty of calculating meaningful comparisons, data on comparative wage costs are not generally published. An indication of the range encountered in international shipbuilding can be obtained, however. The United States Bureau of Labor Statistics produces an annual comparative report on international labour costs for countries where statistics support this (BLS, 2013). The 2013 report includes the following comparison of countries that have significant shipbuilding interests. The table includes also a comparative index of costs compared to market leader, South Korea, with Korea set to an index value of 100.

Nationality	US$	Index (ROK= 100)		Nationality	US$	Index (ROK= 100)
Norway	63.36	306		**Italy**	34.18	165
Germany	45.79	221		**Spain**	26.83	129
Finland	42.6	206		**Singapore**	24.16	117
France	39.81	192		**South Korea**	20.72	100
Netherlands	39.62	191		**Brazil**	11.2	54
Canada	36.59	177		**Philippines**	2.1	10
United States	35.67	172		***China 2009***	*1.74*	*8*
Japan	35.34	171		***India 2010***	*1.46*	*7*

Table 6.4 – Hourly compensation costs in manufacturing, US dollars, 2012 (BLS, 2013)

Whilst the absolute values cannot be seen as being an accurate reporting of the labour cost in shipbuilding per se, the relative values demonstrate clearly the range of labour cost between countries that will be encountered. Statistics for China and India are shown in different font because the reliability of statistics is questioned and the comparability with other nationalities is not clear. National Bureau of Statistics Data for China, for example, shows that state-owned enterprises in Shanghai have double the national average wage, at 83,519 Yuan in 2011, the latest year reported (National Bureau of Statistics China, 2014). At the prevailing exchange rate and using an assumption of 2,000 hours worked per annum, this suggests that in a state-owned enterprise in Shanghai a worker would have been earning around $6.50 per hour and the figure given in this table cannot be representative of hourly labour costs in large Chinese shipyards. This rough estimate suggests that labour costs in major Chinese shipyards, including additional employers' costs, are likely to be similar to that reported in the table above for Brazil. The level of cost shown in India in this table is consistent with the level of labour cost in shipbuilding estimated by KPMG in the blueprint for the development of the industry from 2008 (KPMG, 2008). It may have risen since that time.

6.1.4.2 Productivity

The labour cost element in a shipbuilding contract is not a function of the wage cost alone but of the combination of wage cost and productivity. As Bruno and Tenold state of the decline of the European shipbuilding industry in the 1980s: "*European costs, in particular wages, were too high, and the strategic measures did not lead to a sufficiently large improvement in productivity and production costs" (Bruno and Tenold, 2011).* In other words it was not wage costs per se that caused the decline in European shipbuilding but this in conjunction with the failure of improvements in productivity and other strategic assistance to offset the high wage cost in the face of falling contract prices caused by overcapacity.

Labour cost per unit of output is a product of the unit input cost times the productivity defined as follows:

$$labour\ cost\ per\ unit\ of\ output = cost\ per\ manhour \times manhours\ per\ unit\ of\ output$$

The metric normally used to define a unit of output in shipbuilding is the Compensated Gross Ton (OECD, 2007) and labour cost per unit of output is a function of cost per hour and hours per CGT. Benchmarking has shown that the level of productivity achieved in shipbuilding can vary greatly between shipyards (Craggs *et al.*, 1995; Craggs *et al.*, 2004) . Craggs *et al*., (2004) clearly shows a difference between commercial shipbuilding yards in the United States in 1999 of around 55 manhours per CGT compared to an assessed figure for Japan in the same year of about 15 manhours per CGT: 3.7 times as many manhours to produce the same unit of work in the US compared to Japan. Figure 6.7 presents an estimate of the development of productivity in South Korean shipyards between 1990 and 2003, using output data from Sea-Web and employment data from Koshipa (the Korean Shipbuilders Association), including direct and subcontract labour engaged in shipbuilding in South Korean shipyards. Productivity increased from around 50 manhours per CGT in the 1990s to around 20 in the early 2000s.

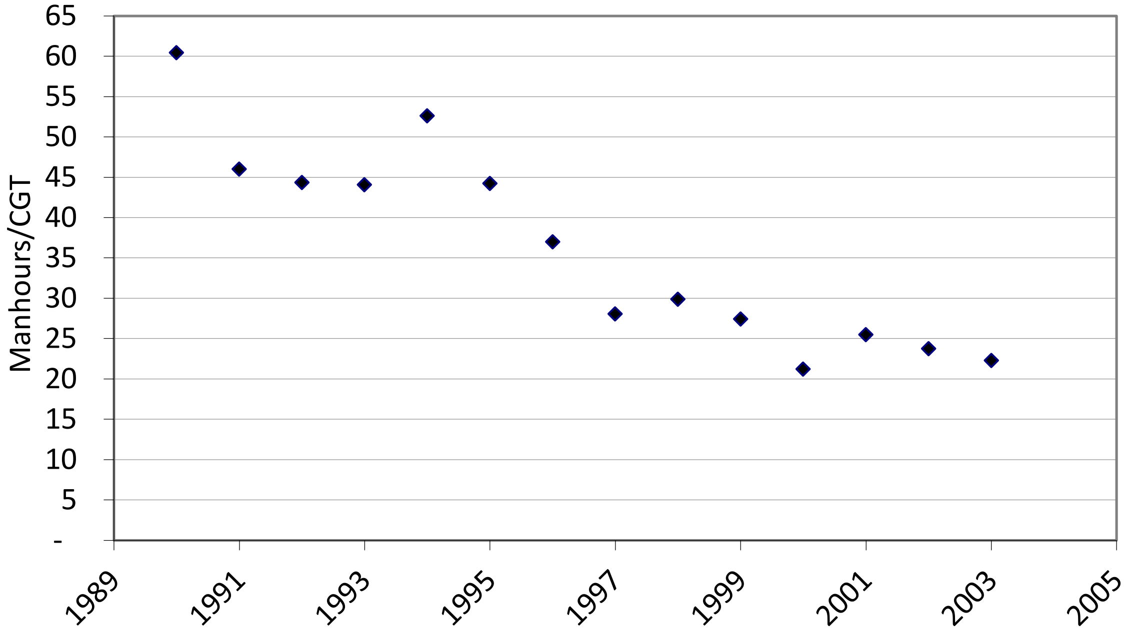


Figure 6.7– Estimated development of productivity in South Korean shipbuilding (Source: analysis of data sourced from Sea-Web and KoShipa)

The development of productivity is discussed by Craggs *et al* (Craggs *et al.*, 2004) where "*organisational learning*" and "*ship learning"* are separately addressed. Ship learning is the improvement in productivity that results from construction of a series of quasi-identical products. Problems are ironed out in the early ships in the series and later ships will be relatively easier to build as a consequence. The workforce will also have learned from experience with the product, and productivity will improve. Conversely, when the workforce shifts to a new product the productivity achieved will reduce, termed by Craggs *et al* "*first of class performance drop-off"*. Organisational learning is the general process of improvement in the building of ships in an organisation over time that results from the experience of the workforce in general and investment in training processes and facilities. The experience of the workforce is significant in this process because of the complexity of the product and the processes to produce it. Because of the extent of human input in commercial shipbuilding, productivity in a new shipyard will inevitably build up over time and early years of operation will incur a penalty in terms of performance.

Jiang and Strandenes estimated productivity in 2011 to range from a maximum of about 8 manhours per CGT in Japan to 14 manhours per CGT in South Korea and between 50 and 111 manhours per CGT in China (Jiang and Strandenes, 2011).

These values are consistent with productivity estimates published from time to time by First Marine International (First Marine International Limited, 1999 to 2005). Significantly poorer productivity than this may be found in some circumstances. Data in KPMG's report on Indian shipbuilding, for example, provides information from which the level of productivity for building handysize tankers in India can be estimated at over 120 manhours per CGT (author's estimate, based on KPMG, 2008). Low productivity can easily eliminate some or all of the competitive advantage gained through low wage cost and low wage cost is not a substitute for good performance but an accessory to it in the pursuit of competitiveness.

6.1.4.3 Steel costs

Steel costs are not constant between countries and between global areas. Shipbuilders located in some areas will pay less for their steel than those located in other areas. Essentially, prices in Asia appear to be generally lower than prices in Europe or North America.   This is demonstrated in Figure 6.8, showing the development of prices over time of hot rolled mild steel plate in Europe, North America and the Far East.

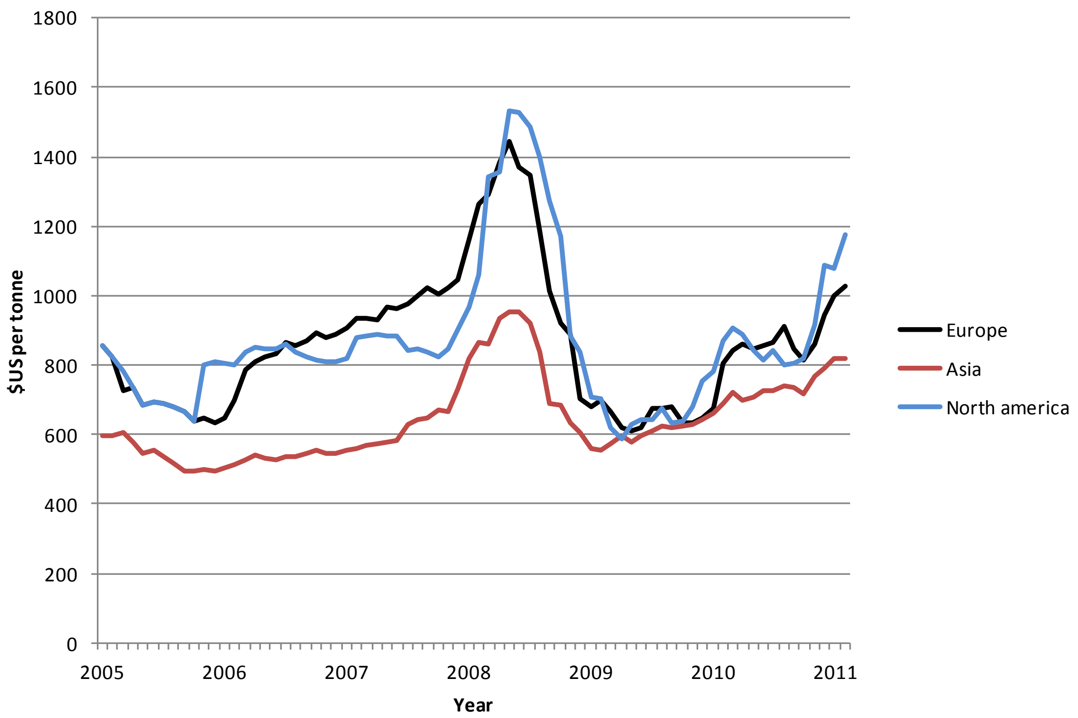


Figure 6.8 – Hot rolled steel plate price development (source: data from MEPS International (www.meps.co.uk))

On average over the period shown in Europe and North America steel prices were around 25% higher than in Asia. It is not only the base price of steel that varies, however. Economy of scale for large producers will enable them to negotiate deals for volume that will be reflected in lower prices specifically for that shipyard. For example in 2009 the Hyundai Heavy Industries Ulsan Shipyard in South Korea delivered 103 significant merchant ships (not including offshore and other non-merchant ship products) with a total estimated net steelweight of around 2.75 million tonnes (author's estimate), equating to over 3 million gross steel tonnes purchased for production in that year. Taking into account that Hyundai Heavy Industries' total production in South Korea in the same year at all yards was around double that at the Ulsan shipyard alone (199 ships in total) the potential purchasing power of the shipyard can be judged to be very significant. Significant demand is likely to lead to a strong local source of supply, minimising delivery and transaction costs. For a competitor in a country with no domestic availability of shipbuilding steel, transaction and delivery costs will increase the cost of raw materials further.

The level of significance of the influence of steel price on the total cost varies according to the type of vessel. This is illustrated in Figure 6.9, where the influence of labour cost is shown additionally for reference.

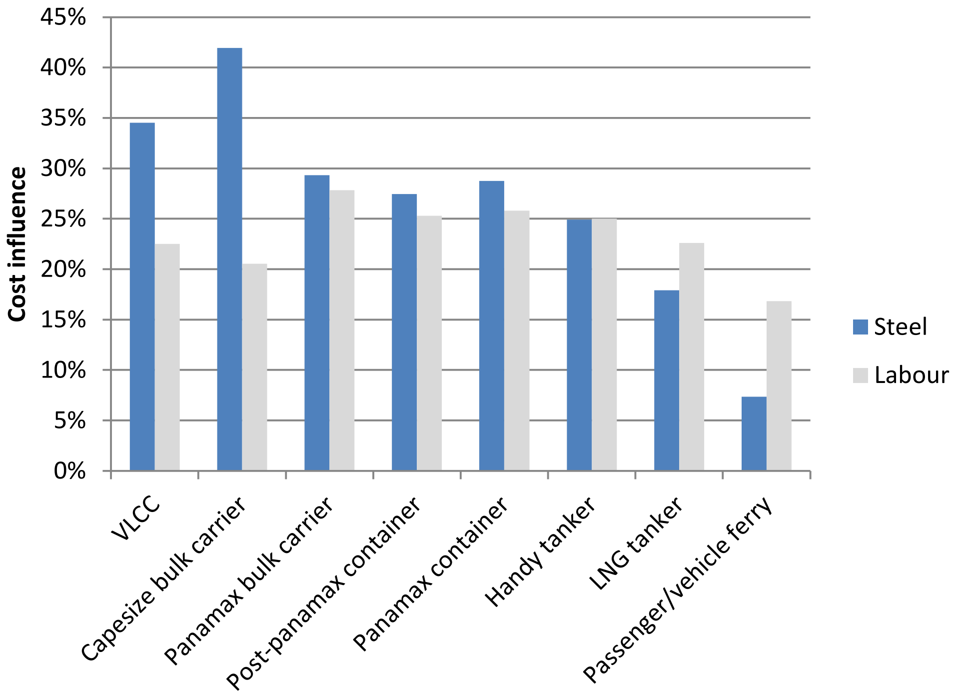


Figure 6.9 – The influence of steel price on total cost (including labour influence for comparison)

The influence of steel price on total cost is higher than that of labour cost in all cases except for the LNG tanker and the passenger ship. The results can be summarised in three categories:

Steel influence is:	Ship type
Significantly greater	• VLCC • Capesize
Slightly greater	• Panamax bulk carrier • Handy tanker • Panamax container • Post-panamax container
Lesser	• LNG tanker • Passenger

Table 6.5 - Relative influence of steel cost compared to labour cost

6.1.4.4 Other material costs

Other material costs, apart from steel, generally make up the largest single category of cost for a commercial shipbuilding contract and cost advantages gained in this sector will therefore inevitably have the greatest influence on total cost. Cost advantages can be gained from three main sources:

1. Pursuit of economies of scale: buying power, and therefore the ability to negotiate a lower cost, will stem from volume of purchases. High throughput is therefore an advantage in the same way that it is for steel.
2. Control of the makers list: volume shipyards will seek to restrict choice of equipment as far as possible. This increases the volume of business undertaken with chosen suppliers, increasing buying power and enabling efficient supply chains to be established.
3. Location in a country with a strong marine equipment supply industry is an advantage, minimising trade costs. Trade costs are not limited only to delivery costs but include a range of transaction costs such as documentation and customs clearance and the cost relates to time as well as pure cash (Sourdin and Pomfret, 2012). The World Bank lists these costs in its annual 'doing business' data, referring to the cost of *"Trading Across Borders: documents, administrative fees for customs clearance and technical control, customs broker fees, terminal handling charges and inland transport*" (World Bank, 2014).

To illustrate the working of these factors, the manufacturers of main engines installed by shipyards in 2010 in the three largest competing nations have been analysed using data sourced from Sea-Web. The results by nationality are shown in Table 6.6.

Nationality	Number of units purchased	Total kW purchased	Total kW purchased domestically	Proportion of domestic purchases	Average engine size (kW)	Number of suppliers	Average purchase per supplier (by number)	Average purchase per supplier (by kW)
South Korea (2010)	485	11,600,866	10,691,166	92%	23,919	14	34.6	828,633
China (2010)	948	10,556,504	4,291,838	41%	11,136	47	20.2	224,606
Japan (2010)	460	5,720,503	5,673,623	99%	12,436	17	27.1	336,500

Table 6.6 – Supply chain analysis for main engines

The effect of economies of scale in the top three shipbuilders is clearly seen in this table. The strength of the domestic marine equipment supply companies in both South Korea and Japan is also clear from this table, with very little importing seen. The marine equipment supply industry in China has improved significantly as the shipbuilding industry in that country has developed, but it still lags behind South Korea and Japan, with more than half of main engines imported in 2010.

The level of control exercised over the makers list can also be seen in Table 6.6, in the number of suppliers and the average number of units purchased from suppliers. South Korean builders show the smallest number of suppliers and the largest number of units purchased per supplier, with Japan also showing a good level of control over suppliers. Chinese shipbuilders had a significantly larger number of suppliers but still show a good number of units purchased per supplier, with the consequent potential for development of the supply chain.

The potential for control of the makers list can be judged further by examining the behaviour of the leading shipbuilding competitors in the countries shown. South Korea has three significant marine engine manufacturers: Hyundai, Doosan and STX and all Korean shipbuilders buy predominantly from these companies. Table 6.7 shows the number of significant suppliers used by the seven large South Korean shipyards, along with the proportion of main engines purchased from the leading supplier and the proportion purchased from all domestic suppliers.

	Number of significant suppliers	Proportion purchased from largest supplier	Proportion domestic
Daewoo Shipbuilding & Marine	1	71%	85%
Hyundai Heavy Inds - Ulsan	1	98%	100%
Hyundai Mipo Dockyard Co Ltd	1	98%	100%
Samsung Heavy Inds - Geoje	1	72%	74%
STX Offshore & Shbldg - Jinhae	1	91%	98%
Sungdong Shipbuilding & Eng	1	100%	100%
Hyundai Samho Heavy Industries	1	100%	100%

Table 6.7 – Profile of main engine suppliers in 2010 for leading South Korean shipyards

It can be seen that the large yards in South Korea all rely heavily on single suppliers, giving a strong opportunity for supply chain integration and economies from volume purchasing. In the case of the three Hyundai subsidiaries shown almost 100% of main engines are purchased from within the Hyundai group.

Japan has one large engine manufacturer, Mitsui, responsible for 40% of all main engines supplied in the country in 2010, but with eight other significant smaller suppliers. A greater choice of maker is therefore given by some Japanese yards, although as can be seen in the table below a number also restrict the makers to a single supplier as in South Korea. Almost all main engines are sourced from

Japanese suppliers. This is shown for the leading ten shipyards (by GT completed) in 2010 in Table 6.8.

	Number of significant suppliers	Proportion purchased from largest supplier	Proportion domestic
Universal Shbldg – Ariake	1	100%	100%
Koyo Dockyard Co Ltd	1	93%	100%
Oshima Shipbuilding Co Ltd	3	64%	100%
Namura Shipbuilding - Imari	2	69%	100%
Imabari Shbldg – Saijo	3	35%	100%
Universal Shbldg – Tsu	2	75%	100%
Imabari Shbldg - Marugame	3	35%	100%
IHI Marine United – Kure	1	100%	100%
Mitsubishi Nagasaki	2	50%	100%
Mitsui Chiba Ichihara	1	100%	100%

Table 6.8 – Profile of main engine suppliers in 2010 for leading Japanese shipyards

The leading supplier of main engines to Chinese shipyards in 2010 was STX of South Korea, and three of the top four suppliers were the three main South Korean manufacturers. China's leading domestic supplier was Hudong, with an 11% share in 2010, but with seven other significant domestic suppliers operating in that year.

	Number of significant suppliers	Proportion purchased from largest supplier	Proportion domestic
Dalian Shipbuilding Ind - No 2	2	68%	68%
Shanghai Waigaoqiao Shbldg	3	44%	89%
Shanghai Jiangnan Changxing SB	2	86%	85%
Jiangsu Newyangzi Shipbuilding	3	64%	21%
Jinhai Heavy Industry Co Ltd	4	44%	11%
New Times Shipbuilding Co Ltd	2	76%	6%
Jiangsu Rongsheng Shipbuilding	2	63%	0%
Hudong-Zhonghua Shipbuilding	2	75%	75%
Nantong COSCO KHI Ship Eng	2	47%	87%
Guangzhou Longxue Shipbuilding	2	57%	57%

Table 6.9 – Profile of main engine suppliers in 2010 for leading Chinese shipyards

It can be seen from this table that control of the makers list by Chinese shipbuilders is less well established than seen in South Korea and Japan, with no shipyard having a single dominant supplier, and the opportunities for domestic purchases are also significantly fewer. This will be reflected in increased material costs in Chinese shipbuilding when compared to shipyards in the other two leading shipbuilding nations, with lower opportunity for streamlining of the equipment supply chain and higher delivery and transaction costs for equipment.

How much the need to import marine equipment adds to the cost is variable and difficult to measure in general terms. Sourdin and Pomfret point out that general measures are difficult because there is no agreed definition of trade costs and evaluations are only possible for countries where data is available (Sourdin and Pomfret, 2012). They point out that the cost of importing "*will exceed the shipping cost if, for example, poor infrastructure or other factors increase dwell times at the port of entry or exit"* and that the cost clearly varies according to distance and other factors. Trading costs are measured into Australia and Brazil, with an average of 6.4%, minimum of 1.6% and maximum of 19.2%. The authors note that *"For economies trading more commodities, the results lie below 10%"*. They also note that trading costs have been reducing steadily over the past two decades.

The level of influence of changes in other material costs, with labour costs for comparison, is shown in Figure 6.10.

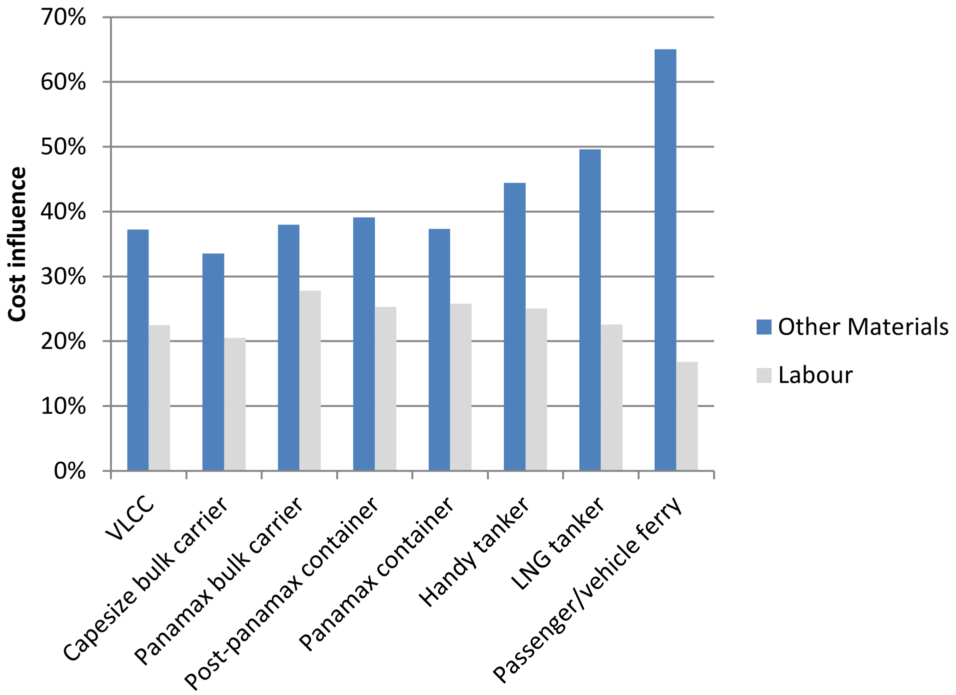


Figure 6.10 - The influence of other material costs on total cost (including labour influence for comparison)

It can be clearly seen that the influence of other material costs is significantly greater than both steel (Figure 6.9) and labour costs. The level is fairly similar across the bulk ship sectors but higher for LNG tankers and significantly higher for the passenger ship sector. This supports the conclusion that an advantage held by European shipyards in maintaining a lead in the passenger ship sector, and in particular the cruise ship sector, is the availability of clusters of well-established specialist suppliers in the locality of the shipyards. Conversely the lack of such an infrastructure of suppliers and the additional cost of importing goods and services over a long distance will inevitably present something of a barrier to entry, although clearly a barrier that could be overcome by the development of such an infrastructure.

6.1.4.5 State aid

State support in many forms has been a common feature of shipbuilding in the past, as discussed in general terms in Section 2. The many forms of aid clearly will have a direct effect on the competitiveness of the recipient.

6.1.4.6 Finance

The availability of sources of finance for new ship construction, including access to repayment guarantees and the provision of loans for construction, can have a significant effect on competitiveness. Details of this provision are outside the scope of this dissertation.

6.1.4.7 Group strength

As a final input to competitiveness, we should not forget the potential assistance in being part of a large diversified group of companies, from which strength can be gained from other members in times of adversity or expansion. This strength has been used in Japan and, particularly, through the Chaebol structure in South Korea. Professor Joon notes: *"Shipbuilders belonging to diversified corporations have the advantage of being able to rely on corporate resources for expansion and support which are independent of the State shipbuilding market" (Joon Soo Jon, 2002)*. At times such group strength can disappear such as happened in 1998 when a number of Daewoo subsidiaries, including Daewoo Motor and Daewoo Shipbuilding and Marine Engineering, got into financial difficulty at the same time. As Joon points out, however, the other advantage in belonging to a powerful group is *"Conglomerates have political clout..This can mean easier access to capital markets and more sympathetic treatment by politicians, than could be expected by a dedicated shipbuilding company"* (*ibid*.). Having said this, the downside to group membership may be bureaucracy and high group costs, which in themselves detract from competitiveness.

6.1.4.8 Summary of determinants of competitive advantage

Based on the foregoing analysis the following determinants of competitive advantage can be summarised:

1. Location of the shipyard in a country with strong steel making and marine equipment manufacturing industries. This minimises transaction and delivery costs.
2. Development of production volume, standard vessels and control of the makers list. These enable strong and efficient supply chains to develop and discounts for volume to be negotiated.

3. Good productivity. If this is coupled to low labour cost, so much the better. Low labour cost per se is not a determinant, however, without being coupled to good performance.
4. Investment in facilities that support the volume and level of productivity pursued. Particularly important are the steelworking facilities and the arrangement of final assembly site and cranage.
5. Investment in human capital and continuity of work to support the level of productivity pursued.
6. Investment in product-specific aspects that may be required for specific sectors where barriers to entry might otherwise exist. A good example is the investment required to gain access to the LNG market. This includes investment in skills and capability in general and also specific investments in facilities, for example for manufacture and installation of the containment system. Another good example is the cruise ship sector, where investment is required in technical skills and product development, and in establishing the required infrastructure of subcontractors and suppliers.
7. Other factors may be important, for example access to finance to support purchasers, membership of a powerful group and government support.

6.2 R5 – How can 'like products' be characterised based on the answers to R3 and R4?

6.2.1 Guidance from WTO case law

It follows from the discussion of 'like product' within the context of WTO, presented earlier in this dissertation, that there can be no single definition of the term in commercial shipbuilding but that 'likeness' will depend on circumstances. The following section, therefore, sets out to explore the potential bounds of the concept, the factors that could be used to determine it in commercial shipbuilding and to give examples of arguments for interpretation of 'likeness' in specific instances. These examples and concepts can only be proven with reference to case law, that is to say that they would have to be confirmed through tribunal and appellate body decisions in the WTO to finally conclude that they hold water. What follows, therefore, is effectively a recommended approach to the subject in commercial shipbuilding, which is congruent with the concept itself and the working of the commercial shipbuilding market and factors of competitiveness.

A number of guidance points are given in the case law relating to ‘like product’, as discussed earlier in Section 4. These are summarised as follows.

The WTO’s 1968 Working Party on Border Taxes (see Section 4) proposed the following four primary considerations to determine likeness:

1. **The products’ properties, nature and quality, i.e. their physical characteristics**: this factor is important in that the physical nature of the product has to be compatible with the shipyard capacity that competes to produce it.
2. **The products’ end uses**: is of relevance only in so far as it determines the physical characteristics of the ship, for example size or proportion of steelwork content, which may be more or less compatible with the unit of capacity competing for it. From the point of view of shipyard capacity the end use of the product *per se* has no bearing on that capacity which may, for example, compete for products that are very disparate in terms of their end use, for example container ships and LNG tankers.
3. **Consumers’ tastes and habits, also referred to as consumers’ perceptions and behaviour, in respect of the products**: domestic buying preferences, for example, indicate that this may be an important consideration in specific circumstances.
4. **The products’ tariff classification:** has already been examined and discounted as not useful in this context.

Two of these considerations (1 and 3) provide useful guidance in the assessment of ‘likeness’, providing that the nature of the product is clearly understood as to encompass both the physical entity produced by a shipyard and the factor of production, that is to say shipyard capacity. This reflects the guidance given by the ruling on *EC-Asbestos* from 2001, which proposed three questions that need to be resolved in assessing ‘likeness’:

1. **Which characteristics or qualities are important in assessing ‘likeness’:** the characteristics in this case are those that render the product accessible to the determinants of competitive advantage attributable to the capacity competing for that product.
2. **To what degree or extent must products share qualities or characteristics in order to be ‘like products’:** the products must be compatible with the capacity competing for them in physical terms, primarily size-related, and also in terms of the attributes that relate to the determinants of competitive advantage.
3. **From whose perspective likeness should be judged:** the point of view of the builder must be used to judge likeness. That is to say that likeness is judged by substitutability between products that compete for the same units of shipbuilding capacity, irrespective of the end use of that product. The ship operator’s viewpoint, that, for example, a container ship is not a substitute for a tanker, is not relevant to this discussion.

Finally, three factors were summarised in the assessment of ‘likeness’, as follows:

1. **Substitutability – consumers have to be willing to substitute one for the other:** in this case it must be remembered that what is being substituted is units of shipbuilding capacity, not differing products. The customer has to be prepared to utilise competing units for the production of their ship, being satisfied that the shipyard has the technical capability to produce the ship.
2. **Functionality – the two products have to perform the same function:** this relates to the function of capacity in producing commercial ships, not to the function of the ship.
3. **Competitiveness – the two products have to actually be competing for the same opportunities:** this is at the core of ‘likeness’ and the determinants of competitiveness are therefore of significant importance. At one level the judgement of likeness from this point of view is simple. If a shipyard has a current track record of competitiveness in the sector in question then products in that sector would *prima facie* be ‘like’. It becomes more difficult when considering

potential competition: opportunities that a shipyard could compete for but for which it has no current market presence. The absence of current market presence, however, does not necessarily preclude capacity from competing for the sector in question providing that it is compatible. The re-introduction of capesize bulk carriers to the product mix of HHI in 2008 (see figure 6.4) being a prime example.

The dimension of competitiveness is central to the consideration of 'likeness' in commercial shipbuilding because from a purely technical standpoint there is only one thing that limits the products that a shipyard could build and that is size. Specialist build functions can be subcontracted if they do not form part of the expertise of the yard and work can also be subcontracted to enhance capacity. A unit of shipyard capacity could, in a technical sense, be used for any product within its size limitation. Certainly in the post-war years shipyard capacity was almost completely flexible within the size limit.

6.2.2 Barriers to entry

A further factor that has to be taken into account that may limit the scope of 'likeness' is the concept of barriers to entry. Clearly, a unit of capacity cannot compete for a fleet sector to which it cannot gain access. A good, but mistaken, example is the general perception that certain shipyards will be unable to build more sophisticated tonnage due to lack of experience. The analysis of what might be regarded as the 'normal' progression of product mix in the development of a shipyard would suggest that the progression starts with the notionally simplest ship type, dry bulk carriers, progressing through more difficult types, tankers to container ships, and with only advanced shipyards able to gain access to the specialist and technically difficult market sectors, LNG, cruise and offshore. This pattern was clearly demonstrated in the development of the product mix at HHI in Figure 6.4. In reality, whilst this pattern may assert itself there are no actual barriers to entry that mandate shipyards to follow this progression. That this is so can be demonstrated by pointing out that ships number 3 and 4 from the (then) new Shanghai Waigaoqiao shipyard in China, delivered in 2004, one year after the shipyard delivered its first ship, were both offshore FPSOs: '*Hai Yang Shi You 111'* (140, 723 dwt) and *'Hai Yang Shi You 113'* (150,000 dwt). Within two years of opening the shipyard was delivering aframax tankers as well as the main product, capesize bulk carriers. It is not only

Waigaoqiao where technically more difficult products have formed an early part of the product mix. The first ship delivered by Hyundai Shipbuilding & Heavy Industries, as it was then, in 1974 was a VLCC.

In general, therefore, there are no barriers to entry that preclude a unit of capacity from any particular sector, providing it is within the size capability of the shipyard, but with two exceptions. These are, firstly, LNG tankers and, secondly, cruise ships. Building of LNG tankers requires investment in specific facilities for the manufacture of the cargo containment system. Additionally, the technical difficulties of LNG construction mean that the quality requirements of the builder are onerous and contracting in this sector will be impossible for general shipbuilding capacity that cannot demonstrate the level of expertise and experience that customers require. Such barriers can be overcome, however, and in 2014 there were 17 shipyards in South Korea, Japan and China building LNG tankers. In the cruise ship sector the barriers are different and relate to the unique characteristics of the product in shipbuilding terms and the nature of the customer. The product characteristics dictate the need for a supply chain the characteristics of which are very different to those of a cargo carrying ship. It is also difficult to break into the mainstream of that sector without experience. Stopford also cites cruise ships as a specific example of competitive advantage based on technical innovation, which new entrants will find difficult to compete with: *"the manufacture of complex products such as cruise ships and aircraft are all examples where one country has developed a competitive advantage based on technical innovation and is protected by barriers such as the high cost of entry"* (Stopford, 2009, p. 399).

From this standpoint the EU was correct in arguing likeness in LNG products. Both Chantiers de l'Atlantique of France and Izar of Spain had current track record in this sector at the time and were seeking to take further orders and the barriers to entry did not apply in this case: the shipyards had already entered the 'club' of LNG builders.

6.2.3 Consumers' tastes and habits

If a product shares a characteristic that would normally be expected to favour a particular shipbuilder because of customer preference then this would form part of the assessment of likeness. A particular case may be found in the consideration of domestic ordering. A strong preference for domestic ordering is exhibited in Japan, for example, and it is no surprise therefore to find a correlation between the products produced by the Japanese shipbuilding industry and the products purchased by Japanese shipowners. This is shown in Figure 6. 11, which shows the proportions of ship types in the Japanese fleet compared to the proportions of ship types produced in Japanese shipyards between 2008 and 2012.

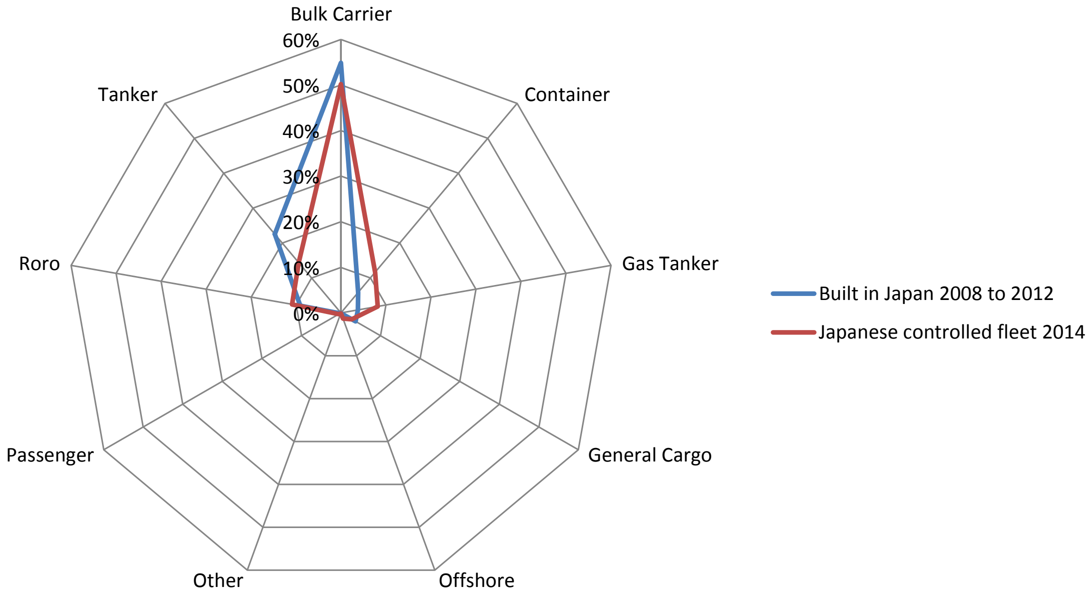


Figure 6.11 – Comparisons of proportions (by GT) of ships delivered from Japanese shipyards and ships controlled by Japanese owners

No such coincidence is seen between the Korean fleet and the output of South Korean shipbuilders, which concentrates on the export markets, as shown in Figure 6.12.

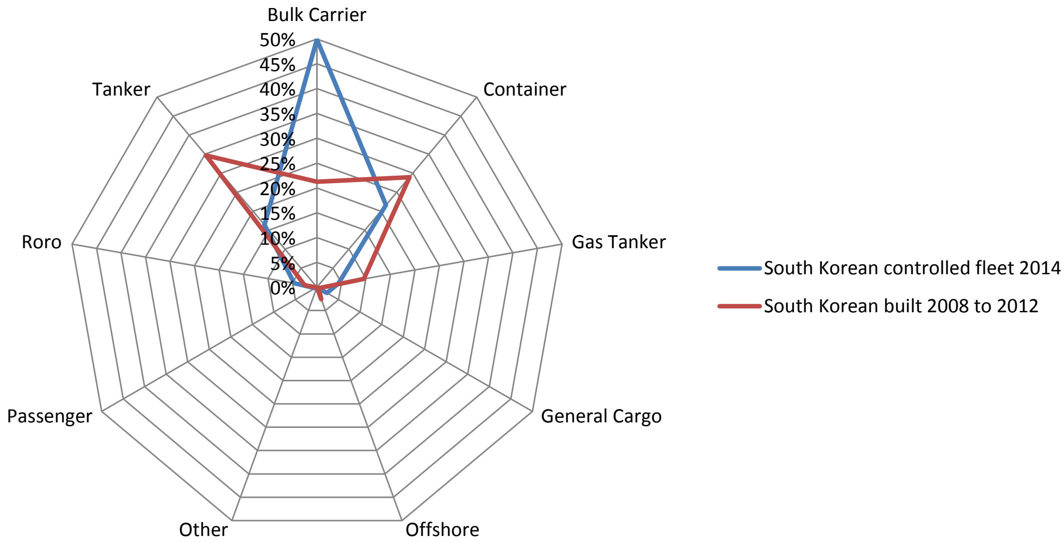


Figure 6.12 - Comparisons of proportions (by GT) of ships delivered from South Korean shipyards and ships controlled by South Korean owners

In competitive terms, therefore, the concept of 'likeness' has to be viewed from this perspective as being different for Japanese shipyards when compared to South Korean shipyards. From Japan's point of view it could be argued that the *"accordion of likeness"* stretches to incorporate any product that is of interest to Japanese ship owners, a relationship by which Japanese shipyards at least partially derive their competitiveness. Thus tankers and container ships, whilst of lesser importance to Japanese shipyards according to their recent track record, could be argued to be 'like products' for Japanese shipyards because of their significance to Japanese buyers, as can clearly be seen in the diagram above.

It should be remembered that there is no mandate for Japanese buyers to source from Japanese shipyards, as may be the case in other countries, such as USA, Canada and Brazil, but domestic purchasing is clearly a significant aspect of *"consumers' tastes and habits"*. This can be more subtle than the general domestic procurement preference seen in Japan. A good example is the use of KG funds to finance ship purchase in Germany: "*the Kommanditgesellschaft, or the KG model, based upon the German limited partnership structure that has been around for nearly 100 years. Originally, in the early 1970s, the policy was aimed at simply attracting equity into domestic real estate and infrastructure project financing via single purpose, single asset companies. Later, in the 1990s, the German government* *provided even greater tax incentives to shareholders who invested in the shipping sector. Under the system a KG has one general partner and several limited partners, comprising private investors who take shares (and therefore limit their liability to the extent of those shareholdings) in a fund established to invest in new or second hand tonnage and, in this way, participate in the profitability of the shipping sector. Individuals, who alone would not be able or willing to invest in the sector, pool their resources with other investors, creating a fund that can invest in single ship companies"*. Norway has had similar arrangements under the 'KS' system (Institute of Chartered Shipbrokers., 2010, pp. 61,62). The arrangement whereby general investors that may be inexperienced in shipping are enabled to participate in ship purchase leads to specific consideration in terms of *"consumer tastes and habits"*. Figure 6.13 shows the proportions of ship types in the German fleet compared to the proportions of ship types produced in German shipyards between 2008 and 2012 along with the profile of KG financed ships ordered between 2002 and 2008:

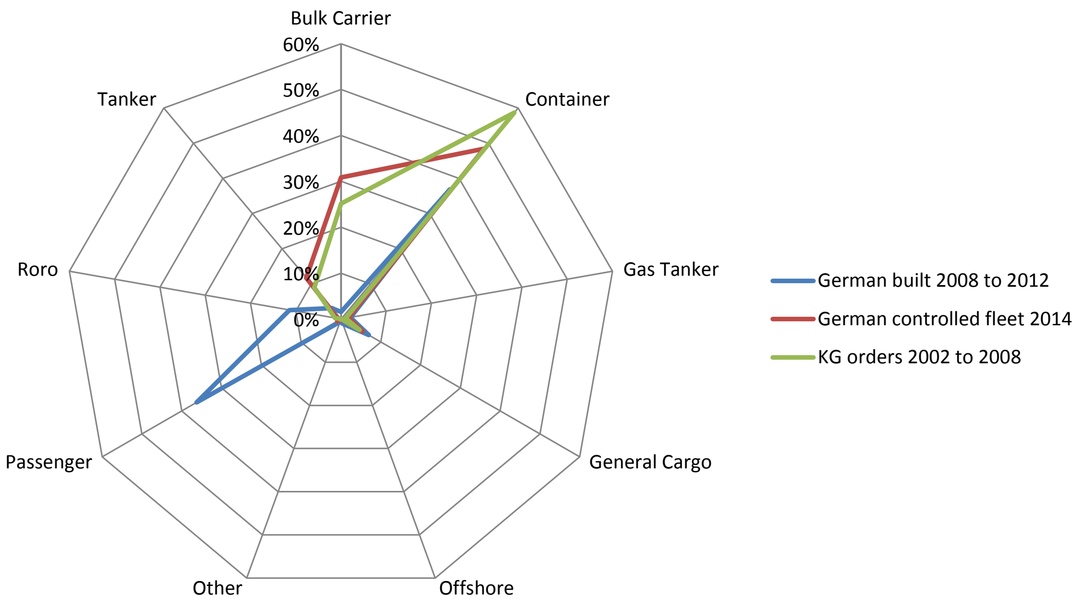


Figure 6.13 - Comparisons of proportions (by GT) of ships delivered from German shipyards, ships controlled by German owners and KG financed ships

The importance of the export cruise sector to the German shipbuilding industry is clear from this diagram. It can also be seen that German shipyards concentrated on container ship orders, specifically mid-sized between 800 TEU and 3,500 TEU, which are consistent with the most important sector of the KG financed fleet in terms of ship type. 61% of container ship orders built in German shipyards in the period examined came from German ship owners. It can be seen that the much smaller general cargo sector also shows congruence between all three profiles. It might be assumed that where the option to order in home shipyards is available, inexperienced investors would perceive lower risk from placing orders with home shipyards. This is confirmed by analysis of fleets that shows:

- The probability of a German ship being ordered in a home shipyard for orders placed between 2002 and 2008 was 8%.
- The probability of a KG financed container ship in the target sector of German shipbuilding, that is to say mid-sized container ships between 800 and 3,500 TEU, being ordered in a home shipyard for orders placed between 2002 and 2008 was 24%.

Given the higher domestic ordering preference in the KG sector where competitive capacity is available it could be argued that at least in part the concept of 'likeness' for German shipyards, when looked at from the point of view of the seller, extends to any product that is of interest to owners planning to use KG financing.

The attribute of customer preference may extend to specific owners and their relationships with specific shipyards. Clear examples can be found in the cruise sector. Carnival Corporation, for example, has purchased over 60% of its vessels from the Fincantieri Group of Italy. Another example was the relationship between Odense Steel Shipyard of Denmark and its owner AP Moller Group. Between 2000 and the closure of the shipyard in 2012, 75% of the ships delivered from the shipyard were container ships for Maersk, AP Moller's shipowning company. From this perspective any AP Moller vessel, particularly container ships, could have been argued to be 'like product' for the shipyard.

From this perspective, therefore, the EU was correct in arguing for container ships in general to be potentially 'like products' for EU-based builders.

6.2.4 Attributes of the product – 'technical substitutability'

6.2.4.1 Summary of attributes that determine likeness

From a competitiveness standpoint in a more general sense there are a number of attributes that impinge on 'likeness' that arise from technical characteristics of the products and the facilities that are developed to build these products and that key into factors of competitive advantage. Another way to term this would the 'technical substitutability' between products. The attributes are grouped into two types in the following discussion: those that consider compatibility between the product and the nature of the investment in the shipyard and those that consider compatibility between the product and factors of competitiveness that may be inherent in a particular shipyard.

- The characteristics of the product should be compatible with the nature of the investment in the shipyard. In particular:
    - **the size of the product should be compatible with the size of the shipyard's launching and fabrication facilities**. Self-evidently a shipyard cannot build a vessel that is too large for it to launch. It may also be difficult for a shipyard to construct ships that are significantly smaller than those for which it is designed. Not only will the investment be inefficient but also the market share requirements to fill capacity increase as size reduces and may become infeasible. Similarly, a shipyard that is designed and invested to build steel panels for large vessels may have difficulty in fabricating thin plate panels needed, for example, for passenger vessels.
    - **The market for the product should be of sufficient volume to utilise capacity within an achievable level of market share**. If this is not the case then investment will be under-utilised and economic efficiency will be reduced. As an extreme example, building tugs in a very large shipyard makes little sense, because even with a very high market share the utilisation of available capacity would be low and the sector would therefore contribute little to the business.
    - **The characteristics of the product in terms of the balance of steel work and outfit work should be compatible with the investment and with the skills balance and experience of the workforce**. This may make it difficult, for example, for a cruise ship builder to seek work in the tanker markets, even where the dock is big enough. This would be a diversification and investment in facilities and training would be needed.

- The characteristics of the product should key into the factors of competitiveness that characterise the shipyard. In particular:
    - **The product should be compatible with the supply chain to ensure efficiency of purchasing**. For example, the construction of cruise ships requires subcontracting and supplier companies that are experienced in outfitting high quality public spaces, and which are acceptable to the image-conscious buyers. Such suppliers are not required for the construction of cargo ship types and cruise ships may therefore be incompatible with the supply chains that contribute to competiveness in the large cargo ship sectors. Another example is found in the diversification from cargo ship building into offshore fabrication. The level of control of the makers list by the shipyard in the offshore sector is limited, with offshore products often designed and specified by external companies, not the shipyard, and the suppliers and subcontractors needed in that sector are not likely to be the same as those found in the supply chain developed to construct large commercial vessels.
    - **The product should be compatible with the proportion of steelwork that is inherent in the characteristics of the investment and which may gain competitive advantage from volume ordering**. For shipyards that have invested in high capacity steelworking facilities it would make economic sense to choose products that will utilise that investment.
    - **The product should be compatible with the experience and skills balance of the workforce**. As described earlier experience is a key to productivity, through *"organizational learning"* (Craggs et al., 2004). Switching between products leads to a drop-off in performance and the level of novelty in the characteristics of the new product will determine the level of the drop-off and thereby the reduction in competitiveness. If the balance of skills is significantly different, for example in switching between large cargo ships with limited outfitting requirements and passenger ships with very high outfitting requirements, retraining will be necessary and competitiveness will reduce.

- **The product should be compatible with any target sectors that may give the shipyard a competitive advantage**. This is difficult to quantify in any general sense and will be shipyard-specific. The most overt example relates to sectors where there may be barriers to entry.

To evaluate these attributes it is necessary to propose proxies that will present information on which judgements can be made relating to fit with the factors proposed above. 4 proxies are proposed with which to evaluate 'likeness':

- Market volume (CGT) of the product sector.
- Typical steelweight for the product in question and typical proportion of work content represented by steelwork.
- Presence of quasi-standard ship types for the product in question.
- Presence of any barriers to entry.

Table 6.10 summarises how these proxies approximate to the attributes that determine likeness.

Compatibility	Product attribute	Proxy for quantification
Compatibility with the nature of investment in the shipyard	The size of the product should be compatible with the size of the shipyard's launching and fabrication facilities.	• Typical GT values
	The market for the product should be of sufficient volume to utilise capacity within an achievable level of market share.	• Market volume (CGT)
	The characteristics of the product in terms of the balance of steel work and outfit work should be compatible with the investment and with the skills balance and experience of the workforce.	• Typical proportion of work content represented by steelwork
Compatibility with factors of competitiveness	The product should be compatible with the supply chain to ensure efficiency of purchasing.	• Typical steelweight • Market volume (CGT) • Availability of quasi-standard ships
	The product should be compatible with the proportion of steelwork that is inherent in the characteristics of the investment and which may gain competitive advantage from volume ordering.	• Typical proportion of work content represented by steelwork
	The product should be compatible with the experience and skills balance of the workforce.	• Proportion of work content represented by steelwork
	The product should be compatible with any target sectors that may give the shipyard a competitive advantage.	• Presence of any barriers to entry.

Table 6.10 - Summary of product attributes that determine 'likeness' and proposed proxies for quantification

6.2.4.2 Fleet sectors, market volume and quasi-standard ships

Market volume is assessed according to the level of work content per product sector, represented by CGT, representing the opportunity presented over time to shipbuilders by each fleet sector. As the mix of products that make up the demand for shipbuilding changes over time, the relative proportions of different sectors of the fleet under construction will vary in response. It is therefore not possible to use any fraction of shipbuilding output data to represent relative volumes per sector. The total volume of the fleet has therefore been used to represent market volume by sector, using fleet statistics correct at July 2014. The data used represents the total quantum of shipbuilding work content inherent in the fleet.

The relative distribution of market volume by main product type is given in Figure 6.14.

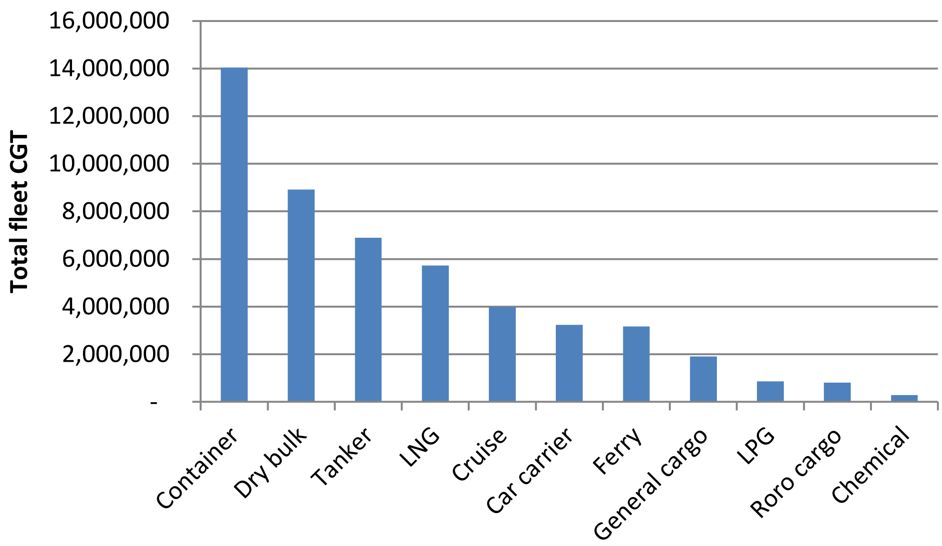


Figure 6.14 – Distribution of work content in the fleet by sector

It can be seen that significant volume of work is contained in the largest four sectors of the fleet: container, dry bulk, tanker and LNG, together accounting for 71% of the total CGT. To analyse the fleet in more detail it has been split into two sector types: volume and niche. These two types are defined as follows:

- Volume sectors provide significant market volume and incorporate quasi-standard sub-product types.
- Niche sectors offer lower volume or little or no opportunity for developing quasi-standard sub-product types.

To make this classification it is necessary to identify which sectors of the fleet incorporate quasi-standard products. Examples of such products are listed in terms of ship brokers' terminology in Appendix 1.

Table 6.11 summarises the important attributes of products from a competitiveness standpoint.

Main fleet sector	Designation	Proportion of total fleet by work content	Level of presence of quasi-standard products	Quasi-standard products identified
Container	Volume	28%	High	Feeder Handy Sub-panamax Panamax Post-panamax
Dry Bulk	Volume	18%	High	Handysize Handymax Panamax Capesize
Tanker	Volume	14%	High	Handy Handymax (supramax) Panamax Aframax Suezmax VLCC
LNG	Volume	12%	High	Small Conventional Qflex Qmax
Cruise	Niche	8%	Low	
Car carrier	Niche	6%	High	Panamax
Ferry	Niche	6%	Low	
General cargo	Niche	4%	Intermediate	Shipyard specific
LPG	Niche	2%	Intermediate	Shipyard specific
Roro cargo	Niche	2%	Intermediate	Shipyard specific
Chemical	Niche	1%	Low	

Table 6.11 – Classification of attributes of competitiveness for the main commercial shipbuilding products

6.2.4.3 *Identification of size classes*

The sub-products in the volume sectors identified are analysed in Figure 6.15 according to vessel net steelweight and vessel size.

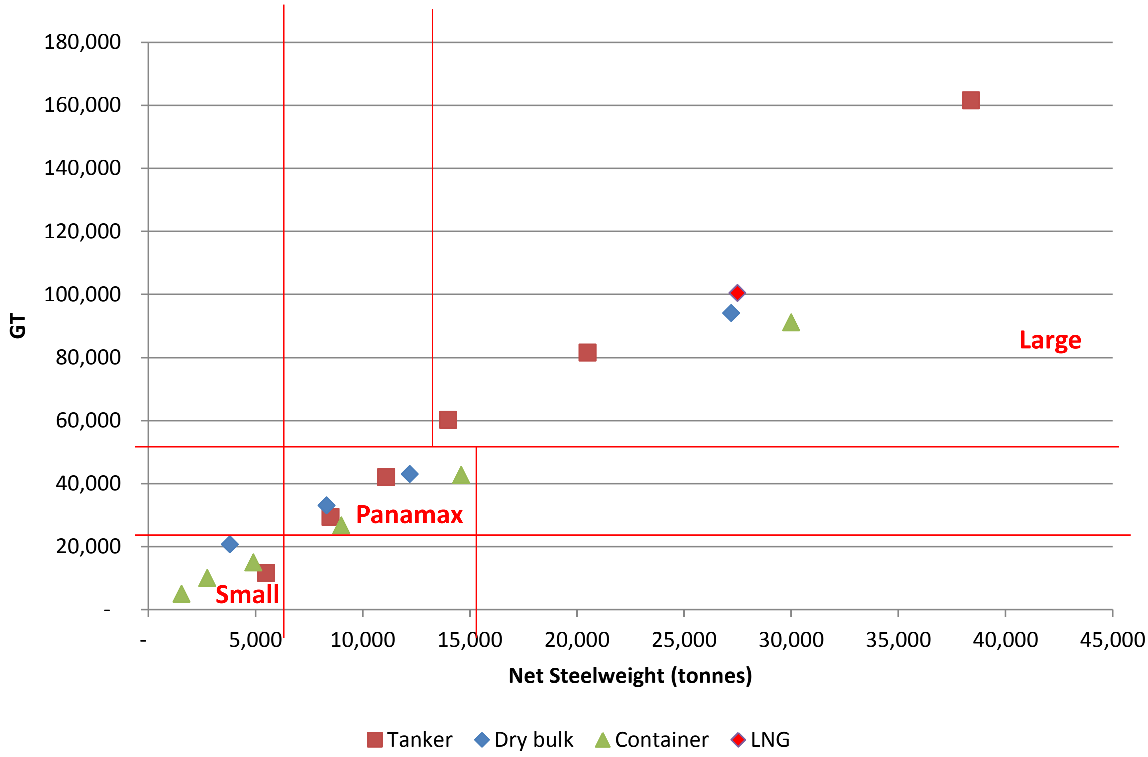


Figure 6.15 – Identification of volume shipbuilding sectors

Each data point in this chart represents the typical characteristics of the quasi-standard products identified in the table above. For example, the three tanker data points in the large sector of the chart represent VLCC, suezmax and aframax products. The market has been subdivided into three divisions in this figure relating to the characteristics of the shipyard to which they are most relevant, that is:

- Large vessels, typically over 20,000 tonnes net steelweight and 80,000 GT, but including also aframax tankers that are slightly smaller than this. This sector relates to shipyards that will typically have VLCC building docks.
- Panamax, typically between 7,500 tonnes and 15,000 tonnes net steelweight and 20,000 GT and 50,000 GT, relating to shipyards that typically have panamax building docks or slipways.
- Small, under 7,500 net tonnes and 20,000 GT, relating to shipyards that typically have small building docks or slipways.

This classification of the market by size of vessel is used in the following analysis.

6.2.4.4 Identification of 'technically substitutable' products

In the following analysis the markets have been subdivided by ship size into the three sectors identified above. For products in each sector for which reliable steelweight information could be obtained and for which reliable market information could be obtained to enable cross price elasticity to be subsequently examined, a chart has been developed that shows the following:

- market volume is represented by bubble size;
- GT by product is represented by positioning on the vertical axis. In effect this is a proxy for compatibility with investment in the launching facility of the shipyard;
- steelweight as a % of work content, represented by typical CGT, is represented by positioning on the horizontal axis. In effect this is a proxy for compatibility with investment in the workshops that support the launching facility and in the development of the human capital and skills base;
- incidence of quasi-standard ship types is represented by bubble colour;
- barriers to entry are indicated by patterned shading.

Technical substitutability is related to proximity of positioning of products in these charts: the closer products appear the greater the level of substitutability. Figure 6.16 presents the substitutability chart for large ship types.

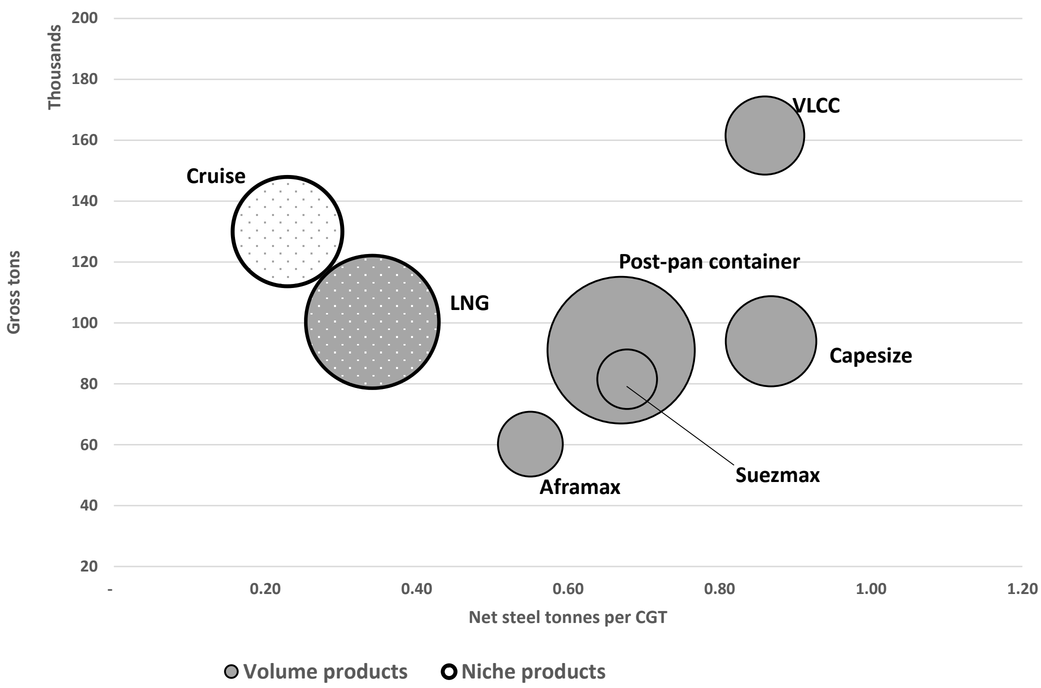


Figure 6.16 – Identification of technical substitutability in the large ship sector (patterned shading indicates barriers to entry)

- The potential for standardisation is present for all products except cruise, where short series remains the norm.
- Barriers to entry exist in the cruise and LNG sectors.
- Steelwork density can broadly be divided into three categories:
    1. low, under 0.5 tonnes per CGT, for cruise and LNG tankers;
    2. high, clustered around about 0.7 tonnes per CGT, for aframax, suezmax and post-panamax container;
    3. very high, at about 0.9 tonnes per CGT, for capesize and VLCC.
- Low steelwork density for the cruise sector in particular indicates low compatibility with volume products.
- The range of size of vessels is high, with the largest, VLCC, being over double the size of the smallest, aframax.

Figure 6.17 presents the substitutability chart for panamax ship types.

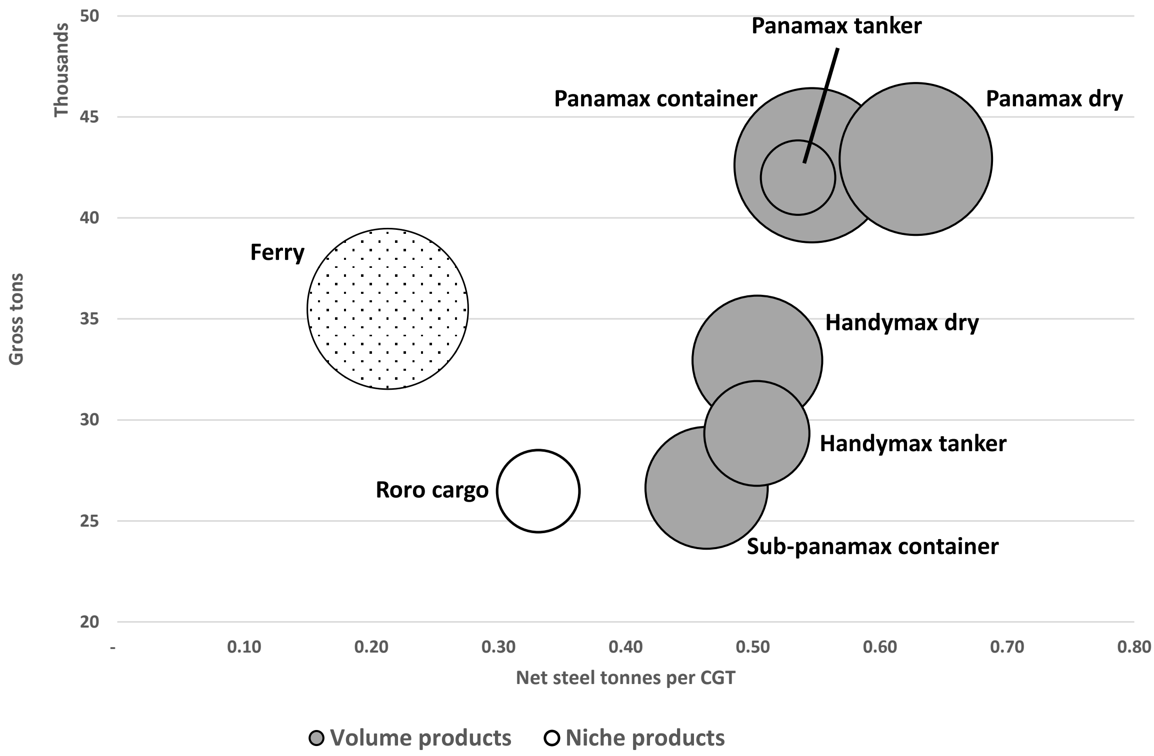


Figure 6.17 – Identification of technical substitutability in the panamax ship sector (shading indicates barriers to entry)

- The potential for standardisation is present for all products except ferry and roro, where short series remain the norm.
- Barriers to entry exist in the ferry sector, although arguably are less strong than for the cruise and LNG sectors.
- Steelwork density is similar for all the volume products at around 0.5 tonnes per CGT for the smaller products and 0.6 tonnes per CGT for the panamax products. This may be due to some degree to scantling difference, rather than relating to relative steelwork content absolutely.
- Steelwork density for the niche products is low, with the ferry sector in particular indicating low technical substitution with the volume sectors.

Figure 6.18 presents the substitutability chart for small ship types.

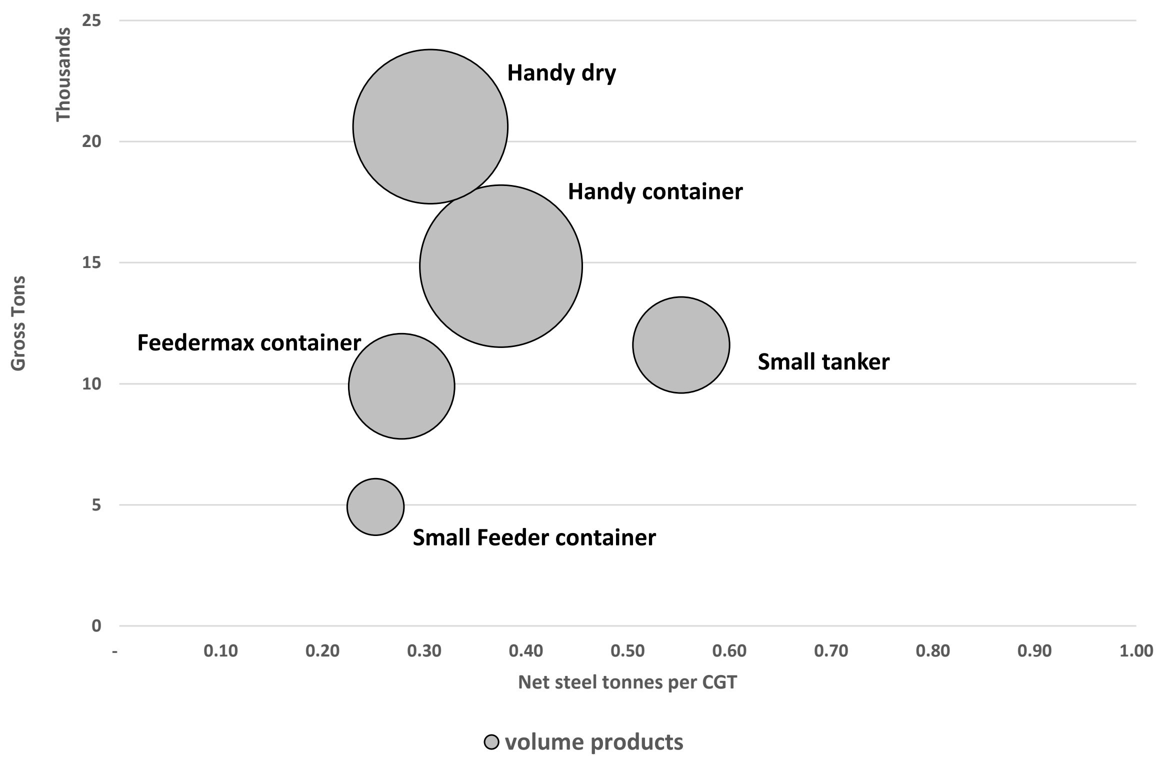


Figure 6.18 – Identification of technical substitutability in the small ship sector

- Only volume products are shown although it should be noted that minor niche sectors also exist, for example dredgers or research vessels.
- No barriers to entry are identified in the products shown.
- Steelwork density is consistent for the dry cargo products, at around 0.35 tonnes per CGT, but considerably higher for the tanker at around 0.55 tonnes per CGT.

The vertical scales in the above charts are adjusted to obtain the optimum illustration of trends. The following chart plots the three sectors together so that relative positioning between the sectors can be seen.

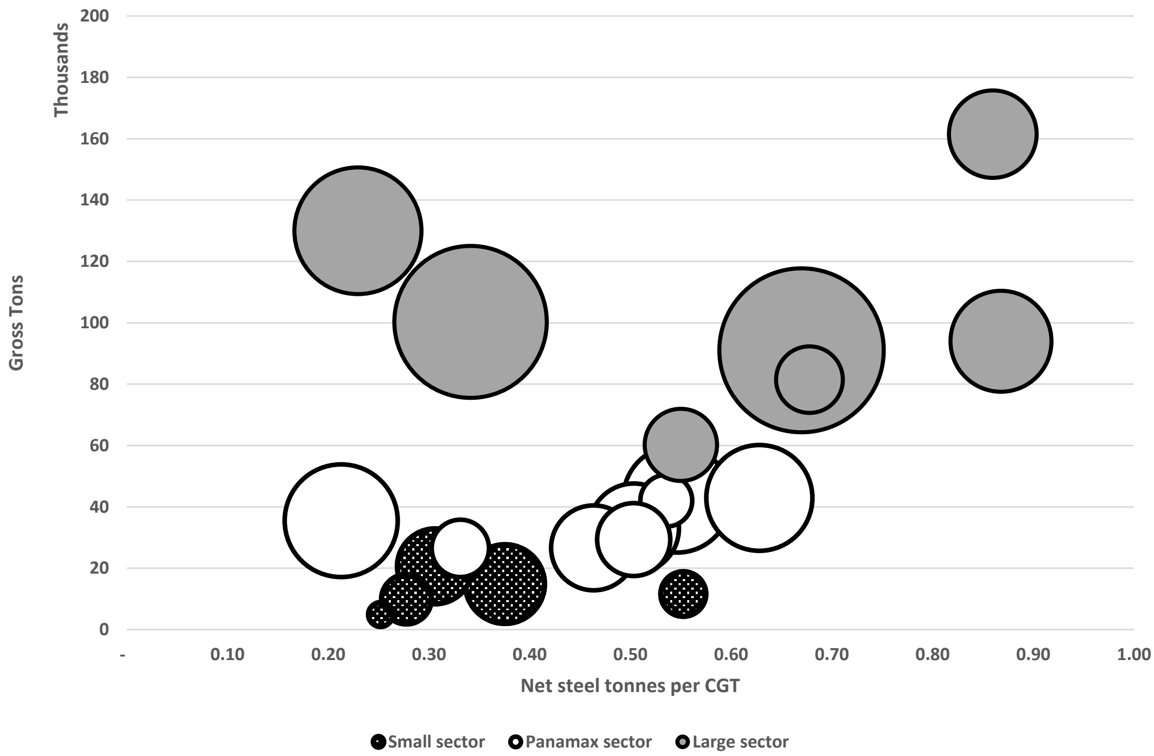


Figure 6.19 – Identification of technical substitutability in all sectors

A small number of significant cross sector compatibilities are suggested by this chart:

- aframax tankers show a close proximity to panamax vessels (dry bulk, tanker and container);
- roro cargo shows a close proximity to the smaller handy size dry cargo and container sectors.
- Small tankers and ferries have few close technical substitutes.

Steelwork density for volume products reduces with ship size. Average values are 0.73 tonnes per CGT for large ships, 0.53 for panamax and 0.35 for small ships. This may be expected due to reducing scantlings.

These charts summarise why, for example, from a technical sense a suezmax tanker may be ‘like’ a post-panamax container vessel, despite the radically different nature of the products from the viewpoint of the ship operator. It also summarises, importantly, why, for example, a small bulk carrier is technically ‘not like’ a capesize bulk carrier, despite their apparent similarity, and why a cruise ship is not like a VLCC or a large container ship and a shift of product mix from one to the other would constitute a diversification for a shipbuilder. It is important to understand that this does not mean to say that a volume shipbuilder could not physically build a cruise ship. What it does mean is that competitively it is likely to find this difficult. The cruise ship does not key into the factors of competitiveness for the VLCC builder.

It should be remembered that these technical characteristics alone may or may not define ‘like product’ but should be reviewed along with attributes of consumers’ tastes and habits that may transcend the cells identified in this matrix. The examples presented in Section 6.2.3 relating to Japanese ships or German container ships may in some circumstances be regarded as more significant than the attributes of competitiveness presented in the matrix.

6.2.5 Flexibility of product mix

To evaluate the extent of flexibility of shipyard capacity between products and size sectors, all vessels built in the five years between 2008 and 2012 have been examined to look at shipyard product mixes.

Only one shipyard sector showed exclusivity to a single ship type and that was cruise ship builders. Cruise ships were built in 8 shipyards, all in Europe. 98% of the work undertaken by these shipyards was for cruise vessels and the other 2% was for occasional ferry work. Other general capacity did not compete successfully for work in this sector and it is regarded therefore as different to any other sector. Cruise ships are ‘not like’ any of the other products examined apart from ferries. Ferries are competed for, however, by general shipbuilding capacity that is engaged in building other ship types. The LNG sector is also different by virtue of the barriers to entry and thereby builders are restricted in number, but LNG tankers are mixed with other ship types as part of product mixes and are not built in dedicated shipyards. For those that can build LNG tankers, therefore, they are ‘like’ other products because they are competed for within the structure of product mix.

The following analysis therefore considers all products excluding only cruise ships. The analysis is undertaken separately for the three size categories: large, panamax and small, as described above. Table 6.12 presents a summary of the statistics relating to the shipyards operating in each sector.

		Large	Panamax	Small
Number of shipyards		88	161	221
Output per year in CGT	Average	321,784	67,615	13,818
	Max	2,994,151	1,410,928	131,733
	Min	3,780	2,629	2,275
Market share (by CGT)	Average	1.1%	0.6%	0.5%
	Max	10.6%	13.0%	4.3%
	Min	0.01%	0.02%	0.1%
Output per year in number of ships	Average	11.5	4.2	1.3
	Max	81.4	69.0	8.4
	Min	0.4	0.4	0.4
Number of product sectors competed	Average	3.9	2.4	1.5
	Max	13	9	5
	Min	1	1	1
Number of shipyards with single product range		5	48	137
Proportion of shipyards with single product range		6%	30%	62%

Table 6.12 – Analysis of shipyards and product mix size per sector

The following conclusions are drawn from this table:

- The output per shipyard in terms of both CGT and number of ships increases as the size category increases.
- The number of product sectors making up the product mix reduces as size category increases.

* The potential to focus on a single product increases as the size category reduces.

Whilst the focus on a single product in the small sector is shown to be significant, the low level of output of only 1.3 ships per year per shipyard on average is also significant. The number of products produced over the 5 years examined is only 6.5 ships, compared to 21 ships on average in the panamax sector and 57.5 ships in the large sector. The significance of focus on a single product in the small sector is therefore regarded as misleading over the longer term. Shipyards in the small ship sector that managed to maintain output on a single product basis over these five years are likely to have to find alternative products to react to market shifts at some point when demand shifts.

Histograms of the number of products offered by each size category are presented in Figure 6.20.

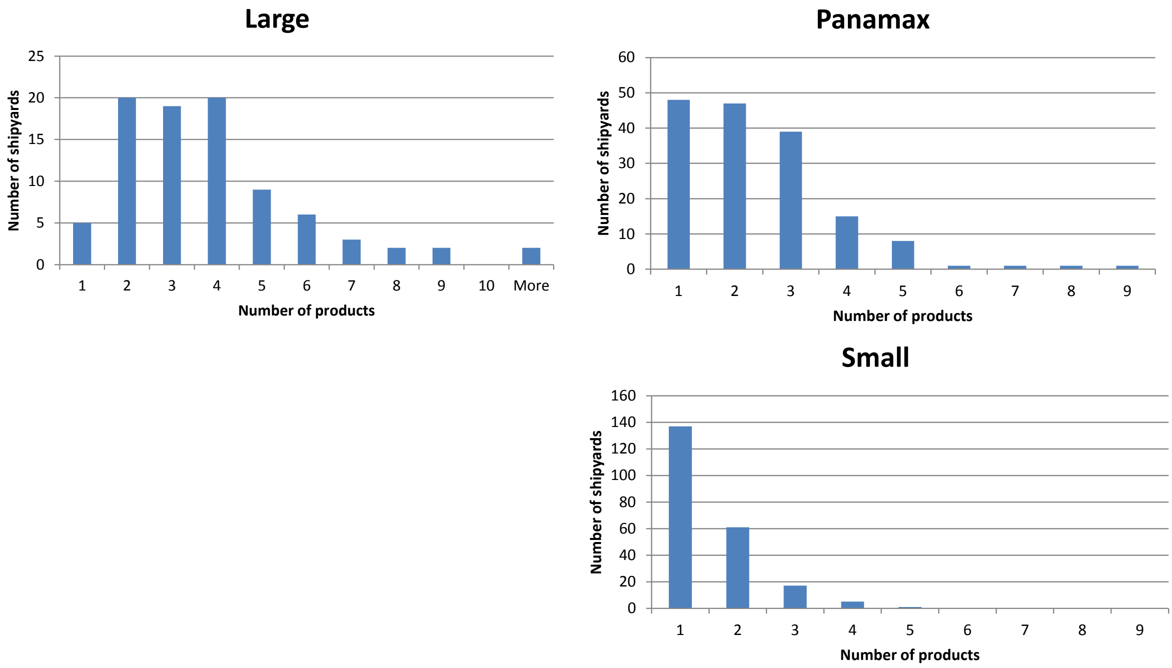


Figure 6.20 – Distribution of number of products offered by size class

The spread of the distributions clearly reduces as the size class reduces and the opportunity to offer a single product increases as size class reduces. Generally speaking, therefore, the larger the shipyard the larger the product range offered. Within each size class, however, only the large class shows a correlation between number of ships built and number of products offered. The relationship between the two factors is shown in Figure 6.21.

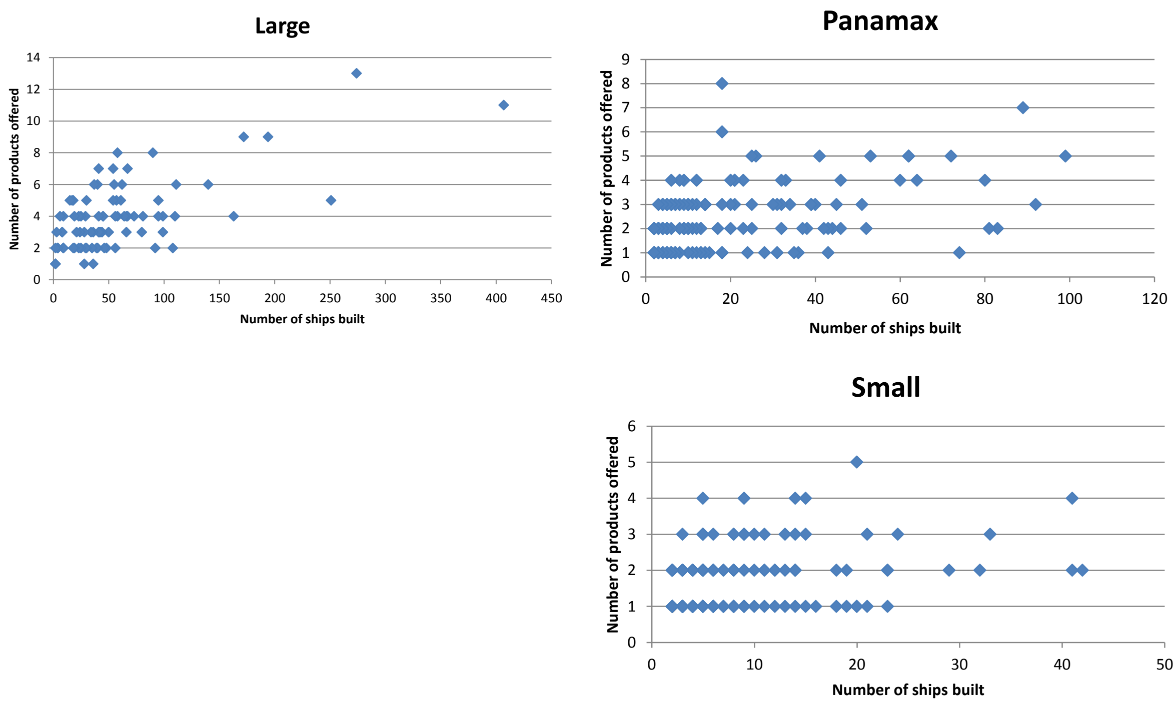


Figure 6.21 – Number of ships built and number of products offered per size class

In the large class there is some relationship seen in this figure and the two largest shipyards, HHI and DSME, have to have particularly wide product ranges in order to achieve the market share needed for viable capacity utilisation. In general in the large size class those shipyards delivering over 30 ships per year, that is to say over 150 ships in total in the graph shown above, required a product range of 9 or more ship types to achieve the throughput needed. The exception to this is the third largest shipyard, Samsung, which achieved its throughput across only five product types, container, VLCC and tanker, but with Samsung building a small number of ferries also. Daewoo also built a small number of ferries whilst HHI did not participate in that market sector in the five years examined.

It can be deduced from the above that the potential flexibility between products for which a unit of capacity can compete is wide. The width includes variations by vessel type and also by size. Figure 6.22 presents an analysis of the product mixes for shipyards operating in the large ship sector.

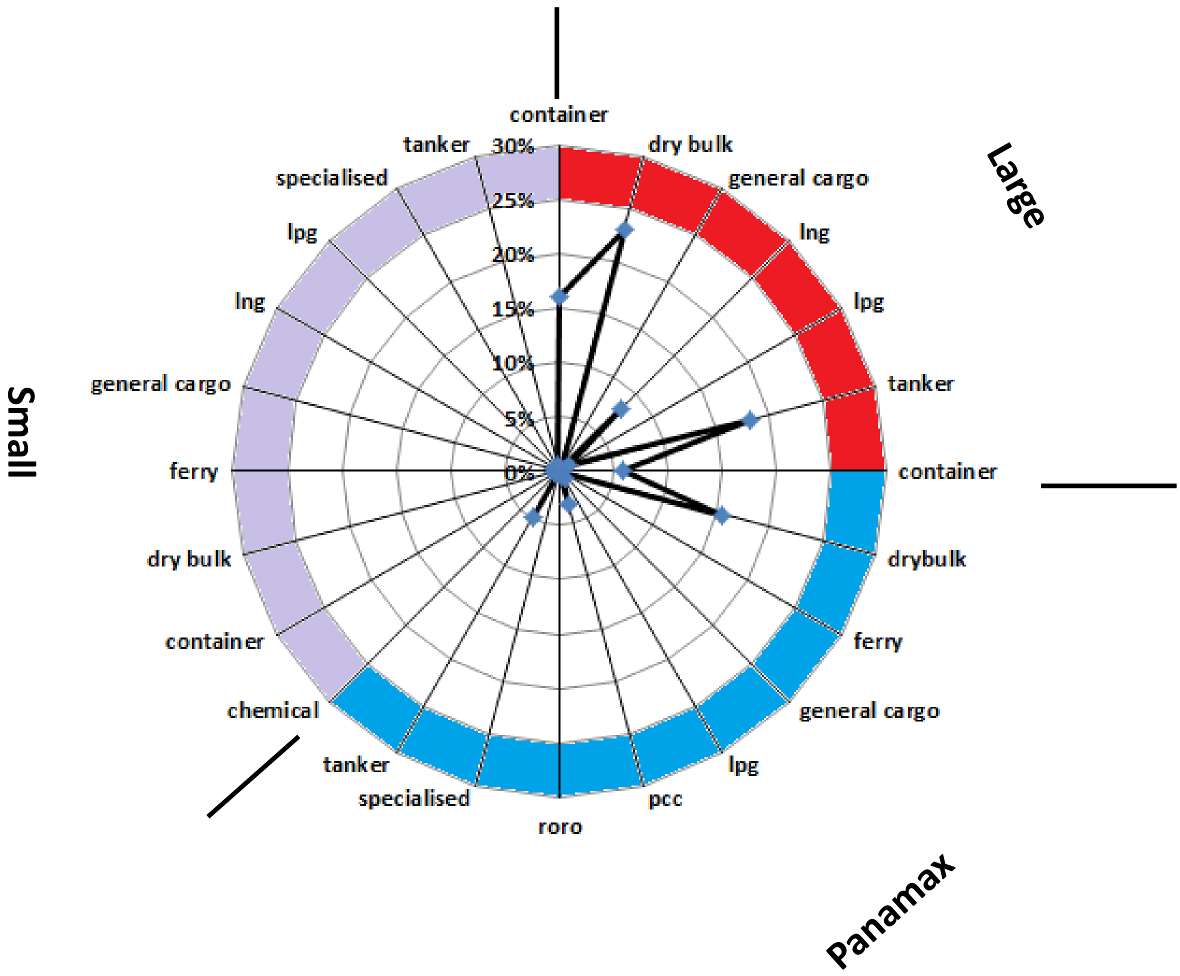


Figure 6.22 – Share of CGT per product built 2008 to 2012 for shipyards building large vessels

It can be seen that whilst the majority of work is in the large ship type sector, in particular container, dry bulk, LNG and tanker, significant share is also taken from the panamax sector, in particular panamax container, panamax dry bulk, pure car carrier (PCC) and panamax tanker. To compete for sufficient throughput it is concluded that large shipyards have to be flexible by size and will 'trade down' to find work where necessary. Trading down in this way clearly provides a potential mechanism for cross price behaviour between the size categories as well as within the product sectors. Some small and specialised vessels were also found in this largest size category, in particular ferries and other specialised niche sectors, although this is at its most significant for yards with low throughput, building one or two vessels per year.

A similar pattern, including trading down, is seen in the panamax size sector, with shipyards competing for smaller vessels to maximise throughput. The product mix is shown in Figure 6.23.

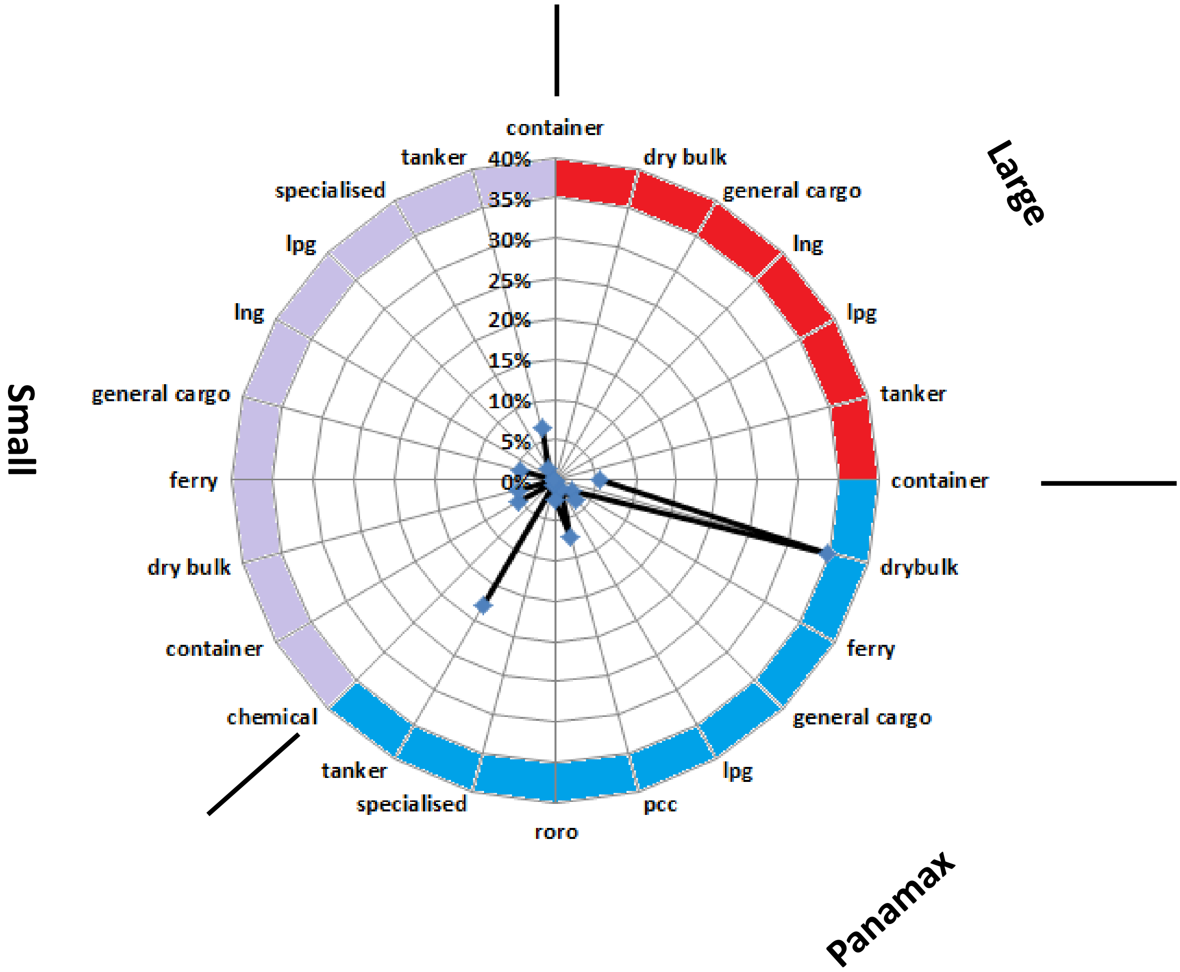


Figure 6.23 – Share of CGT per product built 2008 to 2012 for shipyards building panamax vessels

The sector is dominated by dry bulk (including both panamax and handymax (supramax) vessels), with significant contributions from container, panamax (including handymax) tankers and from pure car carriers. The smaller classes of container, tanker and bulk carrier are also of significance to panamax shipyards along with general cargo ships, again indicating trading down.

The pattern of product mix in the small shipyard sector is shown in Figure 6. 24.

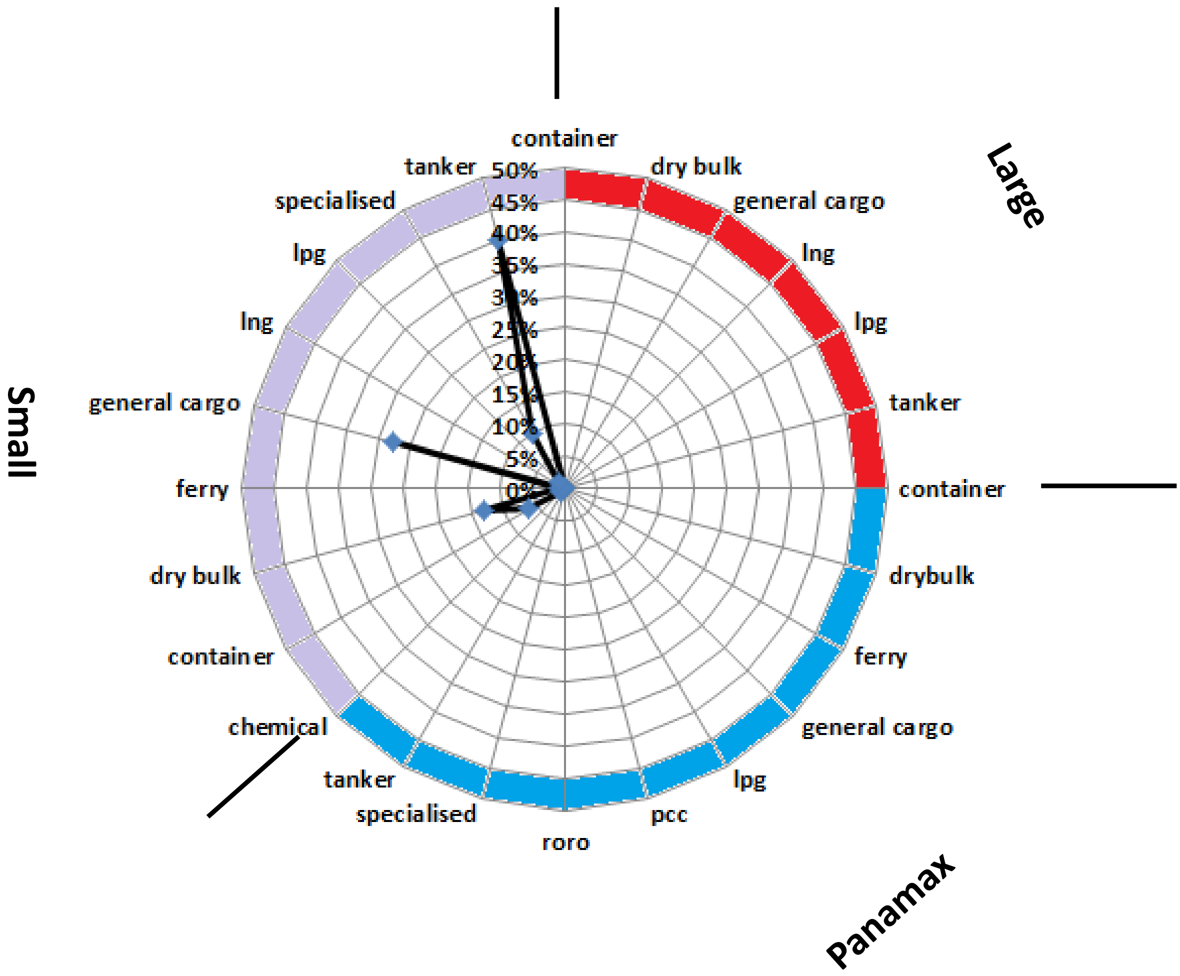


Figure 6.24 – Share of CGT per product built 2008 to 2012 for shipyards building small vessels

The small shipyard sector clearly cannot ‘trade down’ into a smaller sector within the context of this analysis, although could potentially take work from the smaller market sectors not included within the scope of this study, providing a potential link for cross price elasticity between the three shipbuilding markets (including additionally small ship and workboat) that have been identified.

Based on this analysis it is possible to state that the ‘accordion of likeness’ for commercial shipbuilders is wide, with the exception of the cruise ship sector. Shipyards clearly cannot build vessels that are too large for the launching facility but it has been shown that to gain sufficient market share to utilise capacity, shipyards will compete for smaller vessels and for specialist and niche sectors when the opportunity arises. In terms of the attributes of the product, therefore, these are of little significance to a shipbuilder with the exception of cruise ships and LNG, for which barriers to entry exist. Vessel size is of greater significance and shipbuilders are likely to target the largest vessels that the yard can construct to maximise throughput but targeting smaller vessels also where the opportunity to utilise capacity arises. Factors of the product that would seem to determine 'likeness', for example between cruise and ferry sectors, are not as significant as might be intuitively supposed. In terms of competition for capacity utilisation, ferries have more in common with volume shipbuilders than with cruise ship builders.

6.2.6 Flexibility between niche and volume ship types

The factors of competitive advantage outlined earlier suggest that it may be difficult for niche shipbuilders to compete for volume ship types because of the limited potential for a niche builder to obtain economies of scale in the supply chain due to low volumes. Conversely, volume shipbuilders may have difficulty in competing for niche sector orders if the build does not key into the factors of competitive advantage for the yard, in particular the control of the makers list, and volume ordering of materials. Analysis of the output of shipyards in the period 2008 to 2012, however, reveals significant building across the two sectors.

Overall, 73% of shipyards reporting deliveries between 2008 and 2012 concentrated in the volume sectors only, 25% built both volume and niche ship types and only 10% built in the niche sector only.   The statistics vary depending on the size of the shipyard, however, as analysed in Table 6.13.

	Large	Panamax	Small
Number of yards operating	88	161	221
Number participating in volume	88 (100%)	147 (91%)	187 (85%)
of which 100% volume	68 (77%)	119 (74%)	156 (71%)
Number participating in niche	20 (23%)	34 (21%)	62 (28%)
of which 100% niche	0	13 (8%)	34 (15%)

Table 6.13 – Number of shipyards delivering ships between 2008 and 2012 by size class

The presence of shipyards concentrating only on the niche sectors increases as size reduces but the number that concentrate solely on volume sectors and the number participating in both is similar for each of the size classes. Shipyards operating solely in the niche sectors tend to have low output but shipyards competing for both niche and volume products tend to be larger than the average in the sector, as shown in Table 6.14.

	Large	Panamax	Small
Average output all shipyards	11.5	4.2	1.3
Average output for shipyards operating 100% in the volume sector	9.9	3.7	1.4
Average output for shipyards delivering combined volume and niche vessels	16.8	7.6	1.6
Average output for shipyards operating 100% in the niche sector	NA	1.0	0.7

Table 6.14 – Average annual output per shipyard, number of ships, for ships delivered 2008 to 2012

From this analysis it is concluded that the ability to compete in both volume and niche sectors is dependent on the order and the specifics of the shipyard and that in general it is not possible to conclude that niche and volume ship types are 'not like'. In fact the data suggests that there is an imperative for large shipyards to compete for as wide a range of products as possible to provide sufficient work to occupy capacity.

6.3 Conclusions for Hypothesis H2: Like products exist in the commercial shipbuilding market

'Likeness' in this context has to be judged from the point of view of the shipbuilder and, from this point of view, differences in end use in the shipping industry are of no relevance. Likeness is concerned with attributes that determine whether or not a unit of capacity can competitively bid to attract a particular product. This means that 'likeness' is determined to some degree by whether or not a product keys in to the factors of competitive advantage inherent in a particular shipyard.

Technical substitutability is limited in terms of guidance of likeness because, at least within size classes, substitutability is high for the main products. From this viewpoint likeness is shown to be wide, with few exceptions: primarily cruise and LNG, both of which have barriers to entry. Likeness is not found to be limited by vessel size, function or market size or depending on the availability of quasi-standard products.

As well as technical substitutability and factors of competitiveness, the element of ‘consumers’ tastes and habits’ may also be relevant in specific circumstances. Examples of strong preferences for nationality of build, between established customers and shipyards or by virtue of government schemes such as the German KG scheme.

As is accepted in the interpretation of like product in WTO case law, there is no absolute definition of likeness that can be applied to commercial shipbuilding. The determinants of likeness are linked to the nature of investment in the shipyard, its personnel and their skills and training, the characteristics of the product and aspects of customer consumers’ tastes and habits. The analysis demonstrates that the ‘*accordion of likeness’* in commercial shipbuilding is very wide, ultimately restricted only for cruise ships and with a limited influence from barriers to entry, for LNG ships in particular, and from consumers’ tastes and habits.

It is true to say that at the peak of output between 2008 and 2012, the majority of shipyards competed within their own size category (small, panamax or large) but with trading down where this was deemed to be advantageous by the shipyard. It may be possible to argue that ships built in this way are to some degree ‘less like’ ships from the appropriate size category, but it cannot be argued that they are not like. This aspect of trading down provides a mechanism for price effects between the three size categories as well as within the categories.

7. H3 – Cross price elasticity exists between like products in the commercial shipbuilding market

7.1 R6 – How is price determined in commercial shipbuilding?

The following review looks at prior research into newbuilding price, including references to the existence of market price, determinants of price and prior suggestions of cross price behaviour between products in commercial shipbuilding.

Cross price behaviour in the shipbuilding market was noted, without naming it as such, almost 100 years ago. Shipbuilder Maxwell Ballard, in a paper presented to the North East Coast Institution of Engineers and Shipbuilders in 1921, produced a set of curves of newbuilding price for six different ship types and noted *"a marked consistency of movement"*, not only between the different ship types but also between newbuilding prices and freight rates (Ballard, 1921). Ballard also noted as strange that high peak prices in 1900 and 1912 were of a similar magnitude and had not reduced as expected due to improving technology and lower shipbuilding costs: *"It might have been expected that, by virtue of the saving in weight of the material used, the increasing production, more scientific construction and economical machinery, an appreciable difference would have been observable"* (*ibid*.). Maxwell mistakenly, however, concluded that the failure of peak price levels to fall was due to increasing labour cost: "*Labour is ultimately receiving a greater proportion nowadays than ever, which is actually the case"*. This was despite noting in the very next paragraph of the paper that: *"A comparison of these price fluctuations with those of the freights shows a marked consistency in movement"*. What Ballard was commenting on, which clearly came as unexpected for a shipbuilder 100 years ago, was that newbuilding prices are determined not only by shipbuilders' costs but also by what the customer is willing to pay for the ship, which in turn is determined by their predicted earnings from freight. It is not only costs and the state of the shipping market that determine price, however. For example, in a low market the price may be determined by the lowest cost producer that has acceptable available capacity, or by a higher cost competitor with sufficient subsidy to undercut a lower cost supplier. The determinants of price are therefore predicted to vary at different stages of the cycle. Ballard drew this conclusion in his paper, despite the 'red herring' of labour costs: *"Prices of cargo tramps are governed in times of good trade mainly by freight* *levels…In periods of depression, however, prices would seem to be more a matter of the state of the yards”*.

Wijnolst and Wergeland in 1996 further discussed the correlation of prices between sectors and noted: “*Newbuilding prices are not necessarily linked to actual shipbuilding costs for the yards. The prices of newbuildings are determined by the forces of supply and demand*” (Wijnolst and Wergeland, 1996, p. 282). Haddal and Knudsen, quoted by Wijnolst and Wergeland in the same source, repeated the analysis that Ballard had undertaken and noted a strong correlation between prices for 12 different ship types between 1970 and 1994, strongly suggesting cross price behaviour between products in commercial shipbuilding: *“...prices are quite closely correlated to those of other segments…All correlations are above 0.70, so the general conclusion must be that newbuilding prices are affected by the same market forces over time*” (Wijnolst and Wergeland, 1996, p. 184). The authors use this to demonstrate that commercial shipbuilding products are competed within a single market.

Concurrence of pricing between products in commercial shipbuilding and the relationship between newbuild price and the shipping market has therefore long been known. Acknowledgement of cross price mechanisms in price modelling has been rare, but the use of freight rates and, in particular, time charter rates, has been more or less common in econometric analysis of prices in shipbuilding. Inclusion of shipyard cost as a determinant has been more problematic, because of the difficulty of finding an adequate proxy. Identification of an adequate proxy for shipyard capacity has also proven to be difficult.

Zannetos in 1966 discussed the relationships between freight rates and demand for new ships. He also, to some degree, addressed price, although the analysis of price in his work is limited. One of his main problems was the lack of data that characterised maritime economics at that time: *“To give operational content to the theoretical relationships governing orders for new vessels, we need to have, among other data, monthly time series of shipbuilding costs. The latter type of information is not available both because it is often considered proprietary and because transactions for tankship building do not occur continuously*” (Zannetos, 1966, p. 82). He also came up against the problem that the variety of products at the time was too great to allow practical analysis even within a single ship sector, tankers in the case of Zannetos. Notwithstanding, some important principles were established in this work. Zannetos argued that demand for new ships is a function of "*freight rates and shipbuilding costs*" (*ibid*., p. 51) and that *"The movement in short-term rates can explain 86.5% of all changes in shipbuilding cost"* (*ibid*., p. 83). There is some confusion in this work in that the words 'cost' and 'price' appear at times to be used interchangeably. Zannetos's conclusions indicated freight earnings as the dominating factor determining price in shipbuilding and this has informed much research on the subject since. Note also, however, that the influence of shipbuilding costs (used in the correct sense) is implicit in Zannetos's work and is important in determining price as discussed below. Zannetos argued that government intervention would not have any appreciable effect on the demand for new ships: *"any legislative effect on orders, however important it may be for the domestic industry, is not expected to affect the world total in any significant manner"* (Zannetos, 1966, p. 76), but made no comment on the potential effect of subsidy on market price. Price was stated to be part of an economic system that included also freight rates and demand for new ships, which suggests that Zannetos accepted implicitly the concept of a shipbuilding market with a market price, even though the market was difficult to define due to product variety. Zannetos also noted problems with his model that still recur in the modelling of newbuilding prices, that is to say that prices do not correlate with demand as would be expected. Later research phrased this as: prices show *"a weak dependence with respect to demand for new vessels" (Dikos, 2004)*. Dikos pursued this theme with the question *"why do new building prices appear sub-optimal?"*. A number of reasons were postulated, generally referring to externalities such as subsidy or the strength of labour unions.

Strandenes makes it clear that the principal underlying factor impinging on a buyer's decision to orders new ships is their view of freight rates: *"A decision to order a vessel should reflect the expected future freight rates or correspondingly the future income level over the economic life of the new vessel"* (Strandenes, 2002, p. 189). That freight rates can quickly reach high and occasionally irrational levels due to inherent inelasticity in the shipping markets was much discussed by Zannetos (Zannetos, 1966) and this is reflected in Strandenes' use of the conditional *"should"* in this quotation. Inexperienced investors for example, and in particular speculators, may be overly swayed by current conditions in the freight markets, leading to over-ordering that periodically characterises shipbuilding. This is also reflected in Strandenes' earlier work on pricing and demand in the bulk sectors where she discusses agents behaviour as *"semi-rational"* (Strandenes, 1984), that is to say partially based on analysis of future expectations. Strandenes established that *"Demand for new vessels is a function of expected earnings relative to the newbuilding price...Supply of newbuilding capacity on the other hand is a function of the cost of building the vessel in relation to the price obtained. The newbuilding cost is influenced by the available berth capacity and thus by contracting of other types of vessels"* (Strandenes, 1986). The work referenced in this case relates to the bulk ship sectors, but clearly acknowledges the influence of other ship types on the demand and price mechanisms: *"The shipbuilding industry produces different types of vessels. The capacity available at the beginning of each period is the maximum capacity less the capacity needed to build the tonnage already on order."* (Strandenes, 1986).

The high importance of freight rates as a determining factor for newbuilding price had been firmly established and further research suggested that the economic mechanism centred around demand, and, by extension, capacity utilisation in the shipbuilding industry. Charemza and Gronicki, for example, in econometric modelling of the relationship between the shipping and shipbuilding industries noted that: *"ship prices… are positively correlated with the supply of orders for new tonnage"* (Charemza and Gronicki, 1981), linking price to capacity utilisation. Many researchers refer to shipbuilding costs additionally and further research has also touched on the variation of price determination at different stages of the market. Jiang et al, for example, include a dummy variable *"to control for different conditions in the newbuilding market"* in their modelling of shipbuilders' profit (Jiang *et al.*, 2013). Haralambides et al noted that: "*The price of a ship, like that of every other capital asset, depends on the ship's expected future profitability or, in other words, on the investor's expectations regarding future developments in the markets he* [sic] *operates. Prices, particularly those of second hand ships, thus correlate strongly with freight rates and, together with them, fluctuate widely"* (Haralambides *et al.*, 2005, p. 65). The authors distinguish the behaviour of newbuilding prices from second hand, however, by noting that, in addition to market expectations, the price of a new ship also has to take into account shipbuilding costs and shipbuilding capacity: *"In the face of a burgeoning demand and tight shipyard capacity, second-hand ships would thus sell at a premium* [compared to the newbuilding price for the same ship]. *On the contrary, in a depressed and over-supplied market, second-hand ship prices would tend to converge to the ships' scrap values while newbuilding prices could still keep close to shipbuilding costs"* (*ibid*., p. 66). This conclusion echoes what Ballard had noticed 80 years earlier, suggesting that the determinants of newbuilding price vary depending on the state of the market. It is interesting also that the authors also note the potential for cross price behaviour as a conclusion from their modelling: *"New contract prices for dry bulk carriers may therefore be driven by the demand and price of alternative vessels like tankers"* (*ibid.,* p. 97).

Haralambides *et al* provide a succinct literature review of the econometric modelling of newbuilding and second-hand price, which reveals some surprising and counter-intuitive results that the authors found difficult to explain. The modelling approaches reported by Haralambides *et al* tend to include "*contradictory results"* (Haralambides *et al.*, 2005). A good example is the reporting of the results of Beenstock (1985) where it was observed that "*second hand prices are flexible whereas newbuilding prices are relatively sticky, implying that newbuilding prices adjust to second hand prices over time"*, or in other words the dependency between demand and newbuilding price was found to be weaker than expected. Beenstock's paper is based on an asset pricing approach from the perspective of the buyer and nowhere in the model are shipbuilding costs discussed, except indirectly with a very brief mention that government subsidy to shipbuilding may affect the supply of ships.

Haralambides *et al* reject Beenstock's explanation of this behaviour (Haralambides *et al.*, 2005), which was postulated by Beenstock to be related to newbuilding prices adjusting over time to the second-hand price, but no alternative explanation is proposed. The *"sticky"* nature of newbuilding prices is also discussed by Dikos, where he states: *"newbuilding prices appear far less volatile than time charter rates or oil prices and furthermore, it seems that they adjust really slowly"* (Dikos, 2004), referring to this as a *"paradox"* in economic terms. One possible explanation for this paradox lies in the selection of the parameter used to determine demand and its balance with capacity, which is discussed later in this section. The observation may also be viewed in light of the likely behaviour of shipbuilders depending on the state of the market. In a rising market a shipbuilder would be expected to increase prices as fast as they are able, acting on the profit maximisation basis, with prices determined on the basis of expectations of future earnings, or what Strandenes refers to as a *“rational and semi-rational basis”* (Strandenes, 2002, p. 199), as well as the shipbuilder’s cost and competitive position. Conversely, in a falling market shipbuilders are likely to try to preserve prices for as long as possible, only reducing prices offered to buyers when they are in need of orders, which in turn is dependent on the length of the shipyard’s backlog. At the recent peak of the market in 2008, for example, the backlog in global shipbuilding, estimated by dividing the total orderbook in CGT by the prevailing annual delivery rate in CGT[13], was 4.7 years. With a forward orderbook of this length shipbuilders will be slow to reduce offer prices, not being in any immediate need of new business, and this may help to explain why, in a falling market, newbuilding prices are found to be ‘sticky’, not falling as expected when demand falls. Backlog is psychologically very important for shipbuilders as it measures when the shipyard is likely to run out of work if no further orders are won. A shipbuilder that takes typically nine months to build a ship, for example, will become desperate for work if the backlog falls below that nine month threshold – in effect the shipyard would be working on its last order in that situation. The difficulties of managing a shipyard in this situation are well recognised in the industry, using the term “*last ship syndrome”* (Henderson and Game, 2013). The most difficult issues are that a workforce that believes itself to be working towards redundancy will be reluctant to finish the last order, and the most able workers will find alternative employment and leave. *In extremis*, last orders may never be completed unless towed to another shipyard for finishing. If the backlog falls below the penultimate-order point, that is to say 18 months in the example cited above, the requirement to win new orders is likely to become pressing and shipbuilders will be highly motivated to reduce offered prices.

Dikos argues that prices should be determined with respect to “*construction costs, but also with respect to the demand, and uncertainty in demand, for new vessels and the market prevailing conditions*” (Dikos, 2004). Uncertainty for the shipbuilder will take into account expectations of forward earnings in shipping and the effect of this on future demand, as it does for the buyer, but for the shipbuilder uncertainty is likely

[13] Calculated as the total of deliveries in CGT over the previous 12 months.

to be modified by backlog that will moderate the uncertainty stemming from the shipping market and its prospects. In other words, even if freight rates fall the shipbuilder is likely to take comfort from a confirmed orderbook containing several years' worth of work. From another viewpoint, backlog for the ship owner is equivalent to delivery period and this will form an element in the consideration of risk, along with the forward view of potential earnings. Backlog is therefore an important determinant of price that impinges on risk for both seller and buyer. Another way of looking at this would be to say that backlog provides a measure of scarcity of capacity for the buyer and scarcity of orders for the builder.

Haralambides *et al*'s modelling of newbuilding price reveals some interesting conclusions:

- "*Overall, shipbuilding costs were found to have the most significant and extensive effect on the determination of newbuilding prices for all ship types*" (Haralambides et al., 2005, p. 96)[14].
- "*New contract prices for dry bulk carriers may therefore be driven by the demand and price of alternative vessels like tankers*" (ibid., p. 97). Note that this directly suggests the presence of cross price behaviour in prior theoretical modelling of newbuilding price.
- *"Timecharter rates were found to be statistically significant in the determination of newbuilding prices in* [certain ship types but less so in others]*"* (*ibid*.). The authors explain this by referring to timing of orders but it is generally not adequately explained by the model. The lower significance of freight earnings in the determination of newbuilding price in this model might be explained by the presence of cross price behaviour, with price better determined with reference to overall capacity utilisation rather than in relation to a single ship type and its earning potential.

A number of inconsistencies were noted in the outputs from the model created by these authors, in particular ambiguity over the effect of exchange rates on price and the inconsistency of freight earnings as a determinant of price in different ship types. This ambiguity and inconsistency may possibly be explained by a variation in

[14] Note that this is the opposite conclusion to that reached by Zannetos who found that 86.5% of price was determined by freight rates.

determinants between different market conditions. In market conditions where shipbuilding costs may be relatively more important (compared to other determinants) in influencing price it would be expected that exchange rate fluctuations would show some effect on prices. In market conditions where buyers' expectations of earnings are relatively more important the opposite effect would be expected.

Jiang and Lauridsen provide a further comprehensive literature review of research to determine shipbuilding price, along with modelling of newbuild prices in Chinese shipyards (Jiang and Lauridsen, 2012). Contrary to Haralambides *et al*'s conclusion that shipbuilding costs predominate in importance over freight earnings in determining price, in modelling the formation of prices of dry bulk carriers in the Chinese shipbuilding industry, Jiang and Lauridsen conclude: *"the time charter rate has the most significant positive impact on shipbuilding price; increases in three other factors, namely the cost of shipbuilding, the price-cost margin and the shipbuilding capacity utilisation, have positive influences in the descending order" .* Jiang and Lauridsen note the influencing factors on the price of a ship as: *"national industrial policy, the shipyard cost of production, currency fluctuation, ship design and payment options".* Significant conclusions from this modelling include:

- "*shipbuilding and shipping markets are tightly connected";*
- *"shipbuilding cost index...is found to be the second most important factor";*
- *"capacity utilisation is found to have a significant, but the smallest, effect*". Capacity utilisation in this instance was estimated as output in China compared to an estimate of the industry's total capacity.

This last conclusion may be caveated with the observation that capacity utilisation had remained high over the period evaluated by the authors, with limited variation. It also addressed capacity utilisation in China only, not taking into account utilisation in competitor industries, which may be expected to be competing in the same market. The data period examined by the authors was 1995 to 2009, which corresponded both to a period of extended and almost unbroken growth in demand and also the establishment of the modernised and expanded Chinese industry. The conclusions are therefore based on a specific set of market circumstances and evaluation of data using this model outside these boundaries may confirm the variation of determinants depending on market conditions and could explain the difference in conclusions compared to other researchers. The authors also conclude that *"What is also implied from the model is that international competition in the shipbuilding industry is more closely tied to the dry bulk carrier prices than shipbuilding capacity utilisation"*. This provides further theoretical evidence for the expectation of cross price behaviour in the market, although again was linked to a very specific market construct.

Further suggestion of the existence of cross price behaviour between substitute products can be found in Papapostolou *et al*, who consider the effect of sentiment in the second hand values in the dry bulk shipping markets and conclude that sentiment '*leaks*' across boundaries between ship types (Papapostolou *et al.*, 2013). The authors conclude that "*The fact that market sentiment contains significant information for future vessel price returns and cycle phases implies the existence of possible cross section sentiment contagion in the dry bulk shipping market*". The authors also conclude that: "*On the whole, synchronization statistics point toward market integration and herd-like behaviour, where the market sentiment may play a major role compared to the sector-specific sentim*ent". The authors also show that sentiment and herd behaviour act between fleet sectors, not just within sectors, although they consider only the different sectors of the dry bulk fleet in this analysis. They also consider second hand prices, rather than new. The question remains, therefore, as to whether this behaviour stretches across sectors and how much it might apply to newbuilding prices, which are not considered specifically by the authors.

Based on the above review it is concluded that the determinants of newbuilding price vary in importance over time, the most important determinants being (in random order) shipbuilding costs, shipping market expectations of earnings, demand and shipbuilding capacity. Based on these determinants, Jiang and Lauridsen usefully summarise prior approaches to newbuilding price research as having been predominantly in two camps: models based on supply and demand theory and models based on an asset pricing approach (Jiang and Lauridsen, 2012). This could be elaborated, bearing in mind that a shipbuilding contract requires both a buyer and a seller and the motivations of both are unlikely to be the same. For the buyer, the decision to purchase a new ship is likely to be taken on the basis of an asset pricing approach, taking into account the expected future value of the vessel in relation to the price to be paid and the delivery period. For the seller, the decision to accept an order for a new ship is likely to be taken on a profit maximisation basis, assuming no ulterior strategic motive, in relation to the building cost and the backlog. The negotiation of price between the two parties will be undertaken within a supply and demand framework, most often with the assistance of a sale and purchase broker, whose motivation is also profit maximisation for the ship broking firm. The determinants are summarised in the following table, indicating the significance to buyer (ship owner) and seller (shipyard) in a newbuilding contract.

Determinant	Significance to the ship owner	Significance to the shipbuilder
Freight earnings	Forward view of freight rates determines the rational value of the vessel to the buyer	
Backlog (capacity utilisation)	Contributes to risk, determining the delivery date for the new vessel and provides a measure of scarcity of capacity	Contributes to risk, determining the extent of forward work and how important the sale is to the shipyard and provides a measure of scarcity of orders
Shipbuilders' cost		Determines the minimum price without incurring loss or requiring subsidy

Table 7.1 – Summary of the principal determinants of newbuilding price

The economics of the supply and demand system within which price is determined are described succinctly by Stopford (2009, pp. 628-638). Shipbuilding prices are set by the interaction between supply (capacity), demand and cost. The theoretical supply function may be described in the form of a series of steps ordered by cost of production. The theory is that there are few differentiators between suppliers and that shipbuilding contracts will be placed with the lowest cost acceptable supplier that has available capacity. As demand increases the identity of the lowest cost available supplier moves up the stepped function up to the point that all acceptable capacity is full, at which point the supply curve becomes near vertical and *"there is an auction for any remaining berths that the yards have held back in the hope of such a situation arising"* (Stopford, 2009, p. 633) and prices become very high. With falling demand the price descends back down the stepped function, leaving higher cost producers unable to cover the cost of building the ship without subsidy.

Stopford's supply and demand curves are shown in Figure 7.1.

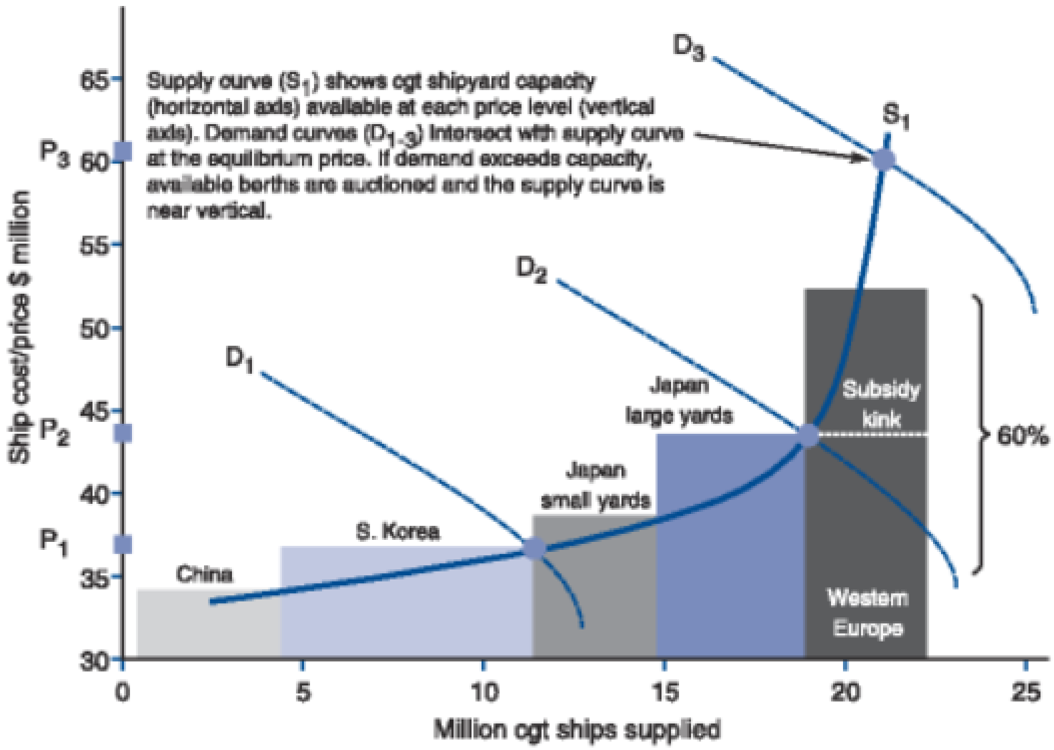


Figure 7.1 – Short run bulk shipbuilding demand and supply functions (Stopford, 2009, p. 633)

A similar form can be found also in Jiang et al (Jiang *et al.*, 2013). The basis of the EU's complaint can be seen in the supply and demand functions. In essence the EU argued that subsidization in South Korea caused a vertical shift in the supply curve in the downwards direction, or what Stopford in the diagram above refers to as the '*subsidy kink'*. In this diagram Stopford refers to subsidies in Western Europe, which was appropriate when the diagram was drawn. EU's argument in *Korea – commercial vessels* was in essence (although not specifically stated in these terms) that support to South Korean shipyards in the early 1990s had caused a significant shift in the supply function (a *subsidy* kink in Stopford's terms and *price suppression and price depression in WTO* terminology (World Trade Organization, 2005)) leading to lower prices in the market. The basis of this mechanism is important in considering cross price elasticity. In particular it should be noted that EU did not argue that alleged subsidy in South Korea led to any detrimental change in demand.

To address the Panel's ruling (*ibid.,* paragraph 7.556 p.128) the analysis must show that products under contention are part of the same market in the context of the supply and demand system. In other words it is required to show that changes in demand for one product may lead to changes in price for a different product that is part of the same market and it is this causation that the EU failed to demonstrate.

7.2 R7 – Can cross price elasticity be demonstrated for 'like products'?

7.2.1 The concept of cross price elasticity

Elasticity is the economic concept that measures how demand, supply and price respond to changes in the economic system: *"it is not enough to know whether quantity rises or falls in response to some change. It is important to know by how much"* (Lipsey and Chrystal, 2007, p. 64). It may be viewed as a sensitivity factor in the determination of price by equilibrium of the supply and demand functions.

Price elasticity of demand is a common way of viewing this concept in economics, being a factor that determines the rate at which the demand for goods or services changes in response to a change in price. It may be defined as: *"a units-free measure of the responsiveness of the quantity demanded of a good to change in its price when all other influences on buying plans remain the same"* (Parkin, 2014, p. 84). It may be calculated as follows:

$$Price\ elasticity\ of\ demand = \frac{\substack{Percentage\ change \\ in\ quantity\ demanded}}{Percentage\ change\ in\ price}$$

Cross price elasticity of demand is a factor that determines the rate at which the demand for goods or services changes in response to a change in price for a substitute good or service. It may be defined as: "*a measure of the responsiveness* *of the demand for a good to a change in the price of a substitute or complement, other things remaining the same"* (*ibid*., p. 92). It may be calculated as follows:

$$Cross\ price\ elasticity\ of\ demand = \frac{\begin{array}{c}Percentage\ change\\ in\ quantity\ demanded\end{array}}{\begin{array}{c}Percentage\ change\ in\ price\ of\\ a\ substitute\ or\ complement\end{array}}$$

Lancaster and Massingham summarise the significance of cross elasticity of demand as: *"a measure for interpreting the relationship between products. It measures the percentage change in the quantity demanded of a product to a percentage change in the price of another product"* (Lancaster and Massingham, 2011, p. 168).

Cross price elasticity of demand of this form is commonly taught in economic text books but cross price elasticity in general can refer to any changes in the factors in the supply and demand system (Lipsey and Chrystal, 2007, p. 79). This is significant in the context of the methodology discussed below. The fundamental requirement is to demonstrate that different products are part of the *'same market'* by showing elasticity of price of one product with demand for another, as discussed in the context of the supply and demand system above. Further comments are made on this context in the methodology discussion below.

7.2.2 Methodology and data

7.2.2.1 Overview

Two statistical techniques have been used to demonstrate the existence of cross price elasticity in commercial shipbuilding:

1. Correlation: provides empirical evidence of the link between prices in the market, demonstrating the potential for price suppression as argued by EU in *Korea - commercial vessels.* This was the methodology used by Wijnolst and Wergerland to demonstrate that a single market exists in commercial shipbuilding, concluding that different commercial shipbuilding products are part of a single market (the *'same market'* in WTO terminology) (Wijnolst and Wergeland, 1996). The method also provides empirical evidence for cross price relationships by reviewing correlations between demand and price. Correlation is further used as part of data examination, in particular in

reviewing the potential for multicollinearity in the subsequent regression analyses.

2. Linear regression has been used to identify the existence and relative strengths of elasticities in statistically valid relationships between demand for one product and price of another.

Prices and demands for the following products are examined:

Sector	Products evaluated
Large ships	VLCC tanker Suezmax tanker Aframax tanker Capesize dry bulk LNG tanker Post-panamax container ship
Panamax	Panamax dry bulk carrier Panamax container ship Panamax tanker Handymax dry bulk carrier Handymax tanker Sub-panamax container ship Roro
Small ships	Feeder container ship Handysize dry bulk Handysize tanker Small feeder container ship

Table 7.2 – Products examined for evidence of cross price elasticity

These products are chosen because coherent time series' of demand, price and earnings are available for them and they map onto the products used to identify technical substitutability in Section 6. Further information on the detailed definition of the products and how they map to the data source can be found in Section 1 of the data annex accompanying this dissertation. All data is sourced from Clarksons Shipping Information Network, with access dates as specified in the data annex.

In all cases statistical analysis has been done using IBM SPSS.

7.2.2.2 Correlation methodology

Data (described in Sections 2 and 3 of the data annex) are not normally distributed and a non-parametric method has therefore been chosen, using the Spearman-Rho correlation coefficient (Field, 2009, p. 179). Correlation between prices and demand for different products is examined, both within each sector and then between sectors.

7.2.2.3 Linear regression methodology

Two potential mechanisms could be postulated for cross price elasticity of demand in shipbuilding, in the common sense of the use of that term in economics, as follows. Either:

1. Change in price of one product may change the demand for another that is a substitute from the point of view of the buyer. This at first glance appears unlikely to be the case in general because products in commercial shipbuilding are not substitutable, at least not fully substitutable, from the point of view of the buyer. A bulk carrier operator engaged in coal transport, for example, is unlikely to consider the purchase of a tanker as a substitute for a dry bulk vessel in the case that the bulk carrier price increases. Having said that, a bulk carrier operator may consider diversification into another fleet sector if it were to present better economic prospects, so this mechanism may exist on that basis.
2. Demand for one product may be suppressed at specific times if price is increased by virtue of increased prices of other products, which are substitutable from the point of view of the seller, and that are competing for the same units of capacity. Correlation matrices (described later) show in the majority of cases a positive relationship between demand for one product and price of another, which would support the existence of this mechanism.

It has not been possible to demonstrate cross price elasticity of demand in this form, however, using linear regression. The most significant problem is the difficulty of constructing demand forecasts, for which accuracy is difficult to achieve for reasons discussed below – certainly the level of accuracy that would be needed to detect suppression of demand for a specific product in a time series.

A common method of demand forecasting is described by Stopford (Stopford, 2009, p. 636) and involves not only forecasting of economic demand for a particular ship type but also analysis of economic and technical obsolescence in the fleet. Stopford summarises this method as: *“expansion demand, which is the tonnage of new ships needed to carry trade growth in a given period, and replacement demand, which is the tonnage of new ships required to replace ships scrapped or removed from the fleet in the same period”*. The level of uncertainty in prediction of the wide range of variables in this method is such that precision in the forecast may be relatively low. As Stopford states: *“the model is simple in principle but complex in practise”* (*ibid*., p. 637). To demonstrate the difficulties inherent in this process, two forecasts from credible representative industry bodies from the 1990s, using this forecasting method, have been examined to see how well they predicted the development of peak demand between 1995 and 2006: AWES[15] (The Association of West European Shipbuilders, 1993) and the SAJ (The Shipbuilders Association of Japan, 1993). The forecast period corresponded roughly to the period of the time series used for linear regression analysis in this dissertation. AWES undertook a forecast in CGT for all ship types and sizes, including fishing vessels, whilst SAJ forecasted only the main ocean-going cargo carrying fleet sectors in dwt. Both forecasts correctly predicted the development of significantly increased output that was experienced over this period but AWES underestimated total demand for this ten years by 31% and SAJ by 94%. This is not to say that these were poor quality or un-credible forecasts but that the extent of uncertainty in the variables used to estimate newbuilding output is such that precision of forecast magnitude may be low. Even the short term predictions of these forecasts had low precision in terms of volume ordered. AWES’ prediction for the period 1991 to 1995 (bearing in mind that these forecasts were published in 1993) over-estimated output by 43% and for the period 1993 to 1995 SAJ’s forecast under-estimated demand by 86%. Whilst these forecasts could be regarded as ‘historical’ in nature they are cited because they correctly forecasted the most significant upturn in demand in thirty years, but without precision as to the magnitude and timing of this upturn. The difficulty lies not in the technicalities of the statistical techniques used but in the problem of accurately forecasting the wide range of inputs needed, including economic growth, trade

[15] The forerunner of the Community of European Shipyards’ Associations (CESA).

growth, scrapping age, fleet productivity and other factors. An example of the difficulties is seen in an echo from the work of Einarsen in 1938, discussed in Section 2.1.2, where he refers to elasticities in ultimate age leading to complexities in the working of the phenomenon of reinvestment, which in practical terms leads to uncertainty in decisions relating to key model inputs.

Notwithstanding the difficulties an attempt was made to look at short term forecasts of demand using the following economic relationship alone:

$$C_{i,t} = f\{E_{i,t}, B_{i,t}, P_{i,t}, P_{k,t}\} + \varepsilon_{it}$$

Where:

- $C_{i,t}$ is the demand (contracting) for vessel type *i* at time *t;*
- $E_{i,y}$ is the proxy for earnings (normally 3-year time charter rate) for vessel type *i* at time *t;*
- $B_{i,t}$ is the proxy for backlog in years for vessel type *i* at time *t;*
- $P_{i,t}$ is the price for vessel type *i* at time *t;*
- $P_{k,t}$ is the price for substitutable vessel types *k* at time *t*, for $k = 1 \dots \dots n$.
- ε_i is the residual error for the prediction of price for vessel *i* at time *t.*

The specific proxies are discussed in more detail below. The variables were found to be significantly poor predictors of demand and could not be used for linear regression analysis in the context of this relationship. This does not mean to say that the mechanism for cross price elasticity listed above does not exist in commercial shipbuilding, but that it cannot be demonstrated over the time period chosen, with the data used and using linear regression. Attempts to narrow the time period to look more narrowly for this were not successful.

Cross price elasticity in this form has therefore not been established. It should be noted, however, that this mechanism does not represent the causation of '*serious prejudice'* as argued by EU. EU did not argue that demand for products for which they were competing was affected by the action of South Korea but that prices were suppressed – the *"subsidy kink"* as discussed above in the context of the supply and demand functions. The panel in its ruling said that the requirement for EU was specifically to: *"Demonstrate such a causal relationship between the subsidy or* *subsidies in question, on the one hand, and movement in the prices of the product of concern to the complaining Member in the relevant market, on the other hand"* (World Trade Organization, 2005, p. 127 para. 7.557). The requirement is to show that price suppression may exist because the products cited in a dispute are part of *"the same market"* (*ibid.,* p. 128 para. 7.5.6.1). Arguments in the panel ruling consider the geographic boundaries of market sectors (*ibid.,* para. 7.5.6.4), with South Korea arguing that a single "*world market"* does not exist and different commercial shipbuilding products do not exist within the same market. It is necessary to consider the same market in its economic context, however, rather than geographically or by considering the end use of the product. The same market would therefore be demonstrated to exist by a relationship between price and demand for different products. This does not require that cross price elasticity of demand is shown in the form discussed above, but does require that cross elasticities between price and demand for different products be identified, taking the wider view of cross price elasticity in the context of the supply and demand system.

An alternative approach, which is consistent with the arguments put to the panel, was therefore adopted to look at cross price and demand relationships between products. The relationship examined is as follows:

$$P_{i,t} = f\{E_{i,y}, C_{i,t}, D_{i,t}, D_{k,t}\} + \varepsilon_{it}$$

Where:

- $P_{i,t}$ is the price for vessel type *i* at time *t;*
- $E_{i,y}$ is the proxy for earnings (normally 3-year time charter rate) for vessel type *i* at time *t;*
- $C_{i,t}$ is the proxy for build cost (steel price being used) for vessel type *i* at time *t;*
- $D_{i,t}$ is the Demand (total orderbook in CGT) for vessel type *i* at time *t;*
- $D_{k,t}$ is the Demand (total orderbook in CGT) for substitutable vessel types *k*, for $k = 1 \dots\dots n$.
- ε_i is the residual error for the prediction of price for vessel *i* at time *t.*

In this case the determinants were found to be strong predictors of price and using this expression it is possible to identify whether the price of one product was affected by demand for other products, in support of the EU's price suppression claim. Both contracting and total orderbook were tried as proxies for demand and orderbook was found to be the significantly stronger predictor. This may be expected as the total orderbook represents a measure of occupation of capacity, although without including a term for capacity itself.

Natural logarithms of the variables were used in the regressions (i.e. log-log regression is used) because *"parameters in linear structural models with variables in logarithms can be interpreted as elasticities"* (Haralambides *et al.*, 2005, p. 83; Benoit K., 2011), and it is the identification of elasticities between demand for one product and price of another that identifies the existence of the cross price relationship. This methodology has been used in published work to evaluate cross price elasticities in a wide range of situations (Cotterill and Samson, 2002; Alves and De Losso da Silveira Bueno, 2003; West and Williams Iii, 2007; Sanders *et al.*, 2008).

An iterative approach was used to identify elasticities between demand for one product and price of another as follows:

1. An initial regression is run including demand for the ship type itself only, that is to say modelling the above expression but excluding variable $D_{k,t}$:
2. Demand for potential substitutes ($D_{k,t}$) are then introduced individually into the model and the effects on the regression and assumptions noted.
3. Substitutes are accepted on the following basis:
   - The RSquare value is improved by the addition of the substitute product's demand:
   - The distribution of the residuals does not deteriorate (i.e. away from normality) by the addition of the substitute product's demand:
   - The introduced determinant has a significant role in the improvement, judged by the coefficients and their significance;
   - Regression assumptions are not violated. In particular that un-acceptable multicollinearity is not introduced, the distribution of residuals is improved and ultimately not significantly different from the normal distribution (judged using

a histogram, normal probability plot and plot of residuals against predicted values and for all accepted substitutes confirmed by a Kolmogorov-Smirnoff test), t values for coefficients remain strong (preferably significant at the 1% level) and the Durbin-Watson Statistic is increased or remains the same .

4. Each potentially substitutable product is introduced in the model first and the strongest candidate for substitute is then accepted. The process is then repeated with each further potential substitute to identify whether more than one significant cross price elasticity can be identified.

The results identify substitutable products that can be demonstrated to be statistically significant in the determination of price for the products examined and for the data and time period adopted. These products demonstrate, in principle that elasticities between demand for one product and the price of another exist. It is important to understand, however, that the substitutes identified are not absolutes and may vary over time, depending on the products that are competing for the same units of capacity. The products identified are likely to be strong substitutes, because the analysis identifies the most significant substitutes over the full time period of over twelve years. Other time periods may identify different substitutes. The methodology can also only identify the strongest substitutes but others may exist. In particular, multicollinearity in demand data is likely to have precluded the identification of all substitutes using linear regression.

Multicollinearity was a specific problem encountered with the data but by keeping the VIF factor low, below 5 (Field, 2009, p. 224), the effects are minimised. A problem was also encountered with a persistently low Durbin-Watson statistic in all regressions analysed. This suggests a structural weakness in the model leading to auto-regression in the residuals, which would need to be analysed and corrected in any attempt to generalise the expression used. Analysis suggests that the expression consistently under-estimates at some times and over-estimates at others and it is possible that analysis restricted to specific market periods, for example splitting growth and decline, would reduce the problem. The sample size (n = 147), however, in relation to the number of variables, meant that it was not possible to do this in the context of linear regression analysis, even though very specific periods relating to different stages of the cycle (growth, decline and trough) can be easily identified in the data. The result is that the substitutes identified can only be viewed as existing for this data and in this time period and cannot be extrapolated outside that framework. Such extrapolation is not necessary for this methodology, however, and the low Durbin-Watson statistic has therefore been accepted at face value. The intent here is to demonstrate that cross price elasticity exists, not to develop a generalised model to predict price.

7.2.2.4 Data and proxies

Data is taken from Clarksons Shipping Information Network for the period January 2003 to March 2015. The reasons for choosing this time period are:

1. This period represents an approximation of a cycle, as demonstrated by the following graphs showing Clarkson's newbuilding price index and total orderbook:

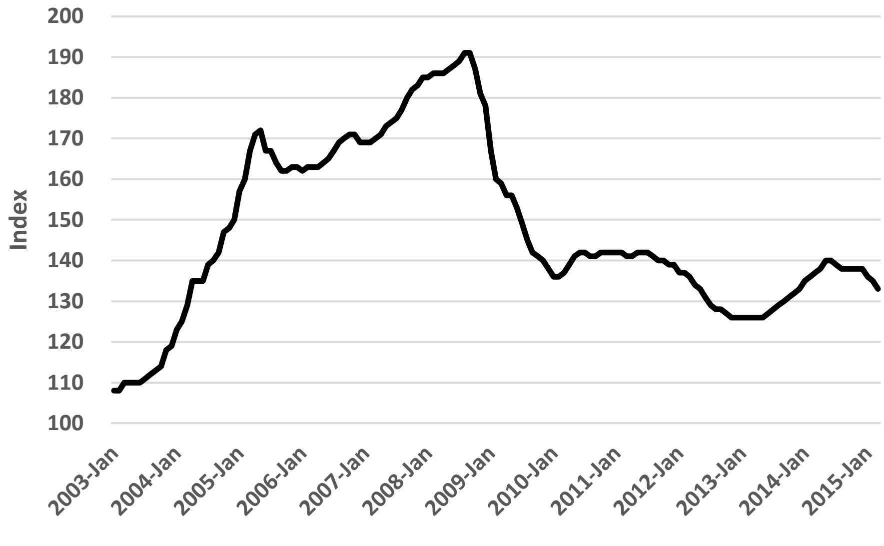


Figure 7.2 – Clarkson Newbuilding Price Index

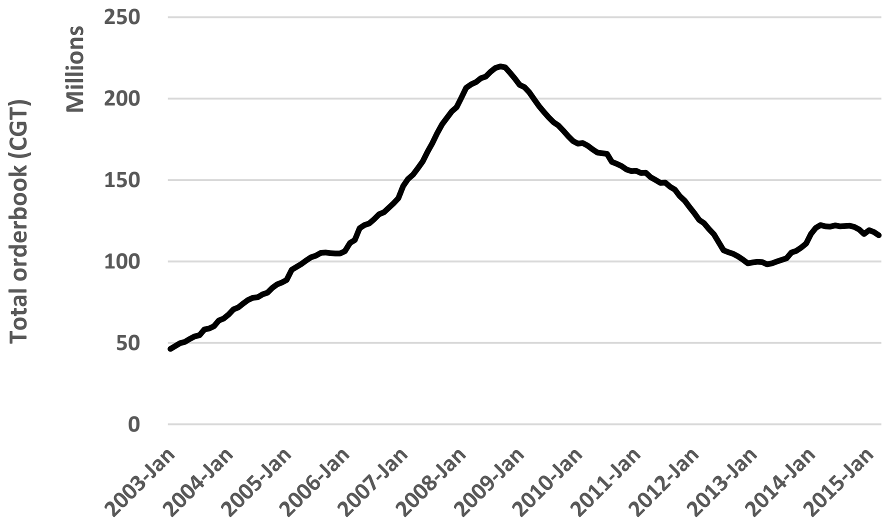


Figure 7.3 – Total Orderbook (CGT)

Four specific coherent periods can be seen in the price figure:

- Very strong growth (Jan 2003 to May 2005: n = 29)
- Growth (June 2005 to September 2008: n = 40)
- Collapse (October 2008 to February 2010: n = 16)
- Trough (March 2016 onwards: n = 62)

2. Data is monthly and the total number of data points in each data sample is therefore 147. This gives sufficient sample size for the number of variables examined in the regression, typically being 4 or 5.
3. For the period prior to January 2003 there is at least a strong suspicion (this was the period corresponding to the EU's WTO action) of subsidy affecting market prices. By choosing the period after that time the economic relationship is less likely to be clouded by that factor, for which a proxy is difficult to identify. Similarly, once the trough has become well established the presence of subsidy, or at least less rational pricing on the part of the shipbuilders, is more likely to appear and this period is, again, avoided.

Proxies used are as follows:

- $P_{i,t}$ is the price for vessel type *i* at time *t;* the proxy used is Clarkson's indication of expected price in a particular month. There is possibly some controversy in this value in that it is not based on actual contract values but on an expected value in any month, reflecting the view of brokers and current negotiations. Another way of expressing this would be to say that it is a ‘guide price’. The value has the advantage that an indication of price is available for all products in all months and this parameter is widely used in research. Any question relates to the meaning and significance of the value, given that it is ultimately an opinion. Future work may review the regressions based on actual contract prices, although these are difficult to obtain and often it is not possible to define precisely the basis of published prices. The availability and use of proxies of this type is discussed in Glen and Marlow (Glen and Marlow, 2009). Price data is summarised for the three fleet sectors in Section 2 of the data annex.

- $E_{i,y}$ is the proxy for earnings for vessel type *i* at time *t;* where 3-year time charter rates are available they are used. In a small number of cases where a specific rate for the product concerned is not available, the closest specific index for the rate is used. Lagging of this proxy was considered, specifically a 6 month lag to represent the period of negotiation of the order, but this was not found to improve the regression results and straightforward current earnings is used in the analysis.
- $C_{i,t}$ is the proxy for build cost for vessel type *i* at time *t*, with steel price being used. Steel price has been used by a number of researchers due to the difficulty of identifying any general proxy for this value. More recent research has developed indices of cost, but this again is specific to place and time and not general (Jiang and Strandenes, 2012; Jiang *et al.*, 2013). Information on cost breakdowns developed for EU, presented earlier in this dissertation, has a similar problem in terms of generality – the percentage breakdowns of cost refer specifically to South Korea and were correct in 2003. It has been possible, however, to construct a set of indices with the aim of validating, or otherwise, the use of steel price alone as the proxy. An index was developed, based on January 2003 = 100 and by varying the component proportions of cost by the following parameters:

Cost component	Average[16] proportion at January 2003	Variable used to adjust the component proportion
Steel	29%	World steel price (source: www.meps.org.uk)
Other Materials	40%	2/3 varied by Clarksons Newbuild Price Index, one third by South Korean Producer Price Index (source: www.oecd.com)[17].
Other direct costs	3%	South Korean Producer Price Index (source: www.oecd.com).
Labour	18%	
Overhead	10%	

Table 7.3 – Variation regime for South Korean newbuilding cost index

The resulting indices for each product are provided in Figure 7.4.

[16] Identified by weighting each specific model by proportion of output in the period 2003 to 2015

[17] These proportions are based on experience and reflect a broad assumption for typical proportions of materials for which the price is dependent on demand specifically in shipbuilding, for example main engines, deck equipment and bridge equipment, and non-ship-specific materials for which price varies with general industrial inflation, for example electrical cables, cable trays, light fittings, minor pumps and motors.

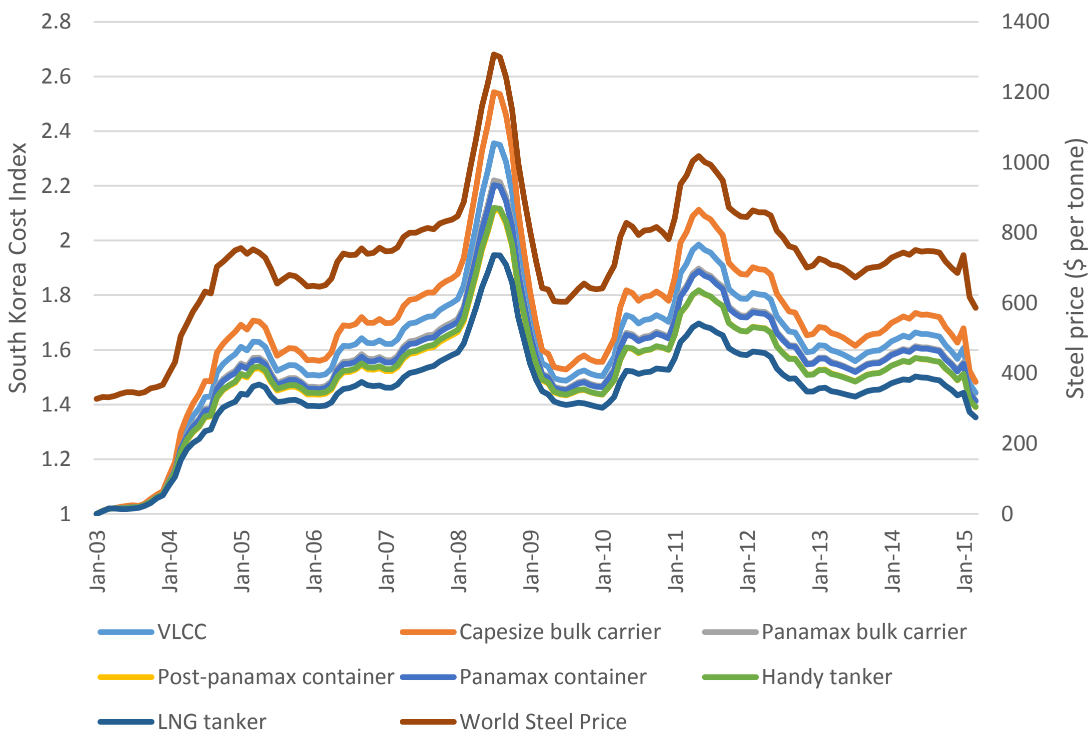


Figure 7.4 – South Korean Shipbuilding Cost Indices (LH Scale) and World Steel Price (RH Scale)

It can be seen that cost changes are heavily influenced by steel price, with the greatest movements seen in the more steel-dependent vessels, i.e. with capesize and VLCC showing the greatest change and LNG the least.

The aim of presenting this chart is not to review the details, however, but to show that cost increases are strongly correlated with steel price, as summarised in the following correlations between the individual product changes and the steel price change. This is presented to confirm that using steel price alone in modelling, at least in the context of this dissertation, is a valid proxy for shipbuilding costs and is used in the regression. Specifically the parameter is World Steel Price.

Correlation with:		Steel price
VLCC	Correlation Coefficient	.987**
	Sig. (2-tailed)	.000
	N	147
Capesize Dry Bulk	Correlation Coefficient	.992**
	Sig. (2-tailed)	.000
	N	147
Panamax Dry Bulk	Correlation Coefficient	.979**
	Sig. (2-tailed)	.000
	N	147
Post-panamax Container	Correlation Coefficient	.977**
	Sig. (2-tailed)	.000
	N	147
Panamax Container	Correlation Coefficient	.976**
	Sig. (2-tailed)	.000
	N	147
Handymax Tanker	Correlation Coefficient	.980**
	Sig. (2-tailed)	.000
	N	147
LNG Tanker	Correlation Coefficient	.968**
	Sig. (2-tailed)	.000
	N	147
Passenger / Vehicle Ferry	Correlation Coefficient	.925**
	Sig. (2-tailed)	.000
	N	147

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7.4 – Correlation between steel price and estimated South Korean product-specific price indices

- $D_{i,t}$ is the Demand (total orderbook in CGT) for vessel type *i* at time *t* and $D_{k,t}$ is the Demand (total orderbook in CGT) for substitutable vessel types *k*, for $k = 1 \ldots \ldots n$: data for these variables is straightforward with no proxy needed. Demand data is summarised in Section 3 of the data annex and a description is given below.

7.2.2.5 Summary of the characteristics of price and demand data

The price data time series' show the characteristics of the cycle over the data period, with the peak around 2008. Variability of price has been measured by coefficient of standard deviation, which is shown in Figure 7.5. It is noticeable that LNG price was significantly less variable than others over the period and that the greatest variability was for handymax, panamax and capesize dry bulk carriers.

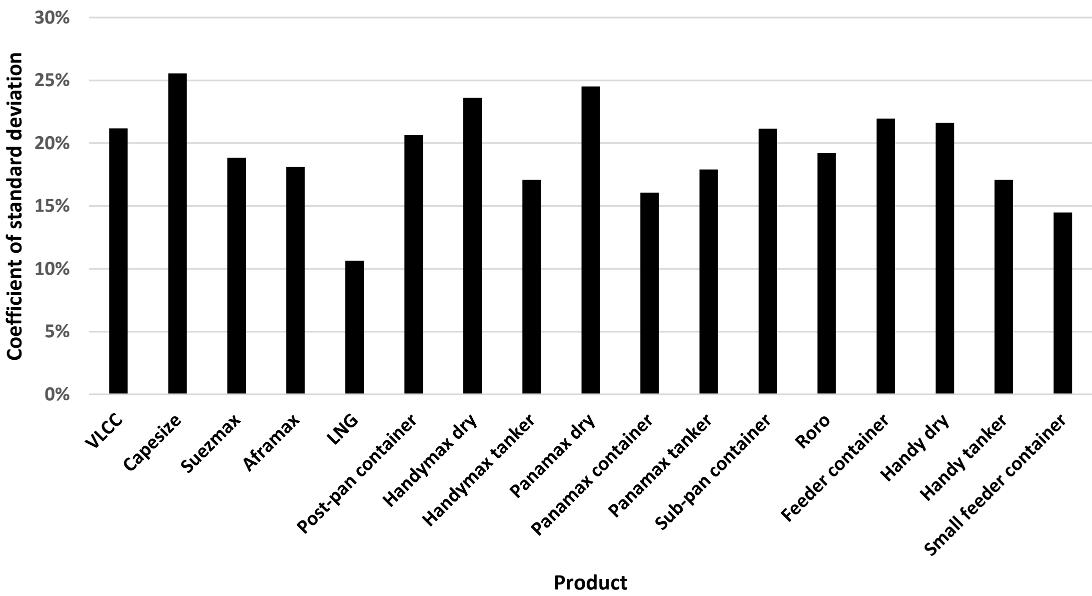


Figure 7.5 – Variability of price data

Demand data is also peaked over the cycle, with, again, the exception of LNG ships, which shows a significant recovery in demand at the end of the period that is not experienced by other sectors. Demand shows greater variability than price, as measured by coefficient of standard deviation and presented in Figure 7.6. Capesize dry bulk showed particularly high variability of demand, as did smaller container ships (sub-panamax and below).

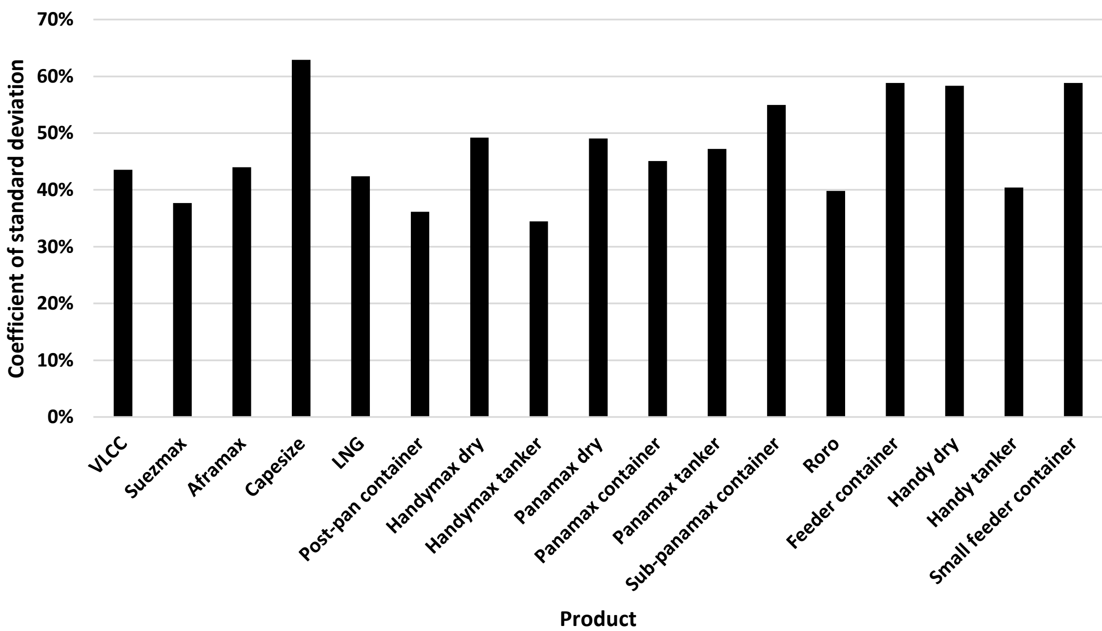


Figure 7.6 – Variability of demand data

As would be anticipated from previous comments on newbuilding price behaviour a high degree of positive correlation was found between prices. A lower but nonetheless significant correlation was also found between demands. Price correlations are summarised in Section 4 of the data annex and demand in Section 5.

For price, all correlations were found to be significant at the 1% level using the Spearman-Rho non-parametric statistic. Average correlations with all other sectors are summarised in Figure 7.7, showing that in all cases the correlation was between about 80% and 90%, except for Roro vessels for which the price correlation with other products was significantly lower. Apart from this exception, correlations were found to be consistently high across the three fleet sectors and between all products.

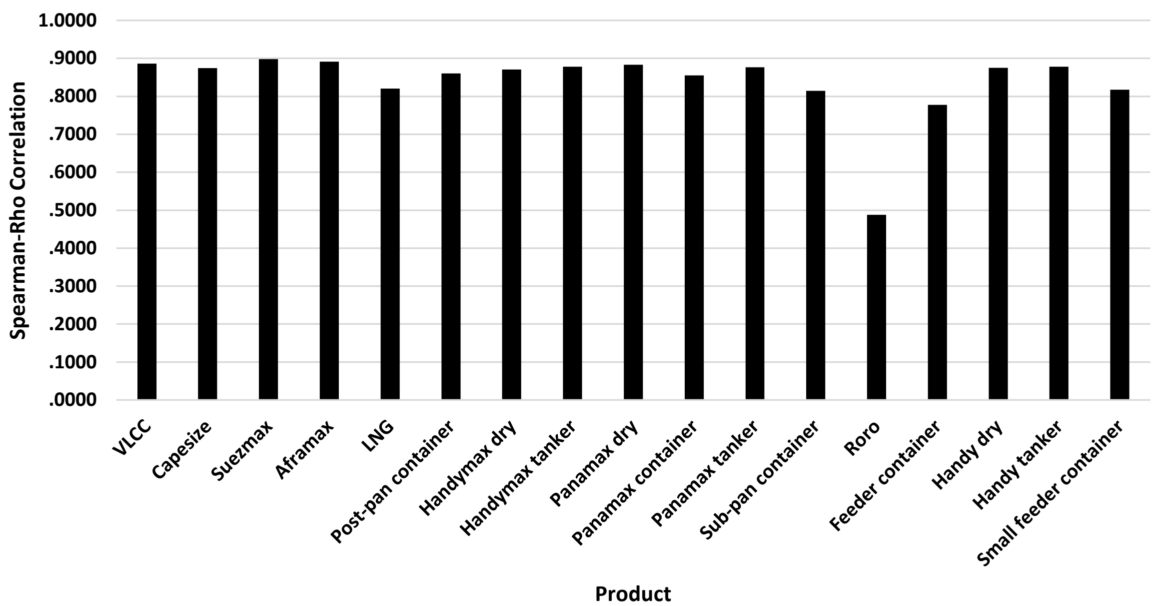


Figure 7.7 – Average Spearman-Rho price / price correlation (correlation with all other prices in all fleet sectors)

Correlations between demand data were mostly positive apart from the following cases, where negative correlations were found:

- between the orderbooks for LNG tankers and panamax and handymax dry bulk carriers;
- between sub-panamax container ships and capesize, handymax and panamax dry bulk carriers.

LNG and Panamax and Handymax dry bulk carriers were also the sectors that registered the fewest significant correlations with other sectors. These negative correlations provide some tentative evidence for the demand suppression mechanism discussed above: it is postulated that the demand for low value bulk carriers may be suppressed by demand for higher value vessels and this is recommended for further study. 100 out of 120 possible cross correlations (83.3%) were found to be significant. 94 of these were found to be significant at the 1% level and 6, all in the small ship sector, were found to be significant at the 5% level.

Correlations were mostly above 50% but with significantly lower seen for LNG tankers, panamax dry bulk carriers and sub-panamax container ships, as illustrated in Figure 7.8. Particularly strong correlations (around 70%) can be seen for VLCC demand and post-panamax container ship demand.

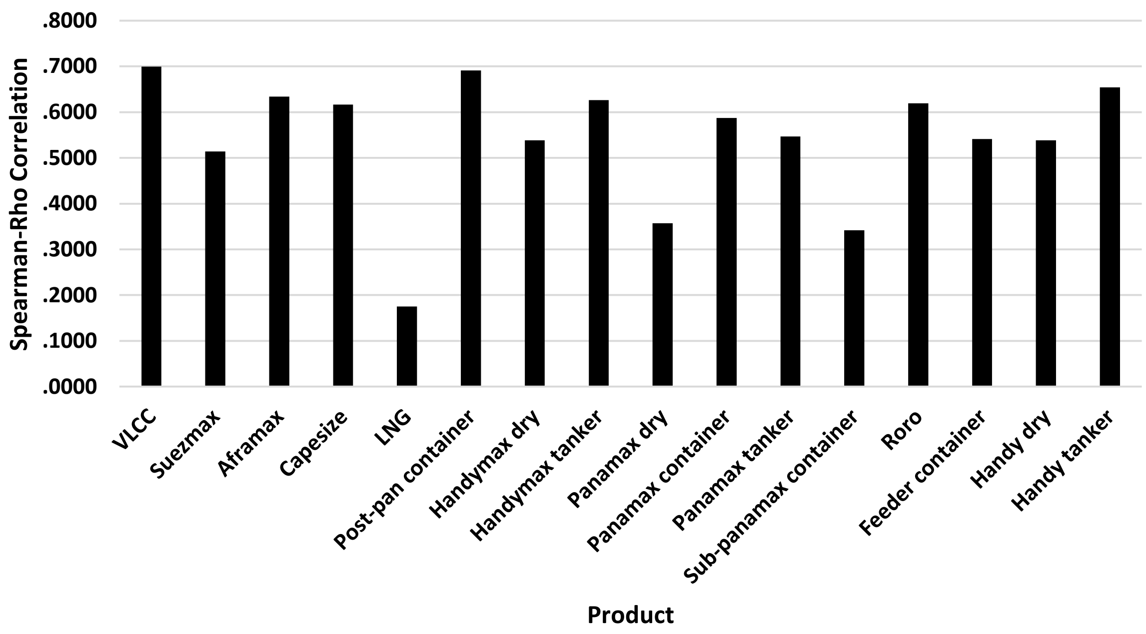


Figure 7.8 – Average Spearman-Rho demand / demand correlation (correlation with all other demand in all fleet sectors)

The relevance of these demand / demand correlations is that they may be expected to generate some degree of multicollinearity between determinants in the regression analysis.

7.2.3 Correlation results

7.2.3.1 Correlations of large sector ship prices with demand

A summary of correlations between prices of large ships and demand for products in the three fleet sectors is presented in Table 7.5.

		Demand																
		Large ship sector						Panamax Sector							Small Sector			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder Cont
Price	VLCC	.753	.558	.800	.523	.432	.743	.405	.855	.262	.805	.739	.600	.636	.754	.489	.875	.754
	Capesize	.644	.476	.879	.423	.454	.674	.282	.925		.819	.793	.722	.502	.823	.378	.926	.823
	Suezmax	.682	.461	.809	.446	.531	.700	.329	.885		.763	.754	.686	.528	.805	.405	.899	.805
	Aframax	.651	.462	.760	.440	.519	.682	.345	.841	.180	.736	.717	.645	.510	.754	.406	.853	.754
	LNG	.730	.485	.751	.506	.526	.745	.376	.836	.249	.736	.676	.565	.642	.727	.470	.852	.727
	PP Container	.516	.438	.840	.203	.436	.493		.800		.857	.884	.798	.313	.875		.801	.875

Table 7.5 – Significant Spearman-Rho non-parametric correlations for prices in the large ship sector with demand in all sectors

It is possible to get some gauge of relative strength of influence from this table. For example, the influence of demand for Post-Panamax container ships on price for VLCCs is stronger than the influence of VLCC demand on Post-Panamax container ship prices. These relative influences can only be considered in the context of the data set analysed, however: general trends cannot be extrapolated for other market periods. It is postulated also that the relative strengths of influence reflect the demographic of demand by ship type at any point in time, rather than technical differences between products – in other words, in different market conditions the relative influences may be found to be different.

The number and proportion of significant correlations in each sector are shown in the following table, along with mean correlations in each sector.

		Correlation of price with demand			
		Number of significant correlations	Potential total number of correlations	Proportion where correlation is significant	Mean correlation
Demand sector	Large	36	36	100%	.59
	Panamax	38	42	90%	.63
	Small	23	24	96%	.73
	Total	97	102	95%	.64

Table 7.6 – Number of significant correlations for large ship prices with demand in all sectors

The mean correlations are strong within the large ship sector and also between sectors. The mean correlations are summarised by ship type in Figure 7.9.

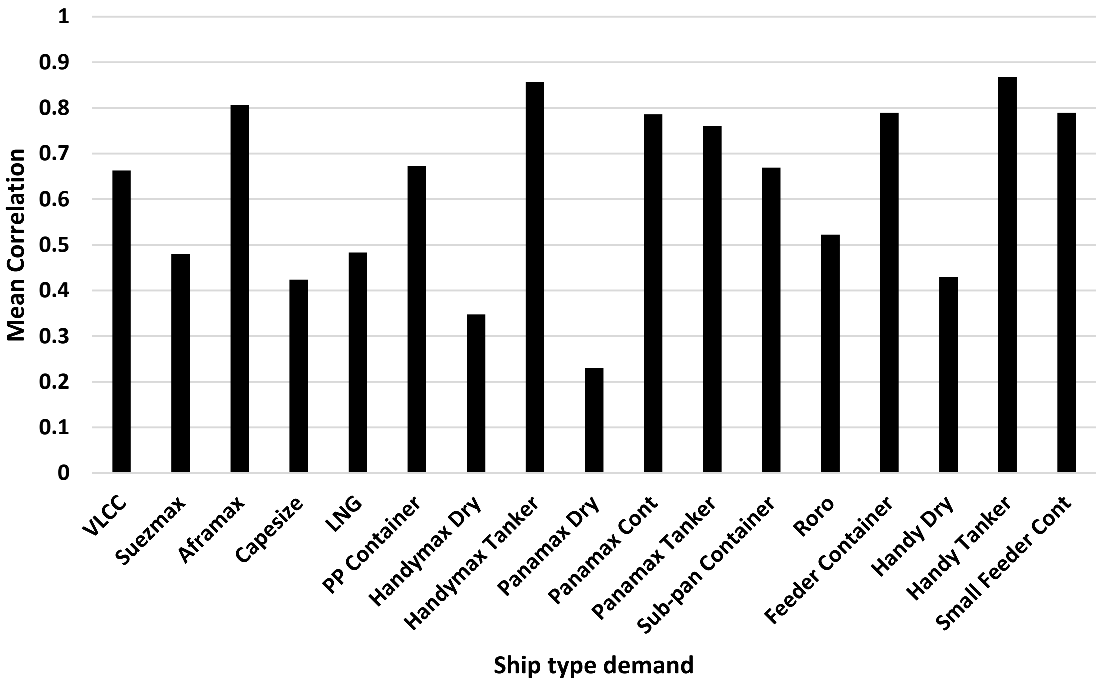


Figure 7.9 – Mean correlations of price in the large ship sector with demand for all ship types

The strength of mean correlations is summarised in Table 7.7.

Correlation of large vessel price with demand for:	
Very Strong (> .7)	Aframax Handymax Tanker Panamax Tanker Panamax Container Feeder Container Handysize Tanker Small Feeder Container
Strong (>.6 and < .7)	VLCC Post-panamax Container Sub-panamax Container
Moderate (>.4 and < .6)	Suezmax Tanker Capesize Dry LNG Roro
Weak (< .4)	Handymax Dry Panamax Dry Handysize Dry

Table 7.7 – Strength of mean correlations of large vessel price with demand in all sectors

The data is difficult to summarise in general terms but the following can be concluded:

- There is a significant correlation between demand and price that extends generally in the market (i.e. the relationship between demand and price is not restricted by ship type or size).
- The correlations extend across the boundaries between the three market sectors: for example, in the period examined the price of VLCCs showed a correlation coefficient of .875 with demand for handysize tankers.
- It is noticeable that the strongest correlations are with demand for tankers and container ships whilst the weakest correlations are for smaller dry bulk

carriers, with panamax dry bulk demand having a particularly weak effect on prices of larger vessels.

- The small number of pairs of products not showing a positive correlation are restricted to the demands for the three smaller dry bulk carriers (panamax and smaller). This suggests that these ship types have the weakest effect on market price.

The correlations cannot be adequately explained by simple coincidence of demand for different products in the market period examined. For example, no correlation was identified between demand for LNG tankers and demand for Post-Panamax container ships over this period but the correlation between price for LNG tankers and demand for Post-Panamax container ships was found to be strongly positive (.745). Other examples identify pairs of products that were found to have a negative correlation for demand/demand relationships but a positive correlation for demand price relationships. There are 20 such instances of no correlation or negative correlation between product demands but positive correlation between demand and price for the same pairs of products, summarised in the following table. It is concluded from these anomalies that correlations show strong evidence for cross price elasticity in the large ship sector.

		Demand																
		Large ship sector						Panamax Sector							Small Sector			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder Cont
Price	VLCC					.432							.600					
	Capesize					.454						.793	.722		.823			.823
	Suezmax					.531							.686					
	Aframax							.345		.180								
	LNG	.730	.485		.506		.745	.376		.249				.642				
	PP Container					.436							.798					

Table 7.8 – Correlations between price and demand for pairs of products that do not have correlated demands or show negative correlations between demands

7.2.3.2 Correlations of panamax sector ship prices with demand

A summary of correlations between prices of panamax ships and demand for products in the three fleet sectors is presented in Table 7.9.

		Demand																
		Large ship sector						**Panamax Sector**							**Small Sector**			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder
Price	Handy-max Dry	.763	.633	.834	.559	.305	.772	.445	.859	.292	.797	.746	.568	.617	.726	.518	.886	.726
	Handy-max Tank	.562	.335	.769	.332	.640	.610	.217	.883		.731	.730	.751	.402	.821	.289	.876	.821
	Panamax Dry	.673	.563	.860	.413	.361	.657	.287	.860		.847	.830	.686	.507	.811	.371	.873	.811
	Panamax Cont	.505	.447	.740	.234	.465	.493		.712		.823	.828	.719	.300	.801	.192	.726	.801
	Panamax Tanker	.695	.446	.801	.485	.565	.736	.355	.902		.750	.715	.668	.552	.790	.439	.914	.790
	Sub-pan Container	.407	.358	.700		.470	.395		.678		.797	.799	.741	.211	.786		.672	.786
	Roro	.773	.631	.412	.880		.897	.813	.583	.695	.351	.165		.793		.853	.618	

Table 7.9– Significant Spearman-Rho non-parametric correlations for prices in the panamax ship sector with demand in all sectors

The number and proportion of significant correlations in each sector are shown in the following table, along with mean correlations in each sector.

		Correlation of price with demand			
		Number of significant correlations	Potential total number of correlations	Proportion where correlation is significant	Mean correlation
Demand sector	Large	40	42	95%	.58
	Panamax	41	49	84%	.63
	Small	25	28	89%	.71
	Total	106	119	89%	.63

Table 7.10 – Number of significant correlations for panamax ship prices with demand in all sectors

The proportion of pairs of products showing a significant correlation is slightly lower than was found for large ship prices (95%) but the mean correlations are consistent between the two sectors, as may be expected given the high price/price correlation for all sectors, suggesting that demand influences on price are consistent between the two sectors and are not varied by size class. This consistency extends to the analysis of mean correlation by product, as shown in Figure 7.10, which shows the mean for both the panamax and large ship sectors together.

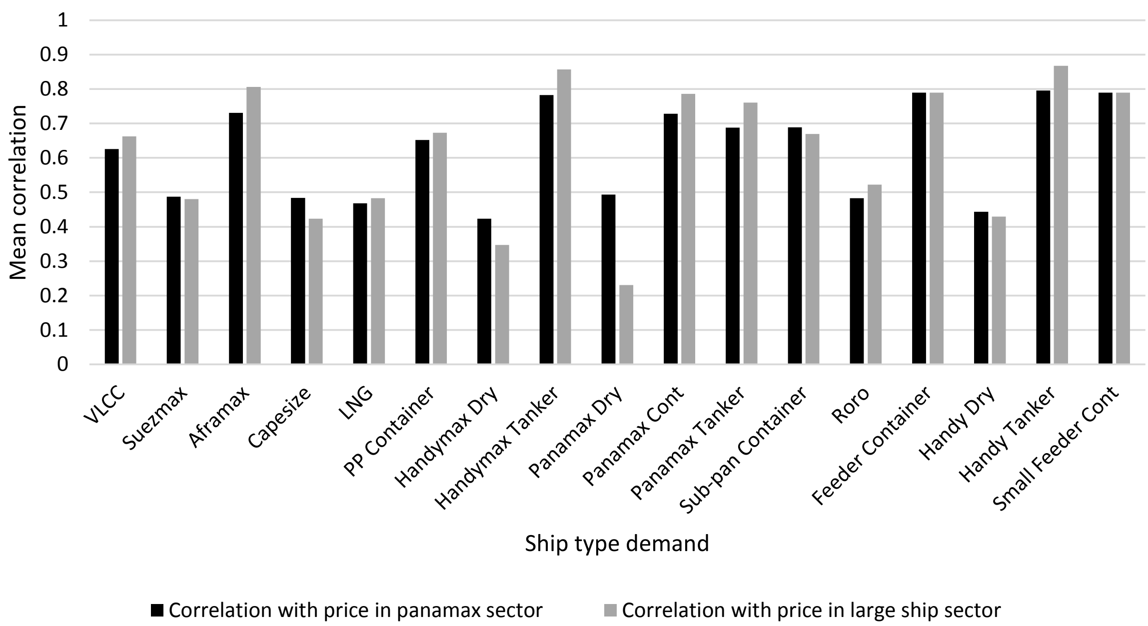


Figure 7.10 – Mean correlations of price in the panamax and large ship sectors with demand for all ship types

The similarity of the mean correlations between sectors means that the conclusions for the panamax sector are broadly the same as expressed earlier for the large ship sector. The most significant difference is in the level of influence of demand for panamax dry bulk carriers which is significantly stronger within the panamax sector.

It is also possible to show that for 24 of the product pairs a significant correlation was found that cannot be attributed to coincidence of demand between the two products: demand/demand correlations for the pairs showed no significant correlation or negative correlation whilst demand/price correlation were significant and positive. As for the large ship sector, therefore, cross correlations between demand and price cannot be explained by coincidence of demand, providing evidence for the existence of cross price behaviour.

		Demand																
		Large ship sector						Panamax Sector							Small Sector			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder
Price	Handy-max Dry			.834		.305					.797	.746	.568		.726			.726
	Handy-max Tank																	
	Panamax Dry			.860		.361			.860		.847	.830	.686		.811		.873	.811
	Panamax Cont															.192		
	Panamax Tanker				.485			.355								.439		
	Sub-pan Container	.407	.358				.395							.211				
	Roro																	

Table 7.11 – Correlations between price and demand for pairs of products that do not have correlated demands or show negative correlations between demands

7.2.3.3 Correlations of small ship sector prices with demand

A summary of correlations between prices of panamax ships and demand for products in the three fleet sectors is presented in Table 7.12.

		Demand																
		Large ship sector						Panamax Sector							Small Sector			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder
Price	Feeder Container	.380	.390	.695		.390	.324		.615		.807	.844	.712	.192	.774		.615	.774
	Handy Dry	.774	.579	.813	.567	.385	.787	.450	.872	.306	.779	.718	.565	.658	.730	.533	.897	.730
	Handy Tanker	.562	.335	.769	.332	.640	.610	.217	.883		.731	.730	.751	.402	.821	.289	.876	.821
	Small Feeder Cont	.422	.325	.691	.169	.449	.425		.718		.720	.765	.736	.269	.781		.717	.781

Table 7.12 – Significant Spearman-Rho non-parametric correlations for prices in the small ship sector with demand in all sectors

The number and proportion of significant correlations in each sector are shown in the following table, along with mean correlations in each sector.

		Number of significant correlations	Potential total number of correlations	Proportion where correlation is significant	Mean correlation
Demand sector	Large	23	24	96%	.51
	Panamax	23	28	82%	.63
	Small	14	16	88%	.72
	Total	60	68	88%	.61

Table 7.13 – Number of significant correlations for small ship prices with demand in all sectors

The results are again consistent with both the large and panamax sectors and a very similar profile of influence by ship type demand is obtained, as shown in Figure 7.11, showing the large ship sector in addition for comparison.

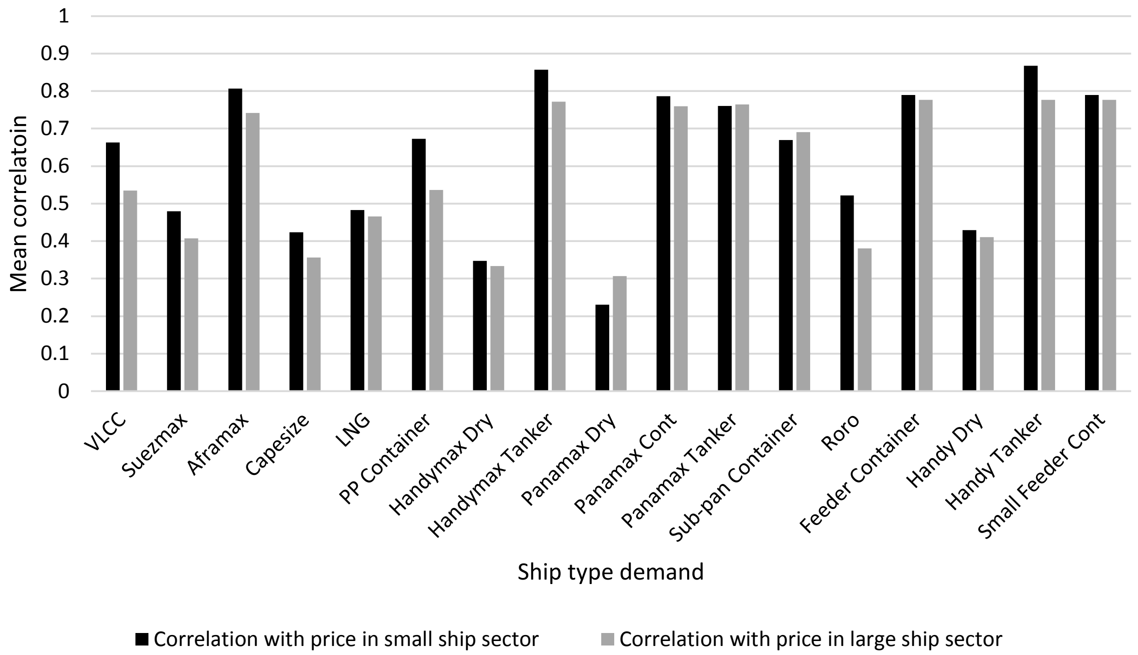


Figure 7.11 – Mean correlations of price in the small and large ship sectors with demand for all ship types

The similarity of the mean correlations between sectors means that the conclusions for the small sector are broadly the same as expressed earlier for the large and panamax ship sectors.

It has also been similarly found that 11 significant positive correlations between demand and price can be identified where demand between the products is either not correlated or negatively correlated, again showing that correlations cannot be the result of coincident demand. Having said that, the cross price correlations identified in this context are relatively weaker than seen in the other two sectors, with the exception of influences on handysize dry bulk carriers from demand for panamax and small vessels. Conclusions for small ships are therefore less clear cut.

		Demand																
		Large ship sector						Panamax Sector							Small Sector			
		VLCC	Suezmax	Aframax	Capesize	LNG	PP Container	Handymax Dry	Handymax Tanker	Panamax Dry	Panamax Cont	Panamax Tanker	Sub-pan Container	Roro	Feeder Container	Handy Dry	Handy Tanker	Small Feeder
Price	Feeder Container		.390											.192				
	Handy Dry					.385					.779	.718	.565		.730			.730
	Handy Tanker																	
	Small Feeder Cont		.325		.169									.269				

Table 7.14 – Correlations between price and demand for pairs of products that do not have correlated demands or show negative correlations between demands

7.2.3.4 *Correlation of prices with backlog.*

The previous sections have shown correlations between demand and price for different products. It is demonstrated that significant influence of demand for one product can be seen in price for another, that the pattern of influence is consistent across all three market sectors and that the results cannot be adequately explained by coincidence of demand over the period examined. Inferences that can be drawn in relation to cross price behaviour are investigated further by examining the relative strengths of prices with demand for the products themselves and with demand in the whole market, represented by backlog.

The strong significance of backlog for both buyer and seller was discussed earlier, taking into account capacity utilisation as well as demand. Backlog alone, for the period of data analysed, was found to be a very strong predictor of price for almost all products. Backlog is calculated by dividing the prevailing orderbook in CGT by output in the preceding twelve months and is measured in years. The value of backlog over the period examined is presented in Figure 7.12

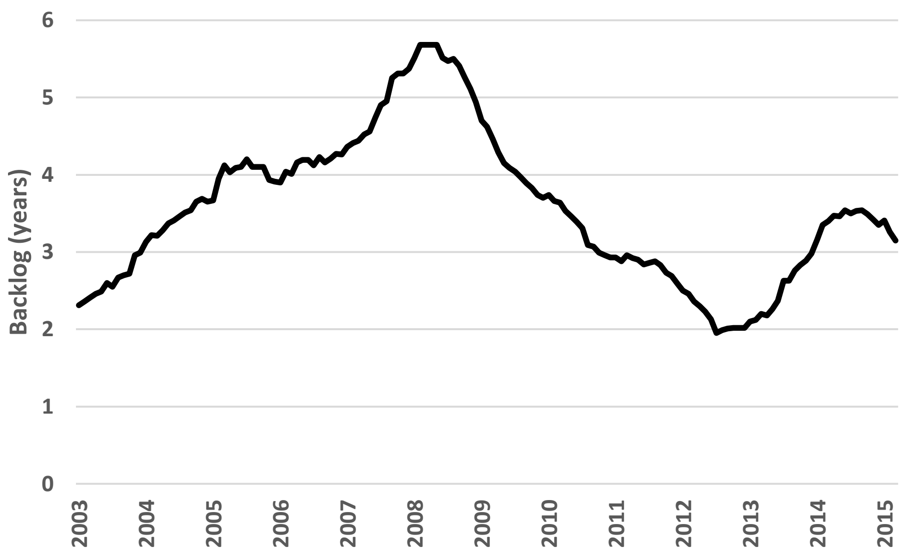


Figure 7.12 – Backlog time series

Correlation between price of each product and backlog is summarised in Figure 7.13

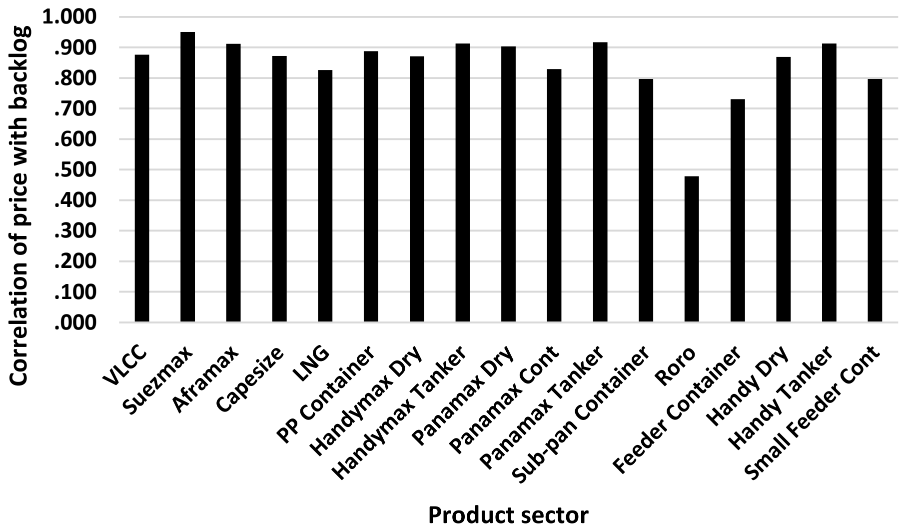


Figure 7.13 – Correlation between price and backlog

Spearman-rho non-parametric factors are reported and all are significant at the 1% level. It can be seen that correlations are generally above .8, with the exception of the Roro sector, which shows a significantly weaker correlation than any other sector, and the feeder container sector which is slightly lower but nonetheless still very strong. Correlation is not constant over the time period examined. In the strongly growing market up to the peak in 2008 the average correlation was 95%, falling to an average of 70% in the weak market following the peak. Further evaluation is therefore undertaken separately for the two market periods:

- period 1 up to the peak in September 2008 (n = 69) and
- period 2 following the peak (n = 78).

The difference between correlation of price with demand for the product itself and with backlog is examined to identify outlying cases where the difference is greater than may be expected based on the distribution of the differences for all products. The correlations and differences are presented in Table 7.14. Spearman-rho non-parametric factors are reported and all are significant at the 1% level, with the exception of feeder container ships following period 2 where no correlation was identified with own demand.

Product:	Correlations of price with: Backlog		Own demand		Difference	
	Period 1	Period 2	Period 1	Period 2	Period 1	Period 2
VLCC	0.98	0.72	0.96	0.90	0.02	-0.18
Capesize	0.94	0.91	0.96	0.83	-0.02	0.09
Suezmax	0.98	0.81	0.74	0.54	0.25	0.27
Aframax	0.98	0.65	0.94	0.72	0.03	-0.07
LNG	0.93	0.73	0.89	-0.39	0.05	***1.12***
Post-pan container	0.97	0.64	0.96	0.80	0.01	-0.17
Handymax dry	0.97	0.78	0.96	0.95	0.01	-0.17
Handymax tanker	0.98	0.76	0.97	0.72	0.01	0.04
Panamax dry	0.95	0.78	0.90	0.57	0.05	0.21
Panamax container	0.89	0.45	0.90	0.54	-0.01	-0.09
Panamax tanker	0.98	0.90	0.85	0.63	0.13	0.27
Sub-pan container	0.92	0.35	0.43	0.33	***0.49***	0.03
Roro	0.99	0.68	0.89	0.58	0.10	0.10
Feeder container	0.94		0.56	0.28	***0.38***	
Handysize dry	0.98	0.77	0.97	0.93	0.01	-0.16
Handysize tanker	0.98	0.76	0.98	0.74	-0.00	0.02
Small feeder container	0.83	0.45	0.48	0.47	***0.35***	-0.02

Table 7.15 – Correlations between price and backlog and own demand and differences between the two. Outliers identified in bold italic script.

The distributions of differences, mean values and box plots are presented in Figure 7.14

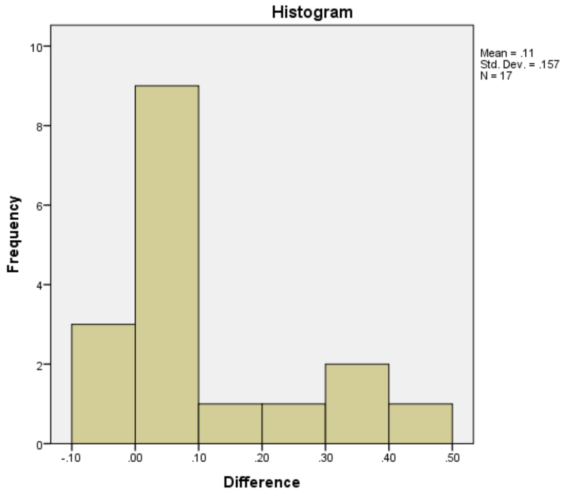
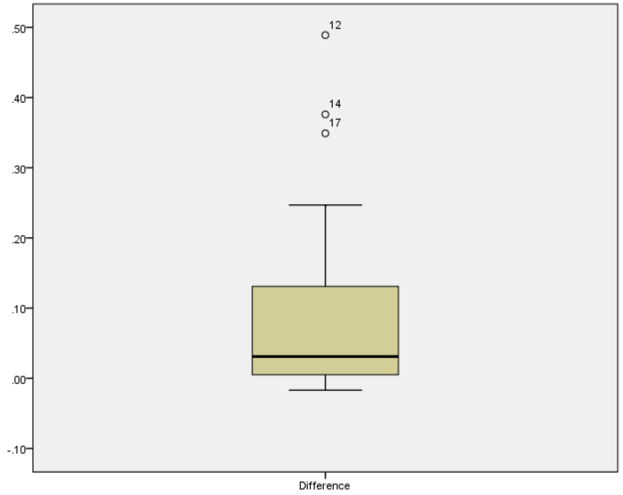
In most cases the differences are small, with some exceptions and with four statistical outliers. Excluding the outliers the average difference in period 1 is 3.8% and in period 2 is 1.0%, showing only a very small advantage in backlog as a predictor over demand for the product itself in most cases. For the outliers the conclusions are as follows:

- Small container ships (sub-panamax and smaller) in period 1: prices were significantly higher than would be anticipated based on the demand for the products themselves.
- LNG tankers in period 2: prices were significantly depressed compared to what would be expected based on the demand for the product itself.

These outliers provide examples of cases where market conditions in general have caused either increased prices or suppressed prices, providing evidence for the existence of cross price elasticity existing in the commercial shipbuilding market.

<table>
<tr><td></td><td>Distribution of differences</td><td>Identification of outliers</td></tr>
<tr><td>Period 1:

Mean difference: 10.9%

Mean difference excl. outliers: 3.8%</td><td></td><td></td></tr>
<tr><td>Period 2

Mean difference 8.0%

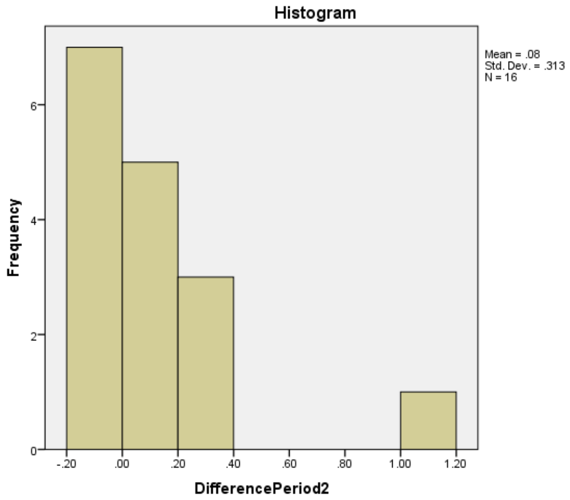
Mean difference excl. outliers: 1.0%</td><td></td><td></td></tr>
</table>

Figure 7.14 – Distribution of differences in correlations between price and backlog and own demand

7.2.3.5 Conclusions from correlation analysis

The following conclusions are drawn from the analysis of correlations:

1. As well as the expected strong correlations between prices, significant positive correlations between demand and prices have been shown.
2. Correlations are found between demand and price for differing products, with few exceptions.
3. Correlations are not limited to specific market sectors but act across the market as a whole.
4. The level of influence of demand on price varies by product and the pattern is consistent across the three market sectors. Demand for container ships and tankers are identified as having the strongest influence on price and dry bulk carriers the weakest.
5. The extent of influence suggests that the definition of the same market, from the point of view of the shipbuilder, is wide in terms of coverage of products.
6. Cross correlations between products cannot be explained by coincidence of demand and provides circumstantial evidence of cross price elasticity in the market for the period examined.
7. Generally strong correlations between price and backlog for almost all products provides circumstantial evidence for the mechanism by which cross pricing occurs, through the valuation of units of capacity. It also provides support for the contention that a single market in commercial shipbuilding may exist.
8. Specific evidence for price enhancement and price suppression is provided by statistical outliers identified in comparing correlation of prices with demand for the products themselves and with backlog, representing demand in the market in general. Prices of small container ships were found to be significantly higher in the strong market up to the peak in 2008 than would be expected based on the demand for the products themselves and prices of LNG tankers in the weak market following the peak were significantly lower than would be expected based on the product demand. These outliers provide specific evidence of cross price behaviour in the commercial shipbuilding market.

7.2.4 Regression results

7.2.4.1 Overview

Reports of the iterative results to identify statistically significant cross price relationships are contained in Section 6 of the data annex to this dissertation along with detailed statistical outputs from accepted regression models in Section 7. Significant results are summarised in the following sections for each ship type where cross relationships between demand and price were identified.

Theoretically, as this is Ln/Ln regression, the coefficients in the derived regression expressions can be regarded as elasticities. Elasticities of price with demand in this case can be compared directly within an expression because no scale effects result from the original data (all prices are in $millions and all demands in CGT). It is therefore possible to compare the relative strengths of elasticity of price with demand for the product itself and with demand for identified substitutes.

7.2.4.2 Regression results for the large ship sector

Statistically significant relationships between demand and price identified in the large ship sector are indicated in Table 7.16.

		Demand					
		Aframax	Suezmax	Capesize	VLCC	LNG	Post-pan container
Price	Aframax						
	Suezmax	*				*	
	Capesize	*	*			*	
	VLCC					*	
	LNG						*
	Post-pan container		*			*	

Table 7.16 – Identification of statistically significant cross price relationships with demand in the large ship sector

The following may be noted from this table:

- LNG tankers were found to be the most influential product having a significant effect on price for all other large ship types apart from aframax. This suggests that Korea was not correct in arguing that barriers to entry meant that LNG tankers cannot be considered as part of the same market as other ships (see Section 2.2.1). All coefficients were found to be positive suggesting that demand for LNG ships had a positive influence on the value of capacity over the period examined. When viewed against the conclusion from the previous section that LNG price was suppressed by low demand following the peak of 2008, the results suggest that prices for other ships in the large sector may have been supported by demand for LNG carriers in the same period. Sample size restrictions mean that it has not been possible to split the data to confirm this.
- Post-panamax container and LNG were the only sectors that exhibited mutual cross effects, suggesting a strong competitive relationship over the period examined.
- Prices for capesize bulk carriers were the most strongly influenced by demand in other sectors (measured by the number of influencing products: 3), whilst at the same time capesize demand was not found to have been a significant influence the price of any other product in the sector. This echoes the influences found in correlation results. Demand for the lowest value and most widely competed product, therefore, was found to have had the least influence on the value of capacity over the period examined.
- The lack of influence of demand for VLCCs on the price in any other sector comes as a surprise, particularly when suezmax and aframax demands are shown to have been influential. This is not explained and is recommended for further study.
- No influencing cross product demands were found in the aframax tanker sector. Further regression to examine the influence of smaller panamax tankers, a relationship between the two products being identified as significant in the panamax sector analysis below, also did not yield significant results.

Further comments on the relative strengths of elasticities are made in the following tables, in which increases in RSquare values are classed as weak below 5%, moderate between 5% and 10% and strong over 10%. The strength of technical substitutability for the significant relationships identified is also summarised.

Suezmax Tanker

Cross price relationships identified

- LNG
- Aframax Tankers

RSquare increased from .907 to .968 (+.061): moderate influence from other products identified.

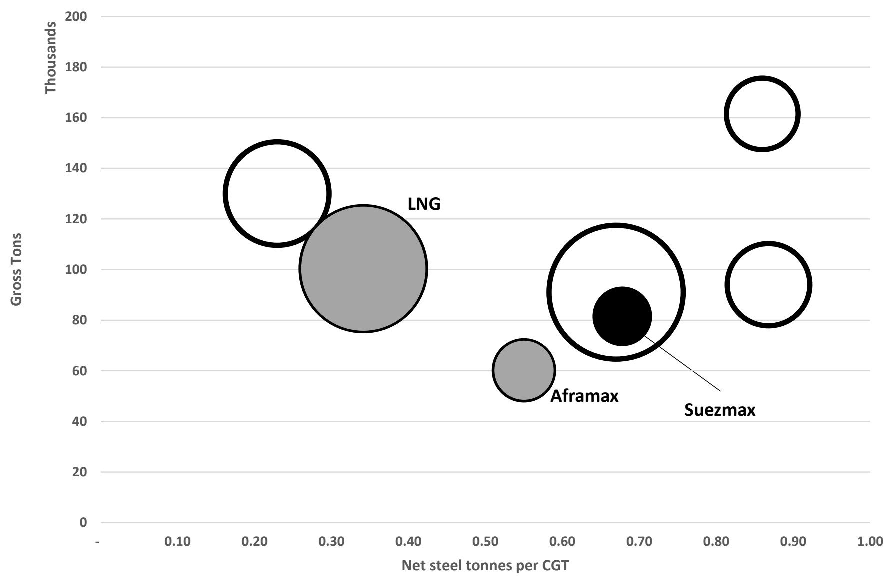
Technical substitutability

- Aframax, the stronger of the two influences identified, is technically well compatible.
- The LNG has low technical substitutability.

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-3.821	0.181		-21.071	0.000
LnSuezmax 3 yr time charter rate	0.193	0.021	0.275	9.110	0.000
Ln World Steel Price	0.329	0.014	0.494	23.454	0.000
LnSuezmax Orderbook	0.030	0.013	0.065	2.372	0.019
Ln LNG Orderbook	0.080	0.008	0.225	10.049	0.000
Ln Aframax Orderbook	0.143	0.012	0.360	11.560	0.000

Dependent Variable: Ln Suezmax Price

Elasticities for the substitute products are both greater than for the product itself with demand for aframax being the strongest demand determinant of Ln Price.

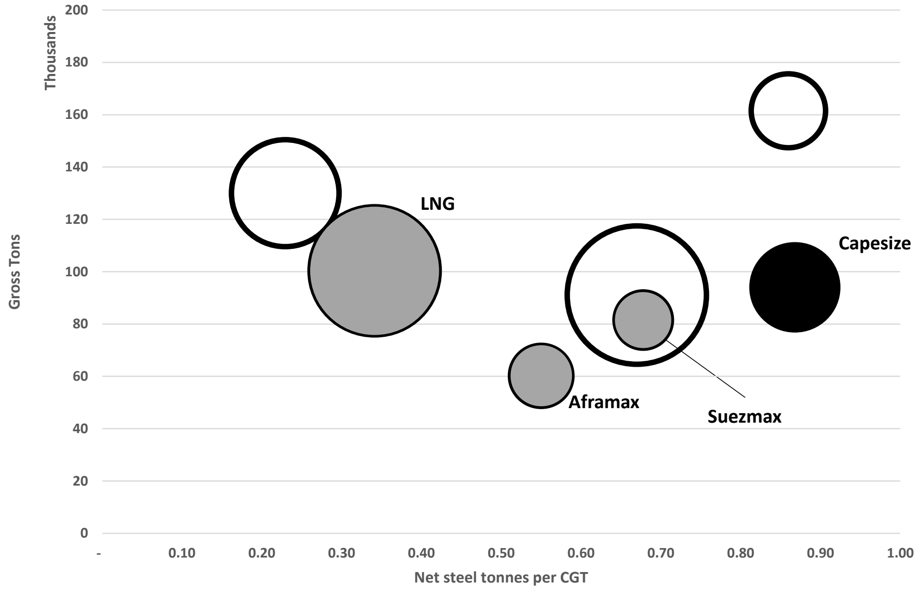


Capesize dry bulk carrier

Cross price relationships identified	**Technical substitutability**
• Aframax • Suezmax • LNG RSquare increased from .832 to .948 (+.116): strong influence from other products identified.	• Compatibility with the tankers is high. • The LNG has low technical substitutability.

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-5.465	0.320		-17.096	0.000
LnCapesize 3 yrTime Charter rate	0.109	0.015	0.268	7.445	0.000
Ln World Steel Price	0.216	0.030	0.253	7.235	0.000
LnCapesize Orderbook	0.053	0.012	0.161	4.220	0.000
Ln LNG Orderbook	0.130	0.013	0.284	10.036	0.000
Ln Aframax Ordbook	0.206	0.020	0.404	10.500	0.000
Ln Suezmax Ordbook	0.067	0.023	0.112	2.938	0.004
Dependent Variable: LnCapePrice					

Elasticities for the substitute products are all greater than for the product itself with demand for Aframax being the strongest determinant. Demand for LNG also shows a relatively strong influence and suezmax the weakest.



VLCC

Cross price relationships identified

- LNG

RSquare increased from .872 to .923 (+.086): moderate influence from other products identified.

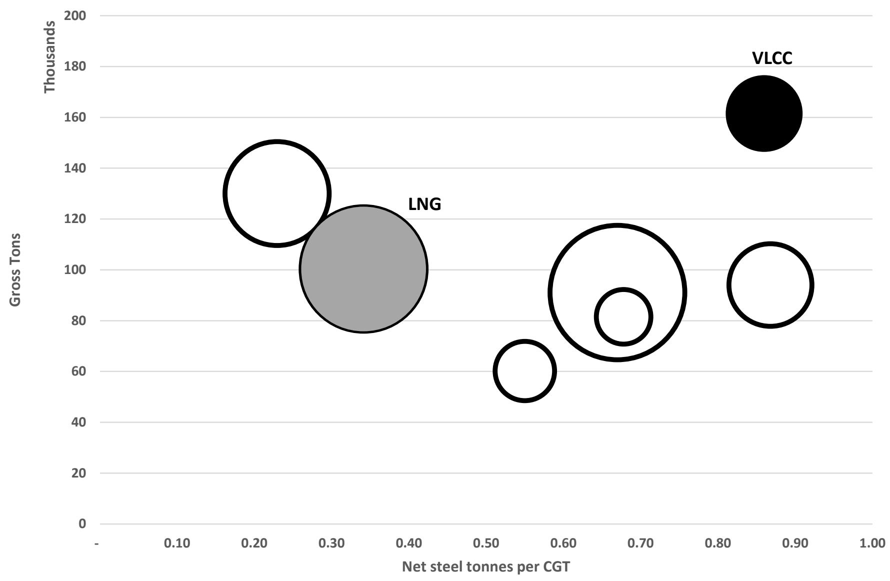
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-4.936	0.259		-19.062	0.000
Ln VLCC 3yr time charter rate	0.262	0.024	0.341	10.857	0.000
LnWorld Steel Price	0.231	0.024	0.301	9.590	0.000
Ln VLCC Orderbook	0.194	0.018	0.407	10.736	0.000
Ln LNG Orderbook	0.148	0.012	0.360	12.510	0.000

Dependent Variable: Ln VLCC Price

Demand for the product itself is a relatively strong determinant of Ln Price. Demand for LNG is also a strong determinant, although elasticity is slightly weaker than for the product itself.

Technical substitutability

- The LNG has low technical substitutability for the VLCC.



LNG Tanker

Cross price relationships identified

- Post-panamax container

RSquare increased from .710 to .837 (+.127): strong influence from other products identified.

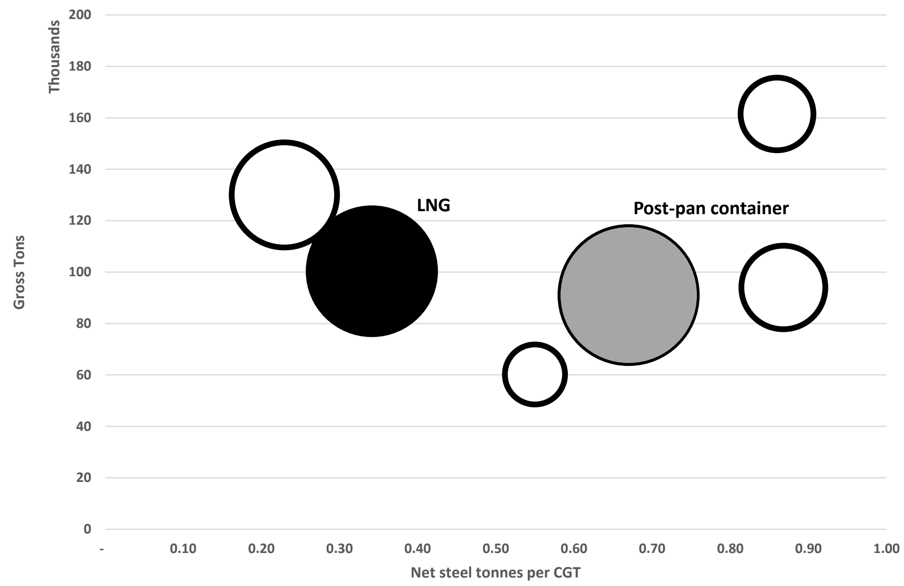
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	0.364	0.206		1.761	0.080
Ln Clarksea earnings index	0.039	0.008	0.175	4.907	0.000
Ln World Steel Price	0.098	0.020	0.250	4.958	0.000
Ln LNG Orderbook	0.081	0.008	0.388	10.722	0.000
Ln Post-pan container Orderbook	0.152	0.014	0.527	10.557	0.000

Dependent Variable: LnLNGPrice

Elasticity for the substitute products is stronger than for the product itself in this case.

Technical substitutability

Both products are complex in terms of building but technical substitutability is not close, in particular in relation to differing steelwork density and taking into account the element of barrier to entry for the LNG tanker.



Post-panamax container

Cross price relationships identified

- LNG
- Suezmax

RSquare increased from .907 to .925 (+.018): weak influence from other products identified.

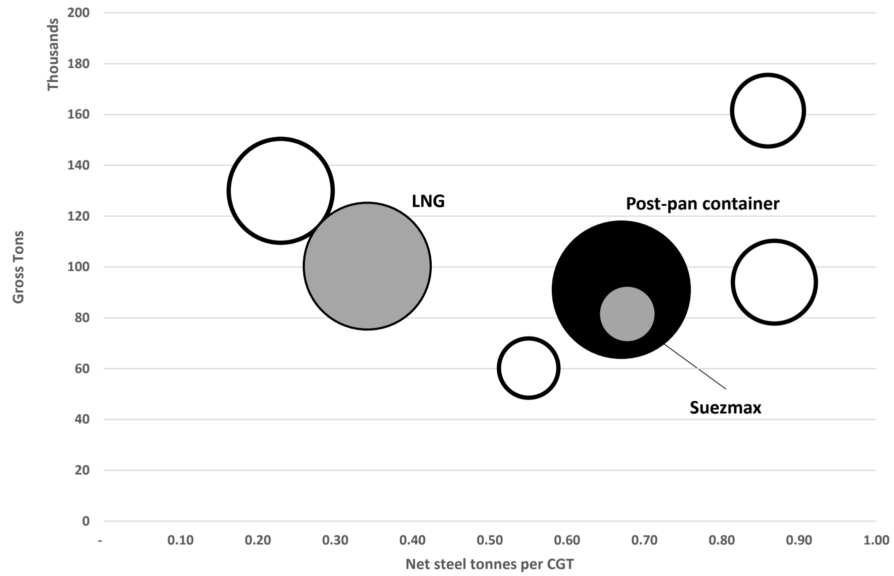
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-4.739	0.287		-16.493	0.000
Ln Container 3Yr Time Charter Index	0.329	0.011	0.793	29.551	0.000
Ln World Steel Price	-0.107	0.024	-0.148	-4.446	0.000
Ln Post-pan container Orderbook	0.343	0.027	0.642	12.944	0.000
Ln LNG Orderbook	0.087	0.013	0.223	6.748	0.000
LnSuezmax Orderbook	0.079	0.022	0.155	3.517	0.001

Dependent Variable: LnPPContPrice

Demand for the product itself was a strong determinant with significantly weaker elasticities for the substitutes.

Technical substitutability

- The container ship and tanker are strongly technically compatible.
- For the LNG ship, both products are complex in terms of building but technical substitutability is not close.



- The elasticities of demand for substitutes were generally found to have been stronger over the period examined than elasticities of demand for the product itself, with the exception of the post-panamax container sector. This was the largest market sector in the period examined and it is concluded that this sector may have dominated in setting the value of capacity.
- In determining price in the LNG sector, demand for competing large container ships was strongly significant. In this case the data suggests that price for one product was significantly influenced by competition for the alternative and LNG tankers and post-panamax container ships provide the strongest evidence for cross price elasticity in the data analysed: the two products can be seen to have competed as substitutes from the viewpoint of the builder.
- Demand for LNG tankers was also seen to have a strong influence on price for the two largest classes of tanker (suezmax and VLCC) and for large bulk carriers.
- Where strong influences are identified the substitute products tended to show relatively strong technical substitutability with the product. The exception to this is the influence of demand for LNG tankers, which played a significant role in determining the value of capacity over the period, but which are not easily technically substitutable with any other product. This suggests that the influence of cross price elasticity is not confined to technically substitutable products but acts through the market as a whole, acting to increase the value of capacity in general.

7.2.4.3 Regression results for the panamax sector

Statistically significant relationships between demand and price identified in the panamax sector are indicated in Table 7.17.

		Demand						
		Handymax dry	Handymax tanker	Panamax dry	Panamax container	Panamax tanker	Sub-panamax Container	Roro
Price	Handymax dry						*	
	Handymax tanker							
	Panamax dry				*		*	
	Panamax container						*	
	Panamax tanker							
	Sub-panamax Container							
	Roro		*			*		

Table 7.17 - Identification of statistically significant cross price relationships with demand in the panamax sector

The following may be noted from this table:

- Demand for sub-panamax container ships was found to be the most influential within the sector, forming a significant determinant of prices for the two dry bulk carrier types and the larger panamax container sector. No influences were observed on the price of the sub-panamax container ship. This result comes as a surprise as the panamax container sector had greater order volume over the period compared to the sub-panamax.
- Panamax dry bulk carrier prices were the most strongly influenced bulk ship type, showing a significant relationship with demand for container ships. Conversely, demand for both the two dry bulk types (panamax and handymax) showed no influence on price of any other sector, suggesting that the two technically most simple ship types were weakest in terms of price determination, again echoing the results of the correlation analysis.
- Outside the bulk sector demand for the roro type was not found to influence other prices but price for the ship type itself was influenced by demand for tankers (handymax and panamax).
- Neither of the two tanker types showed any significant cross relationship with demand for other products in the sector. For the handymax tanker the demand for the ship type itself was a very strong determinant of price, yielding an RSquare value of .965 without substitutes included in the regression. This very high fit may have made the identification of any cross influences difficult. This was not the case for the panamax tanker, however, demand for which was not found to be a significant predictor of price in the regression analysis, whilst demand for all other products were found to have a moderate to strong influence on RSquare, although none could be accepted as none passed all the statistical assumptions tests. This sector was therefore regarded as anomaly and further tests were therefore undertaken to examine potential substitutable product in the large ship sector, which revealed demand for both aframax tankers and LNG tankers as being significant in determining price.

Further comments on the relative strengths of elasticities are made in the following tables, in which increases in RSquare values are classed as weak below 5%, moderate between 5% and 10% and strong over 10%. The strength of technical substitutability for the significant relationships identified is also addressed.

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Handymax dry bulk carrier

Cross price relationships identified

- Sub-pan container

RSquare increased from .833 to .938 (+.105): strong influence from other products identified.

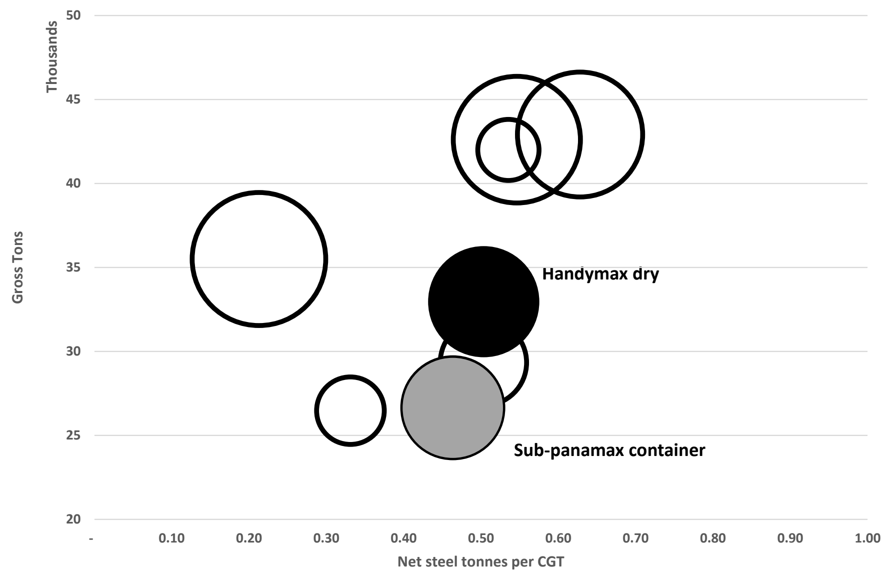
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-4.611	0.209		-22.103	0.000
Ln Handymax Dry 3yr Time Charter Rate	0.233	0.016	0.438	14.864	0.000
Ln World steel price	0.185	0.028	0.232	6.651	0.000
Ln Handymax Dry Orderbook	0.136	0.013	0.384	10.804	0.000
Ln Sub-Pan Container Orderbook	0.166	0.011	0.462	15.461	0.000

Dependent Variable: Ln Handymax Dry Newbuild Price

Elasticity for the substitute product is slightly larger than for the product itself.

Technical substitutability

- The two products are closely technically compatible.



Panamax dry bulk carrier

Cross price relationships identified

- Panamax container
- Sub-panamax container

RSquare increased from .855 to .962 (+.107): strong influence from other products identified.

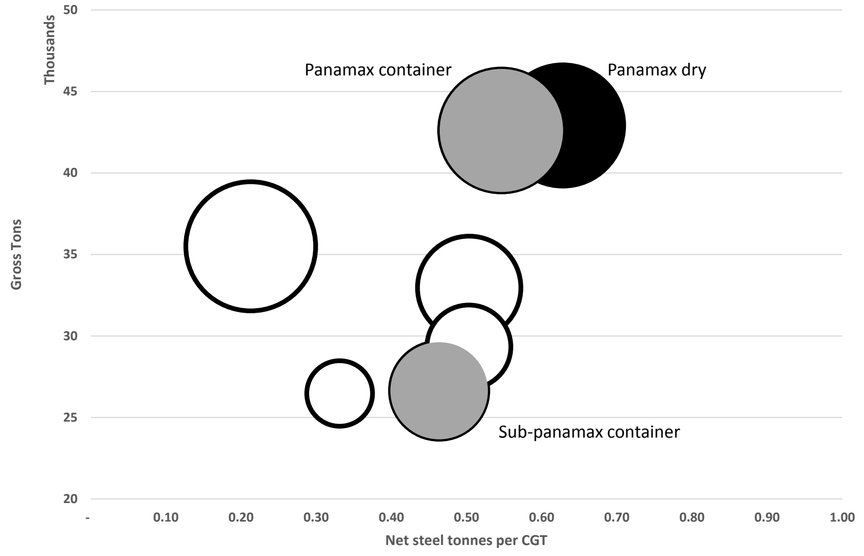
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-5.203	0.233		-22.302	0.000
Ln Panamax Dry 3yr Time Charter Rate	0.175	0.012	0.367	14.191	0.000
Ln World steel price	0.209	0.023	0.253	9.001	0.000
Ln Panamax Dry Orderbook	0.127	0.014	0.303	8.882	0.000
Ln Sub-Pan Container Orderbook	0.181	0.012	0.488	15.589	0.000
Ln Panamax Container Orderbook	0.066	0.010	0.159	6.854	0.000

Dependent Variable: Ln Panamax Dry NewbuildPrice

Elasticity with demand for panamax container ships is greater than for the product itself with a weaker influence also from the smaller container sector.

Technical substitutability

- Compatibility with the larger container ship is high.
- The smaller container ship is less compatible in terms of ship size.



Panamax container

Cross price relationships identified

- Sub-panamax container

RSquare increased from .819 to .909 (+.09): moderate to strong influence from other products identified.

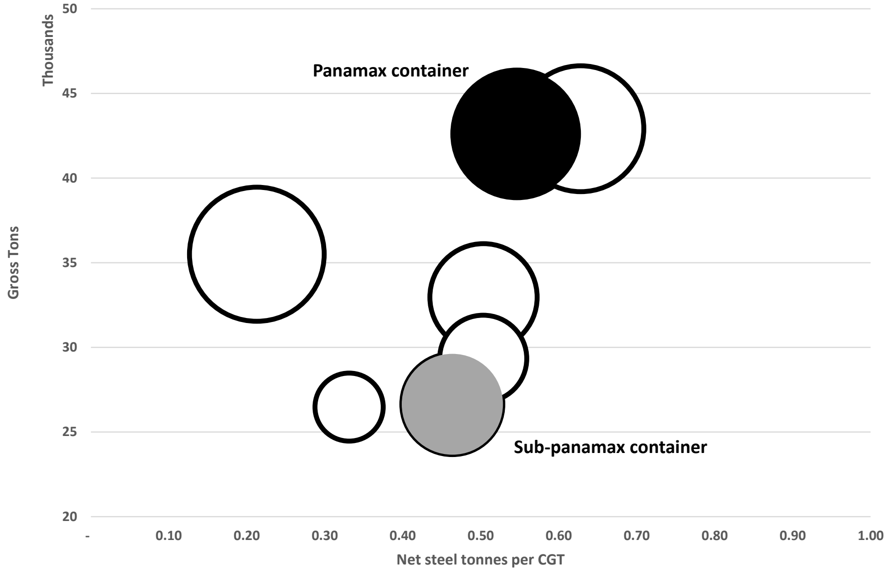
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-1.174	0.150		-7.812	0.000
Ln Panamax Dry 3yr Time Charter Rate	0.050	0.008	0.211	6.019	0.000
Ln World steel price	0.336	0.016	0.584	21.638	0.000
Ln Panamax Container Orderbook	0.066	0.011	0.210	5.849	0.000
Ln Sub-Pan Container Orderbook	0.112	0.010	0.435	11.682	0.000

Dependent Variable: Ln Panamax Container Newbuild Price

Elasticity for the substitute product is stronger than for the product itself in this case, despite panamax container being the larger market sector.

Technical substitutability

- The two ship types are compatible in terms of steelwork balance but show a considerable difference in vessel size.



Panamax tanker

Cross price relationships identified

- Aframax
- LNG

RSquare increased from .865 to .933 (+.068): moderate influence from other products identified.

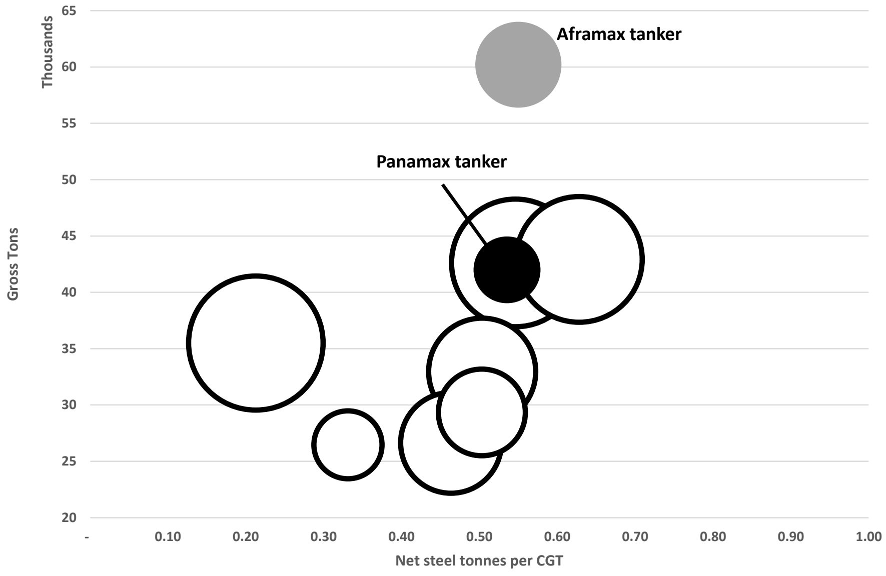
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-3.403	0.173		-19.662	0.000
Ln Panamax tanker 3yr Time Charter Rate	0.099	0.036	0.133	2.754	0.007
Ln World steel price	0.337	0.014	0.531	23.779	0.000
Ln Aframax Ordbook	0.183	0.016	0.484	11.425	0.000
Ln LNG Orderbook	0.082	0.010	0.243	8.627	0.000

Dependent Variable: Ln Panamax tanker newbuild price

Demand for the product itself was not a significant determinant but demand for aframax was found to be a strong predictor, suggesting that panamax tankers are a substitute product for aframax in the large ship sector. Demand for LNG also had a significant influence, improving RSquare from .898 to .933.

Technical substitutability

- The two tankers are compatible in terms of steelwork balance but not ship size. Compatibility with LNG (not shown in the diagram) is low.



Roro

Cross price relationships identified

- Handymax tanker
- Panamax tanker

RSquare increased from .878 to .937 (+.059): moderate influence from other products identified.

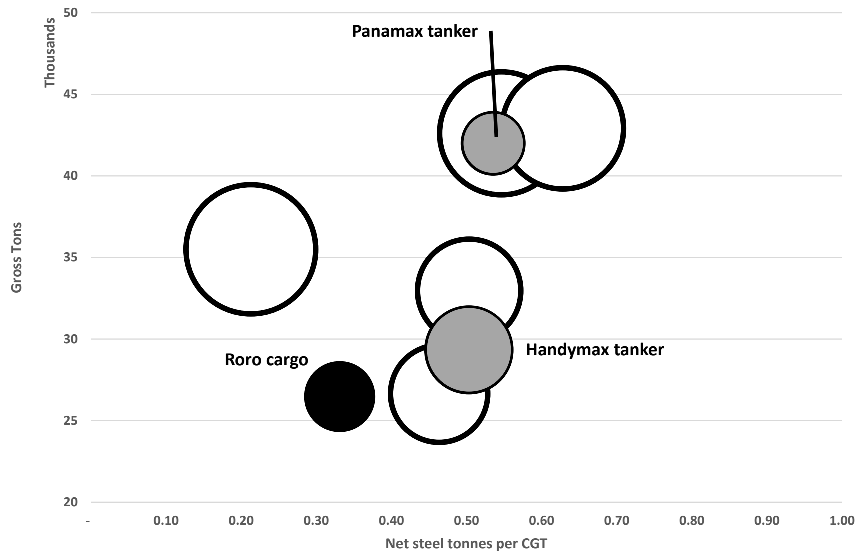
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-3.398	0.228		-14.909	0.000
Ln World steel price	0.362	0.021	0.476	17.510	0.000
Ln Roro Orderbook	0.212	0.015	0.413	13.717	0.000
Ln Handymax Tanker Orderbook	0.217	0.021	0.341	10.146	0.000
Ln Panamaxtanker Orderbook	-0.108	0.010	-0.315	-11.122	0.000

Dependent Variable: Ln Roro Newbuild Price

Demand for handymax tankers was very slightly more significant as a determinant of price compared to the product itself, both being strong determinants of price. Demand for panamax tankers showed a negative correlation (the only one in this analysis), which is not explained.

Technical substitutability

- Compatibility with the handymax tanker is good.
- Compatibility with the panamax tanker is poor.



- As with the large ship sector the coefficients for substitute products tended to show stronger elasticity of price with demand than was found with the products themselves and sub-panamax container ships were found to have the strongest influence on price in this sector.
- The cross relationship between panamax and aframax tankers reflects the close technical positioning of these two products in terms of technical substitutability.

7.2.4.4 Regression results for the small ship sector

No significant cross price relationships were identified for the small ship sector using linear regression. Three of the four products analysed showed high RSquare values in regression without the inclusion of substitutes:

- Feeder container: .921
- Handy tanker: .967
- Small feeder container: .899

For the two small container ship sectors this is unexpected, being apparently contradictory to correlation results that suggest that prices for small container ships had been elevated in the market growth period, compared to what might be expected values based on the demand for the products themselves. The regression looks at the full period, however, whereas the correlation split the market into growth and decline, with the conclusion relating to the growth phase only. Sample size restrictions mean that it is not possible to split the regression to confirm the correlation results for separate periods.

Regressions for the handy dry vessel alone showed significant potential for improvement in fit by the inclusion of substitutes, but none from within the small ship sector were able to satisfy statistical assumptions. Further regression was therefore tried to examine whether this ship type was influenced by demand for the most influential ship type in the larger panamax sector: sub-panamax container ships, which yielded strong evidence for cross price elasticity for this ship type. This model provides statistically valid evidence for cross price behaviour between market sectors. Regression results are shown in the following table.

Handy dry bulk carrier

Cross price relationships identified

- Sub-pan container

RSquare increased from .827 to .957 (+.13): strong influence from other products identified.

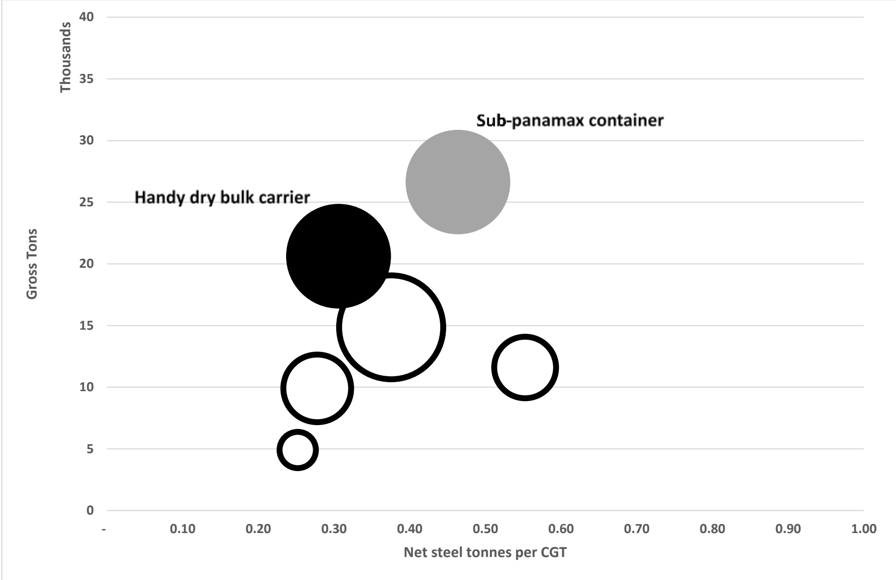
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-4.161	0.137		-30.298	0.000
Ln Handy Dry 3yr Time Charter Rate	0.205	0.016	0.337	13.158	0.000
Ln World steel price	0.200	0.022	0.266	9.213	0.000
Ln Handy Dry Orderbook	0.117	0.008	0.411	14.390	0.000
Ln Sub-Pan Container Orderbook	0.163	0.008	0.483	20.774	0.000

Dependent Variable: Ln Handy Dry Newbuild Price

Elasticity for the substitute product is larger than for the product itself.

Technical substitutability

- The two products are strongly technically compatible.



7.2.4.5 Conclusions from regression analysis

1. The existence of cross price elasticity in the data examined is confirmed by linear regression, demonstrating statistically significant effects of demand for one product on the price of another. It is concluded therefore that the *'same market'* may be constituted by more than one product.
2. It must be stressed that these may not be the only cross price relationships existing in the market but represent the most important relationships that can be demonstrated using linear regression and that were persistent over the data period examined. Other relationships may have been more important in specific market periods. Multicollinearity of demand in the market over the period examined may have obscured other relationships that may exist but which cannot be identified using linear regression. It should also be noted that models were restricted to pairs of products competing directly within the same market sector, with two exceptions. Correlation analysis suggests that other significant relationships could be found between sectors, as was found with panamax tankers and substitute products identified in the large ship sector and handysize dry bulk carriers and sub-panamax container ships. It is possible that linear regression could reveal other significant relationships as substitutes for those identified across the three sectors and this would be expected based on the evidence from the correlation analysis.
3. Cross price relationships were less evident in the small ship sector, compared to the panamax and large ship sectors. The demand for the products themselves were found to be highly significant in three of the four ship types examined and this may have made cross price effects difficult to identify using linear regression. The fourth ship was found to be influenced by demand from a vessel a larger size category. No such lower significance of the effect of demand from substitutes on price was identified in the correlation analysis and the significance of this finding is therefore questioned and recommended for further study.
4. In general, demand for container ships were found to be significantly influential in all sectors, along with demand form LNG tankers that had a strong influence on price setting. Demand for tankers was also found to be significant in the determination of price. This may be expected, with builders competing strongly for higher added value products. These influences are

consistent with those identified in the correlation analysis. Demand for dry bulk carriers, on the other hand, at the other end of the complexity spectrum, was found to have no identifiable influence on price for the period examined.

5. Technical substitutability was found to be present in the results but wider influences from less technically substitutable products was also found, most notably the influence of demand for LNG tankers on prices of other products in the large ship sector and for the panamax tanker. This suggests that technical substitutability may be of low significance in the determination of price, compared to other factors such as capacity utilisation and the perceived value of products to the shipbuilder, confirming the conclusions reached in the examination of correlations of price with backlog.

8. Conclusions

The following sections summarise the conclusions reached in examining market-related problems encountered in *Korea-Commercial Vessels*. Specifically the problems relate to demonstrating that a commercial shipbuilding market exists, that 'like' products can be identified in that market and that cross price elasticity exists in that market between products. Conclusions below are summarised according to the three hypotheses used to structure the research work, following general conclusions on the nature of the industry.

8.1 General

1. The modern commercial shipbuilding industry in terms of construction methods, shipyard design and products commenced after the end of WWII and is a product of globalisation. Key changes defining the industry since WWII, in addition to technical aspects of production, have included increasing size of vessels produced, standardisation of the products and the pursuit of volume and economies of scale in market leading shipyards.
2. Commercial shipbuilding has, through its history, been subject to cycles that lead to economic difficulties for shipbuilders. In particular these difficulties are caused by the persistence of capacity in the decline and trough phases of the cycles. The nature of the cycles changed in the second half of the 20th Century, with output becoming less volatile and the pitch of the cycle increasing, including longer periods of sustained growth and recession.
3. Market leadership in the post-WWII period has passed from Japan to South Korea and then to China. The length of period for which market leaders have retained dominance has declined with each successive leader and the level of dominance has reduced. It is questionable as to whether a true hegemony has existed since the British domination of the industry in the late 19th Century but it is true to say that market leadership has become increasingly concentrated in a small number of shipyards and shipyard groups.
4. Subsidy has been a persistent feature of commercial shipbuilding throughout its history, with many forms of subsidy and many reasons for granting subsidy. Two significant reasons are the economic difficulties that beset

shipbuilders in cyclical downturns and the very high cost of developing a modern high volume competitive shipyard. It is unlikely that such a shipyard can be developed in the modern era without government assistance.

5. The form of very large, high-throughput shipyard that has developed in particular since the 1990s is questioned in terms of viability, given the cyclical nature of demand. Such shipyards are undoubtedly highly efficient in strong market conditions but are very difficult to manage in weak market conditions. The level of throughput required to maintain market share is likely to be unattainable in trough periods and low throughput will seriously impair the efficiency of the shipyard. Inefficiency in trough periods, therefore, is likely to counteract high efficiency in boom periods and over the full cycle the benefits of scale are questionable. The risk inherent in investment in these ultra-large shipyards may in the long run be regarded as too great.

8.2 The legal definition of 'like product' in the context of WTO

1. There is no simple definition of 'likeness', with the concept being interpreted according to case law in WTO instruments. In the context of this work likeness is essentially about competitiveness and like products are those that compete for the same opportunities and thereby compete in the same market.
2. The concept of likeness has to be seen from the viewpoint of the producer, the shipyard. The end use of the product, which might determine likeness for the buyer, the ship owner, is not relevant to the discussion in this context. Thus, that a container ship cannot be regarded as a substitute for an LNG tanker from the point of view of ship operations is of no relevance to the discussion of like product in the commercial shipbuilding industry.
3. Likeness in commercial shipbuilding is therefore about which products compete for the same units of shipbuilding capacity. Like products have to exist in commercial shipbuilding because shifts in demand mean that it is rarely possible for a shipbuilder, with few exceptions, to concentrate on a single product. For this reason capacity has to be flexible to build a range of products, normally referred to as the product mix, to enable a business to react to market shifts. The need for a product mix is particularly important as a consequence of the increase in output volume experienced in the past fifty years.

4. Likeness refers to any aspect of the product that may confer a competitive advantage. This includes not only the technical features of the product and how these relate to the factors of competitiveness inherent in a shipyard competing to gain orders for that product but also factors such as customers' tastes and habits.

8.3 Hypothesis 1 – the commercial shipbuilding market exists

1. There is strong empirical evidence for the de facto acceptance of the existence of a commercial shipbuilding market and numerous references to the market in common usage. This is justified by benchmarking the industry against the features that constitute the concept of a market as an economic construct, in particular that it relates to economic transactions (the buying and selling of ships) and that there is sufficiently close contact between buyers and sellers for a market price to exist.
2. The market is constituted partially by products but also by a factor of production: shipbuilding capacity. When an order is placed the transaction normally involves the sale of a commitment to provide future capacity (a slot) to build a product, rather than a direct and immediate sale of that product. If a contract were to be cancelled before construction starts the slot would be re-sold wherever possible but the substitute trade would not necessarily be for the same product as the original transaction. The substitute would be from a range of products that key into the factors of competitiveness for the capacity being sold.
3. The market in its totality includes any ship structure over 100 GT, below which the market could more readily be defined as boat building rather than commercial shipbuilding.
4. For the market above 100 GT, three distinct sectors are identified, characterised by the products, the nature of competition and the nature of demand. These are the workboat market (up to about 500 GT), the large workboat / small ship market (between about 500 and 5,000 GT) and the international commercial shipbuilding market (over about 5,000 GT). For the two smaller sectors, local and regional purchasing are more common and demand is less volatile than in the large sector. The two very large peaks of demand seen over the past fifty years were experienced only in the large

sector, which accounts for around 90% of all shipbuilding work content. The international commercial sector, over 5,000 GT, was taken as the basis for further analysis in this dissertation.

8.4 Hypothesis 2 - like products exist in the commercial shipbuilding market

1. Like products are determined in part by identifying those products that are compatible with the factors of competitiveness that define a unit of shipbuilding capacity, or in other words the mix of products for which that capacity can compete for orders. Determinants of competitive advantage include labour cost, productivity and the characteristics of the supply chain. Economies of scale and location in a country with strong steel and marine equipment supply industries have been important determinants for market leaders in recent years. Other factors of competitiveness may include state aid, access to finance and advantages from the strength of being part of a diversified group.
2. Few barriers to entry are found in international commercial shipbuilding. Such as have existed recently include protected markets that are not open to international competition, notably the Jones Act market in the United States, the LNG market, for which only qualified and appropriately invested shipyards can compete, and the cruise ship market, for which the unique characteristics of the supply chain and technical innovation present barriers for new entrants.
3. Consumers' tastes and habits are also important in assessing likeness in commercial shipbuilding. Relevant examples identified that could be argued to determine likeness include the tendency for domestic orders in Japan, the KG finance system in Germany and established relationships between buyers and sellers, for example the relationship between Maersk and Odense Lindo (prior to its closure) or the relationship between Carnival and Fincantieri.
4. Technical substitutability is examined in relation to aspects of the product that key into the nature of investment in the shipyard and aspects that key into factors of competitiveness that may be inherent in a unit of capacity. The nature of the investment includes consideration of the size of the ship, the relative steelwork content in the product and the size of the market in relation to market share. Factors of competitiveness include relationship with the

supply chain and the balance of steelwork in relation to the skills and experience of the workforce.

5. Technical substitutability was examined in three sectors: large products that relate to shipyards that typically have VLCC launching facilities (products above 80,000 GT and 20,000 net steel tonnes), panamax products that relate to shipyards that typically have panamax launching facilities (typically between 20,000 and 80,000 GT and 7,500 and 15,000 net steel tonnes) and small shipyards, below about 20,000 GT and 7,500 net steel tonnes.
6. Within each sector technical substitutability was found to be wide with few exceptions. Exceptions include cruise ships and LNG tankers in the large ship sector and ferries and roro cargo in the panamax sector.
7. Whilst opportunities were found to be primarily taken from within the size sector, shipyards were also seen to ‘trade down’ to take orders where possible from a smaller sector where advantage can be obtained from this. Technical substitutability therefore acts across the size boundaries. For example, panamax tankers were found to be more compatible with aframax tankers than with other products in the panamax sector.
8. It was not found that likeness could be restricted by construction material, the difference between niche and volume products or the nature of the shipyard, for example depending on whether a shipyard used slipways or drydock for launching.

8.5 Hypothesis 3 – cross price elasticity exists between like products in the commercial shipbuilding market

1. The existence of different products within the *‘same market’* has been examined by an empirical examination of market data for the period January 2003 and March 2015. Products within the ‘*same market’* would be expected to show a cross relationship between demand for one and price for the other.
2. Correlation analysis reveals a strong link between prices for all products and across all sectors of the market. That this is not a feature only of the market period investigated in this dissertation can be demonstrated by concurrence with two previous studies, one in 1921 and one in 1996 that reached the same conclusion (Ballard, 1921; Wijnolst and Wergeland, 2009) .

3. The correlation between prices cannot be adequately explained by coincidence of demand: the positive correlation persists in the cases where no correlation between demands was found or where negative correlations between demands was identified.
4. Correlations between demand and price are also in general significantly positive between products, with few exceptions. The strength of correlations suggests that the strongest influence on price in the period examined was generated by demand for container ships and tankers and the weakest influence derived from demand for dry bulk carriers. These influences were confirmed by subsequent linear regression analysis.
5. Strong positive correlations between prices for all products in all sectors and backlog measured in the market as a whole suggest that the mechanism for determining the value of units of capacity affects all sectors of the market. Backlog is highly significant for both buyer (for whom it is a measure of scarcity of capacity) and seller (for whom it is a measure of scarcity of orders) and takes into account both demand and shipyard capacity. Backlog was found to be a very strong determinant of price.
6. Correlation analysis therefore supports the EUs contention in *Korea – Commercial Vessels* that price suppression in one sector of the market may result from pricing in different sectors of the market.
7. Two specific cases of cross price effects were identified in the data using correlation. Firstly the price of small container ships was shown to have been significantly higher than would have been expected based on demand for the products themselves in the strong market period up to 2008. Secondly, the price of LNG tankers was found to be suppressed, compared to what would be expected on the basis of demand for the product itself, in the weak market following 2008.
8. Statistically significant relationships between demand for one product and price of another were identified using linear regression, confirming the presence of cross price elasticity in the commercial shipbuilding market, confirming that different products can be shown to be economically part of the 'same market'. Price for one product may be partially determined by demand for a different product, due to cross-elasticity between the two. In many cases

the elasticity of demand for the substitute was found to be stronger than elasticity of demand for the product itself.

9. Having said this, problems were encountered in the use of linear regression to identify cross price relationships because of multicollinearity resulting from correlations between demands for different products. Because of this it was only possible to identify the strongest cross price relationships as being statistically significant in the period examined. Additional influences may exist that could not be identified using this technique and the full extent of the ‘same market’ in commercial shipbuilding has not been established.
10. Cross price effects were strongest in the two larger sectors of the market (panamax and above) but significantly weaker in the small sector of the market. Only one of the four small products tested showed cross price effects and that was with demand for a product in the larger panamax sector.
11. Evidence for the need for strong technical substitutability in determining cross price relationships was weak. Whilst many of the relationships revealed did include a high degree of technical substitutability, others did not. The strongest example is the effect of demand for LNG tankers on the price of all other ship types in the large ship sector, with the exception of aframax tankers, but for which technical substitutability is low. This suggests that technical substitutability is a weak determinant of likeness in the commercial shipbuilding market.
12. In summary the statistical analyses provide evidence for cross price relationships in commercial shipbuilding and that influences act across all market sectors and all products, with few exceptions. In applying this conclusion, however, specific proof can only be provided in specific circumstances and each case would have to be assessed on merit pertaining to the market conditions and competitive relationships at the time of a complaint. It is not possible to generalise the findings of this dissertation.

8.6 Final conclusion

1. The thesis is found to be supported, that the international commercial shipbuilding industry is not fundamentally different to other industry sectors in that it can be defined and analysed to make it governable by WTO instruments that aim to regulate competition. This was achieved by

addressing the underlying issues relating to the nature of the market, which caused difficulty in *Korea – commercial vessels*.

2. It is hoped that these conclusions may assist in opening the way for future disputes that may arise but that might otherwise have been discouraged by the difficulties identified in 2003.

9. Recommendations for further work

A number of areas of further work are suggested by this research:

1. Investigation of the possible oligopoly effects on the shipbuilding market, generated through increasing concentration in the industry.
2. Consideration of the optimum form of shipyard investment, given the vulnerability of the high volume approach in relation to market volatility. Consideration of the viability of the strategies of the industries in Japan and South Korea and lessons that could be learned for the sustainability of the development of the industry in China are particularly important.
3. Consideration of the technical potential for flexibility of capacity to gain advantage from strong market conditions but also to minimise the dis-benefits that accrue in weak market conditions.
4. Further theoretical investigation of the empirical analysis of cross price elasticity presented herein and the limits of the ‘same market’ in commercial shipbuilding. Investigation of the relationship between backlog and price and its impact on cross price behaviour is particularly recommended.

10. Appendix 1: Generic ship size classifications (examples)

November 2011

Newcastle University

Typical ship principal dimensions

Revision 1

The following pages contain typical dimensions for the main classes of common ship types. The classes are ordered according to common usage in the shipping industry and the values are based on modern ships. The data is given without guarantee of accuracy, in particular relating to the estimates for Net Steelweight. (Sources: principal dimensions are based on vessels reported by Sea-Web. CB is calculated using displacement and principal dimensions. Steelweight estimates are from various sources)

Dry Bulk Carriers:

SHIP CLASS		L [m]	B [m]	T [m]	D [m]	Δ (tonnes)	C_B	DWT (tonnes)	GT (tons)	Design Speed [knots]	Approx. Net Steelweight (tonnes)
Handysize	10,000 - 39,999 dwt	179.5	27.2	10.2	14.5	39,353	0.771	27,307	20,619	15	3,800
Handymax	40,000 - 59,999 dwt	190	32.26	12.8	18.0	67,682	0.842	57,000	32,957	14.2	8,325
Panamax	60,000 - 99,999 dwt	229	32.26	14.45	20.05	94,590	0.864	82,188	42,917	14.5	12,200
Capesize	100,000 – 200,000 dwt	292	45	18.2	24.7	205,754	0.839	180,132	94,008	14.5	27,200
VLBC	> 200,000 dwt	360	65	23	30.4	448,479	0.813	400,000	201,000	14.8	NA

Tankers:

SHIP CLASS		L [m]	B [m]	T [m]	D [m]	Δ (tonnes)	C_B	DWT (tonnes)	GT (tons)	Design Speed [knots]	Approx. Net Steelweight (tonnes)
Small	10,000 - 29,999 dwt	128.60	20.4	8.7	11.5	17,472	0.747	13,100	11,600	14	5,500
Handymax	30,000 - 59,999 dwt	183	32.2	12.2	18.8	56,242	0.763	46,803	29,335	14.6	8,500
Panamax	60,000 - 79,999 dwt	228.48	32.2	14.47	20.9	89,093	0.817	74,999	42,000	16	11,100
Aframax	80,000 - 119,999 dwt	243.8	42	14.92	21.3	124,873	0.797	107,529	60,205	15	14,000
Suezmax	120,000 - 199,999 dwt	274	48	17	23.2	183,150	0.799	158,000	81,500	15.5	20,500
VLCC	>200,000 dwt	333	60	22.5	30.4	362,931	0.788	318,000	161,500	14.4	38,400

Container Ships:

SHIP CLASS		L [m]	B [m]	T [m]	D [m]	Δ (tonnes)	C_B	DWT (tonnes)	GT (tons)	TEU	Design Speed [knots]	Approx. Net Steelweight (tonnes)
Feeder	100 – 499 TEU	112.5	18.2	6.712	8.7	9,486	0.673	7,040	4,914	420	15	1,550
Feedermax	500 – 999 TEU	139.95	21.5	8.42	11.65	17,715	0.682	12,500	9,900	766	17	2,750
Handy	1,000 – 1,999 TEU	167.24	25	9.5	13.4	27,200	0.668	20,147	14,856	1,388	17.25	4,900
Sub-Panamax	2,000 – 2,999 TEU	211.85	29.8	11.4	16.7	46,256	0.627	34,325	26,638	2,578	22	9,000
Panamax	3,000 – 4,999 TEU	268.8	32.2	12.5	19.1	69,845	0.630	52,300	42,609	4,178	24.8	14,600
Post-Panamax	>4,999 TEU	334	48.2	14.5	24.8	135,536	0.566	101,200	91,051	8,500	25.6	30,000
Emma Maersk	15,550 TEU	397.71	56.4	16.02	30.2	218,788	0.594	156,907	170,794	15,550	24.5	NA

11. Appendix 2 – Development of research in maritime economics

Maritime economics is relatively young as a specific research discipline, the origins dating, according to Heaver, to 1973: *"the first year of publication of the journal Maritime Studies and Management, changed in 1976 to Maritime Policy and Management*" (Heaver, 2012, p. 18), although there were, of course, earlier researchers in the field, notably Isserlis and Tinbergen working in the 1930s and Metaxas and Zannetos working in the 1960s and 1970s. Zannetos was particularly influential in developing modern economic theories of shipping markets in his work on the tanker markets published in 1966 (Zannetos, 1966).

Early researchers faced a significant barrier in that data was scarce. They were also faced with a bewildering complexity of routes and commodities, in the era prior to the consolidation of dedicated bulk trades and before consolidation of liner and tramp cargoes into containers. Isserlis's paper "*Tramp Shipping, Cargoes and Freights*" from 1938 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…"* (Isserlis, 1938). This apparently disparate array of goods was consolidated into a series of freight rates and indices, although Isserlis points out that he was not the first to achieve this, noting the first use of such indices being in 1904. Isserlis's contribution was to develop the indices into a coherent and extensive set of time series'.

In the discussion of Isserlis's paper, the President of the 'Royal Statistical Society', to which the paper was presented, notes: *"Dr Isserlis has performed an enormous task in giving us chain-indices for freights on all important commodities and routes for 68 years, a task which justifies the epithet 'monumental'".* These statistics enabled cycles in freight volumes and freight rates and their primary causes to be clearly identified, a subject much extended in recent times by Stopford (Stopford, 2009), and showed volatility that would be recognisable in modern statistics, although forecasting of future market states was found to be intractable: *"The fact remains that it is comparatively easy to find explanations for the various stages of a trade cycle that is past, and that it is impossible to predict correctly the occurrence of the successive phases of a cycle which is in progress, and still more so in the case of a* *cycle that has yet to commence"* (Isserlis, 1938). This statement strikes a chord with modern maritime economics, with forecasting remaining elusive, and Isserlis's paper presents a wide range of statistics that, whilst not without critics both at the time of publication and in more recent times (Klovland, 2002), can be seen as seminal in the context of future industry reports such as the annual UNCTAD Review of Maritime Transport. The paper also considers the link between *"futures"* in the cotton and grain markets and forward freight rates, demonstrating further prescience relating to subjects that exercise the minds of maritime economists in the modern era.

A further issue to face the early researchers is also identifiable in the discussion section of Isserlis's paper, where a representative of the *"Tramp Shipping Administrative Committee"*, that is a representative of the ship owners, demonstrated scepticism bordering on hostility in relation to the use of statistics to describe the fortunes of the shipping industry, stating: *"If statistics were published, they should have some relative value to the conditions of an industry"*. The reluctance of ship owners to be measured by statistics would be a recurring theme up to the 1980s. For example, Zannetos notes in his preface: *"Oil companies collect some data for their internal purposes but often consider what they have as proprietary. Moreover, the information that is available in any one place is usually segmented or specialized, and cannot be readily put together into meaningful time series"* (Zannetos, 1966, p. vii). The importance of Isserlis's contribution would be confirmed by the widespread use of freight indices in future eras. The usefulness of indices was summarised succinctly by a commentator on Isserlis's paper as: *"he need not believe that the statistics were absolutely true, but that they might be taken to have a general aggregate truth".*

In the discussion of Isserlis's paper at the Royal Statistical Society meeting at which it was presented, a contributor noted that *"Dr Isserlis was forced by present circumstances to forage for information"* and another that: *"The statistics were extremely important, but extremely difficult to produce, and the information could not be supplied every year or so. To his mind it was astonishing that shipowners should have been willing to reveal so much of the particulars of their business as they had done"*. Scarcity of data would remain a problem for researchers for many decades. In a controversial (at the time) book that sought to answer the question: *"why has the tonnage of ships registered in the United Kingdom declined from over 45% of the* *world total in 1900 to about 16% of the total in 1960?"* (Sturmey, 1962), British economist S.G. Sturmey wrote of the difficulties he faced in answering this question: *"shipping is not an industry which enjoys scrutiny and, having its own answers to the disparity between the growth rates of British and world shipping, has been loath to lift, to an outsider, the traditional veil of secrecy which shrouds so many of its operations…and facilities do not exist to enable an outside research worker to collect such data"* (*ibid*., p.3). Writing thirteen years later in a book titled 'Shipping Economics', the same author indicated that since his initial research was published the situation had at least started to change: *"there has been a recognition of the need for more research into all aspects of ship operating, including that necessary to determine trade trends and predict changes"* (Sturmey, 1975, p. 7). Improvements were slow, however. In this latter book Sturmey notes that the President of the Chamber of Shipping had, in his presidential address in 1974, stated: "*This is an age when professors and economists seated in their studies surrounded by statistics and other data but, I am afraid, insulated from the hard facts of life, can reach some astonishing conclusions"* (*ibid*., p.2). This has direct echoes of Isserlis's efforts forty years earlier and the reluctance of the 'old guard' of the shipping industry to open up data to analysis is only very thinly veiled in this statement. It is interesting to note that Sturmey's 1975 book contains very little data or analysis in 255 pages of collected papers and articles. It is not a book on shipping economics that would be recognised as such today.

Notwithstanding some residual reluctance in the shipping industry, relating to the availability of data, the situation had definitely begun to change by the mid-1970s. Writing in 1977, R.O. Goss pointed out that a decade earlier: *"it was possible to complain that, although Britain had been a major maritime power for a very long time, it had produced no school of writers on the economics of sea transport. Today, the situation is changing rapidly"* (Goss, 1977, p. 1). Goss goes on to quote from Fairplay Magazine of 22nd August 1973 where an editorial remarked: "*twenty years ago the number of academics interested in shipping could have been counted in a telephone kiosk"* but notes then that *"today the volume of research in progress is so great that a periodic index is needed"* (*ibid).* Goss then went on to note the difficulty of "*quantification"* in the research at the time because of reluctance of the industry to make data public. In discussing the development of modern shipping Goss notes that *“the failure to collect and present primary data, to analyse them and to publish the results led, however, to many mistakes being made, and an entirely unnecessary level of risk for shipping companies”* (Goss, 1977, p. 27). At the time Goss reported that the industry was sceptical of data analysis because the data appeared to be too variable to yield generally applicable results but also noted that *“it is the variations themselves which are important, and which need comparison in economic, and not only in physical, terms”* (Goss, 1977, p. 31). This comment turned out to be prescient indeed.

Heaver points out in relation to research prior to 1939 that: “The focus..was on technology. It was not until after World War II that the application of formal economic analysis to the selection of ships was encouraged” (Heaver, 2012, p. 17). The exceptions to this were Tinbergen, who applied mathematical analysis to the cycles seen in tanker markets in 1933/34 and Koopmans who developed the ‘transport algorithm’ as a special case in linear programming, in looking at the problem of shipping in the North Atlantic in WWII (Ibid, pp 19,20).

The important topics discussed by Goss in 1977 were predominantly about the economics of ship design and operation. Much of the discussion was based on the experience of the researchers, with some data and analysis to support the conclusions. The methodologies remained largely similar in a summary of “*Current issues in maritime economics”* published in 1993 (Gwilliam and Molenaar, 1993) but research had firmly moved from ship operation to the economics of shipping, shifting from the economics of ships and their operation to the economics of seaborne trade and supporting industries. By this time data analysis techniques had also improved. Globalisation had increasingly become the driver of the industry and was therefore the subject of research and the economics of competition had also become of significant interest. Focus was also coming to bear on the microeconomics *“concerning the decision processes of firms in this changing shipping world”* (Gwilliam and Molenaar, 1993, p. 5). Forecasting of supply and demand by sector was of interest to assist ship operators in every day decisions and more sophisticated econometric modelling was being introduced (Strandenes, 1984; Strandenes, 1986). The pricing process in the volatile bulk markets (the determination of freight rates and asset values) had also become of interest. Gwilliam and Molenaar describe the *“developing techniques”* that were consequent on the availability of more capable computer software, and also the improving availability of shipping data to analyse in those models (although this latter point is not mentioned specifically by the authors) and "*the extension of forecasting models to the dynamics of the market, notably joint responses of investors to initial market outlooks. The weak element thereof remains the behavioural equations"*(Gwilliam and Molenaar, 1993, p. 6). The methodologies adopted in the papers published in that book remained similar to those used by Goss 16 years previously, that is to say drawing conclusions based on a thorough analysis of the systems and causative relations, supported by data analysis.

The subject was enhanced in 1993 by the publication of Beenstock and Vergottis's influential book *Economic modelling of world shipping* (Beenstock and Vergottis, 1993), building on work that the authors had started to publish in the 1980s. Beenstock and Vergottis themselves noted that little up to that time had changed since publications by Tinbergen in 1931 and 1934, and Koopmans in 1939, which defined "*what might be called the classical econometric approach to modelling shipping markets"* (Cullinane, 2005, p. 20), although this is perhaps less than objective given the work published by Strandenes and others since the 1970s. A good example can be seen in the work published by the Norwegian School of Economics and Business Administration (Strandenes, 1984), modelling the bulk markets. In this publication Strandenes notes that the model is *"an updated version of the original analysis published by Eriksen and Norman (1976)"* (*ibid*.).

As predicted by Goss in 1977 and as mathematical and computer capability developed, coupled to the increasing availability of data, after this time it became variability itself that was of greatest interest to many maritime economists. In particular the evaluation of volatility and the assessment of financial risk for ship operators became central to the discussion. In commenting on Beenstock and Vergottis's work, Glen and Martin note that: *"The key feature of this work..is not in the econometrics rather it is in the seminal development of a coherent explanation of ship price behaviour" (Cullinane, 2005, p. 26)*, referring to second hand value in particular. The development of data, computers and modelling techniques were therefore being brought to bear on the problem identified by Isserlis in 1938, although the uncertainties remain despite improved methodologies, data and equipment for analysis.

In a more recent update of the main issues relating to maritime economics published in 2005, Cullinane discusses that in the previous 20 years the analysis of shipping markets has progressed from a "*hypothesized causality and structural modelling* [approach]*" to "methodologies revolved around data-driven approaches that focus on the statistical properties of market data and determining reduced form dynamic relations therein" (Cullinane, 2005, p. 3)*. Whilst this approach tends to be widely used, there is some question about its ability to provide real insight and the resulting work sometimes tends to be long on statistical detail and short on causality and pragmatic conclusions that relate to the real world, in particular taking into account that markets are constituted above all by human beings and are not simply statistical constructs. In discussing the history of modelling in maritime economics, Cullinane goes on to summarise Glen and Martin, who contribute a chapter to the book, as follows: *"One of the…conclusions that Glen and Martin draw from their survey of the literature and ensuing empirical analysis is that the contemporary reliance on data-driven methodologies does not yield the same insight or depth of understanding that may be derived from approaches based on structural modelling* [and]… *it may be time to revert again to a more traditional approach" (Cullinane, 2005, p. 4)*. This appears to be advocating a shift back from an over-reliance on inductive analysis of statistics to a more deductive approach where theories are derived from a broader range of research methodologies, with statistical analysis providing a supporting role, rather than leading. Without considering causation the reductive reporting of statistics is limited as to what it can add to the understanding of the subject and it is not possible to be sure of the significance of the statistics reported.

The empirical approach to shipping market analysis questioned by Cullinane is in some cases neither deductive (no theory is proposed to be tested by the statistical analysis) nor inductive (very little theory of causation is developed based on the data collected) and the move back to "*a more traditional approach"* suggested by Cullinane appears to be suggesting a return to the more broadly based research philosophy and approach of the eras of Goss, and Gwilliam and Molenaar discussed earlier.

12. Appendix 3 – The World Trade Organization (WTO)

The WTO is a surprisingly young organisation, established by the "Marrakesh Agreement Establishing the World Trade Organization", 15th April 1994, which concluded the "Uruguay Round" of the General Agreement on Tariffs and Trade (GATT) which lasted from 1986 to 1994. It is located in Geneva and counted 154 member states as members at 2nd March 2013 (World Trade Organization, 2013b). The WTO was established in response to a widely perceived need for a legal framework to regulate trade in the context of increasing globalisation. The aim of this framework is to protect the interests of weaker countries seeking to develop their economies and to assure access to global trade that is as free as possible from restrictive practises. The need for the WTO's foundation is summarised by Bossche as follows:

"*One of the defining features of today's world is the process of economic globalisation, with high levels of international trade and foreign direct investment. There is a broad consensus among economists and policy-makers that economic globalisation in general and international trade in particular offer an unprecedented opportunity to reduce poverty significantly worldwide.*

However, to ensure that this opportunity is realised, economic globalisation and international trade have to be 'accompanied' by good governance in developing countries and more development assistance from developed countries and have to be managed and regulated at the international level. If not, economic globalisation and international trade are likely to be a curse, rather than a blessing to humankind, aggravating economic inequality, social injustice, environmental degradation and cultural dispossession. Managing and regulating economic globalisation and international trade so that they benefit all is one of the prime challenges of the international community in the twenty first century" (Bossche, 2008, p. 2).

The WTO's own summary of the function of the organization includes the following:

"*At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations. These documents provide the legal ground rules for international commerce. They are essentially contracts, binding governments to keep their trade policies within agreed limits. Although negotiated and signed by* *governments, the goal is to help producers of goods and services, exporters, and importers conduct their business, while allowing governments to meet social and environmental objectives.*

The system's overriding purpose is to help trade flow as freely as possible — so long as there are no undesirable side effects — because this is important for economic development and well-being. That partly means removing obstacles. It also means ensuring that individuals, companies and governments know what the trade rules are around the world, and giving them the confidence that there will be no sudden changes of policy. In other words, the rules have to be 'transparent' and predictable" (World Trade Organization, 2013b).

The law of the WTO is made up of a complex set of rules, at the heart of which "*five groups of basic rules can be distinguished: (1) rules of non-discrimination; (2) rules on market access; (3) rules on unfair trade; (4) rules on the conflict between trade liberalisation and other societal values and interests; and (5) institutional and procedural rules, including those relating to WTO decision making, trade policy review and dispute settlement*" (Bossche, 2013, p. 35).

The group of regulations appertaining to this dissertation are the third in the above list, regarding unfair trading practices. Bossche goes on to summarise this sector as follows:

"*WTO law, at present, does not provide for general rules on unfair trade practices, but it does have a number of detailed rules that relate to specific forms of 'unfair' trade. These rules deal with dumping and subsidised trade.*

Dumping, i.e. bringing a product on to the market of another country at a price less than the normal value of that product, is condemned but not prohibited in WTO law. However, when the dumping causes or threatens to cause material injury to the domestic industry of a Member producing a 'like' product, WTO law allows that Member to impose anti-dumping duties on the dumped products in order to offset the dumping…

Subsidies, i.e. financial contributions by governments or public bodies that confer a benefit, are subject to an intricate set of rules. Some subsidies, such as export and import substitution subsidies, are, as a rule, prohibited. Other subsidies are not *prohibited but, when they cause adverse effects to the interests of other Members, the subsidising Member should withdraw the subsidy or take appropriate steps to remove the adverse effects…If a prohibited or other subsidy causes or threatens to cause material injury to the domestic industry of a Member producing a 'like' product, that Member is authorised to impose countervailing duties on the subsidised products to offset the subsidisation*" (Bossche, 2013, p. 38).

It was within the ambit of this section of the WTO rules that the European Union in 2003 raised a case of unfair trade practices against South Korea relating to the uneconomic pricing of commercial ships in the international market, which it was alleged was supported by the South Korean government and caused harm to the EU's shipbuilding industry. There were a number of problems in the prosecution of a shipbuilding case that can be seen as inherent in a careful reading of the quotations above. Firstly, how does one define the term 'like product' in shipbuilding? This is a significantly more complex concept than it at first appears and the meaning of the term is continuously being defined through case law (panels place emphasis on the application of previous judgements in making their decisions). Put simply, how can an oil tanker be shown to be 'like' a container ship? Secondly how can one demonstrate harm to a competing national industry when the international nature of the commercial shipbuilding industry means that the products are sold into a global market and not specifically imported into the complaining Member's country (or region in the case of EC)? Finally the very existence of a "commercial shipbuilding market" as an entity was brought into question.

13. Appendix 4 – EC and WTO legislative definitions of the commercial shipbuilding market

Definition 1: European Commission in the Framework on State Aid to Shipbuilding (European Commission, 2011)

> "(a) '*shipbuilding' means the building, in the Union, of self- propelled commercial vessels;*
>
> *(d)[18] 'self-propelled commercial vessel' means a vessel that, by means of its permanent propulsion and steering, has all the characteristics of self-navigability on the high seas or on inland waterways and belongs to one of the following categories:*
>
> *(i) seagoing vessels of not less than 100 gt and inland waterway vessels of equivalent size used for the transportation of passengers and/or goods;*
>
> *(ii) seagoing vessels of not less than 100 gt and inland waterway vessels of equivalent size used for the performance of a specialised service (for example, dredgers and ice breakers);*
>
> *(iii) tugs of not less than 365 kW;*
>
> *(iv) unfinished shells of the vessels referred to in points (i), (ii) and (iii) that are afloat and mobile;*
>
> *(e) 'floating and moving offshore structures' means structures for the exploration, exploitation or generation of oil, gas or renewable energy that have the characteristics of a commercial vessel except that they are not self-propelled and are intended to be moved several times during their operation".*

This definition is virtually identical to that in the previous (2003) version of this framework except that sub-paragraph (e) has been added to cover the trend for shipyards to diversify activity into the offshore sector. It is also important to note that

[18] Sub-paragraphs *(b)* and *(c)* refer to definitions for shipbuilding and conversion and are not included in this quotation.

a useful part of the definition that was included in the 2003 and previous versions of the framework has been removed, the paragraph being as follows:

"For the purposes of the above, 'self-propelled seagoing vessel' shall mean a vessel that, by means of its permanent propulsion and steering, has all the characteristics of self-navigability on the high seas. Military vessels (i.e. vessels which according to their basic structural characteristics and capability are specifically intended to be used exclusively for military purposes, such as warships and other vessels for offensive or defensive action) and modifications made or features added to other vessels exclusively for military purposes shall be excluded, provided that any measures or practices applied in respect of such vessels, modifications or features are not disguised actions taken in favour of commercial shipbuilding inconsistent with State aid rules;"

This makes the important distinction that prior to 2011 naval vessels were excluded from the EC definition of the commercial market. It is proposed to retain this exclusion in the definition used in this dissertation, because military and commercial vessels rarely compete for the same units of capacity. It can also be seen in this definition that inland waterway vessels are included. This is appropriate because they may compete for capacity with sea-going vessels.

Definition 2: OECD in the "OECD Agreement" (OECD, 1994)

> "1. *This Agreement covers the construction and repair of any self-propelled seagoing vessels of 100 gross tons and above used for transportation of goods or persons or for performance of a specialised service (for example, ice breakers and dredgers) and tugs of 365 kW and over.*
>
> *2. This Agreement excludes:*
>
> *a. military vessels and modifications made or features added to other vessels exclusively for military purposes. This exclusion is subject to the requirement that any measures or practices taken in respect of such vessels, modifications or features are not disguised actions taken in favour of commercial shipbuilding and repair inconsistent with this Agreement. If a Party considers that this requirement has not been met, it may, without prejudice to its rights to initiate the other procedures foreseen in this Agreement, request further*

information, which the other Party shall co-operate to provide as fully and quickly as possible.

b. fishing vessels destined for the building or repairing Party's fishing fleet. This exclusion is subject to the requirement that the Party provides full transparency in accordance with Article 4.

3. For purposes of this Agreement:

a. a vessel is considered "self-propelled seagoing" if its permanent propulsion and steering provide it all the characteristics of self-navigability in the high seas;

b. "repair" includes, inter alia, conversion and reconditioning of self-propelled seagoing vessels as defined in subparagraph (a) above; and

c. "military vessels" are vessels which according to their basic structural characteristics and ability are intended to be used exclusively for military purposes."

It can be seen that the basic definition coincides with the EC definition, including vessels above 100GT or 365 kW in the case of tugs, and excludes military vessels (although with the proviso noted above that this has been excluded from the latest EC definition and with the caveats that this exclusion may be waived in the OECD case under certain circumstances). Beyond this the OECD definition excludes fishing vessels and inland waterway vessels, although on the factor market argument this is inappropriate for a definition of a shipbuilding market as these ships will compete for capacity alongside cargo carrying and seagoing vessels. It can also be seen that the OECD definition does not cover the offshore products envisaged by the EC in the latest draft of the framework, for the reason that the OECD agreement was drafted before the construction of such products became more common in shipyards.

14. Appendix 5 – Industry definitions of the commercial shipbuilding market

For commercial data providers the market is primarily constituted by larger vessels (typically over about 5,000 GT) involved in transporting cargo, plus sometimes other sectors such as cruise and ferry, offshore supply and other specialist vessels. Some recent examples include:

- Clarkson Research in its publication "World Shipyard Monitor" includes detailed information on bulk vessels (wet and dry) over 10,000 dwt only. For the other ship types included, no lower size limit is given but the coverage is predominantly of larger ships: gas carriers, cruise, roro ferry, container ships. OSV are included in addition and a category described as "others", which includes multi-purpose, reefer, pure car carrier and ro-ro cargo (Clarkson Research, 2014). Whilst no lower limits are given in some sectors, it is clear that the data provided in this source addresses the large steel payload-carrying sector, plus offshore supply.
- Astrup Fearnley's weekly report on newbuilding activity tracks only vessels of handysize and above (Fearnleys, 2014).
- The annual 'Platou Report' in the section on newbuilding includes only tankers, bulk carriers, container, gas, car carriers, chemical tankers and cruise ships.
- A report produced by the consultancy 'Worldyards' commissioned in 2012 by OECD to support discussion of 'market distorting practices' at a special session of WP6 (OECD Working Party 6, 2012b) includes "*commercial vessels above 1500 dwt trading internationally"* and specifically excludes offshore tonnage.   This deadweight limit will exclude workboats such as tugs and fishing vessels and other small vessels such as inland waterway craft.

The building of workboats and small ship types, with the exception of OSV in some sources, is generally ignored in the routine reporting and analysis of the industry. There are some exceptions to this. For example, SeaEurope (incorporating The Committee of European Shipyards' Associations and European Marine Equipment Council) include a category '*NCCV'* (non-cargo-carrying-vessels) in their annual statistical review, because this sector is of significant importance in the modern

European industry, although no size limits or scope are indicated by the organisation. This is the exception, however, and the question arises as to whether the general industry view of the commercial shipbuilding market is correct in only taking into account a limited number of ship types and sizes in the context of what could be constituted as a coherent market?

Industry sources provide an important lead in the definition of products, in that products are classified in terms that the shipping industry uses them (derived from the characteristics of ‘parcels’ of cargo, in terms of the form of the cargo and the quantity, that are typically shipped (Stopford, 2009, p. 58 to 60)). For example a dry bulk carrier of 80,000 dwt with 32.2 m beam is effectively the same product as one of 83,000 dwt with 32.2m beam: both are panamax bulk carriers in shipping industry nomenclature and are directly substitutable. Examples of the products and definitions commonly included in published data sources are included in Appendix 1, compiled by the author from numerous sources. The definition of products in terms of industry usage provides an important framework for use in analysis. This is not only because it helps greatly in the analysis and definition of ‘like product’ but also because it reduces the variety of potential products in analysis and greatly clarifies the picture derived. The size limitation and the exclusion of certain ship types that is common in commercial data have to be questioned in the total context of the commercial market, however. Yachts and fishing vessels, for example, do compete with cargo-carrying ships for capacity and thereby have to be considered in a market definition.

At the most detailed level, Lloyd’s Register (LR) uses a taxonomy (adopted by Sea-Web, the fleet data source used in this analysis) that at the most detailed (fifth) level includes 110 classifications of ship, not counting two instances of the word “*etc.”* in the classifications. This taxonomy is shown to the fourth level in Figure A5.1.

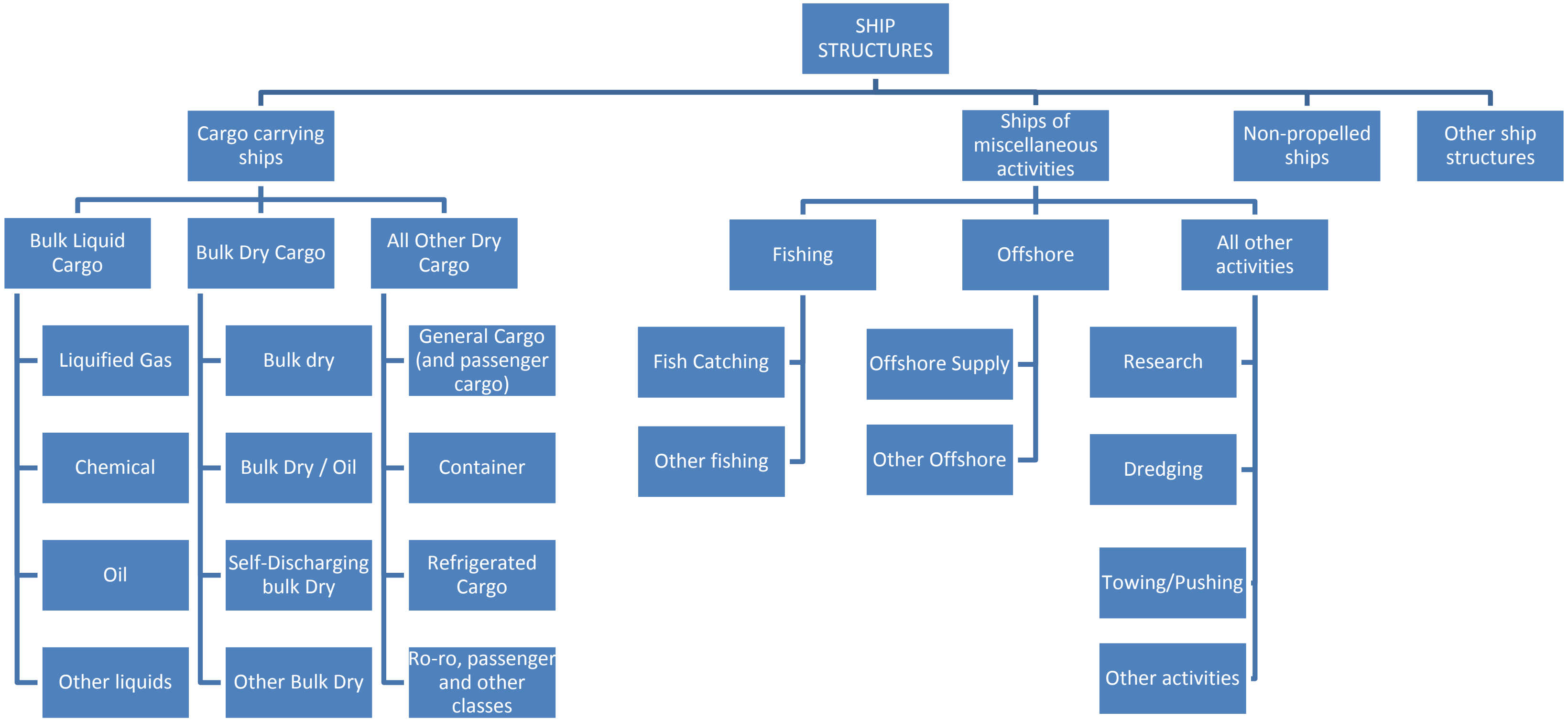


Figure A5.14.1 – Summarised Lloyd's Register ship type taxonomy to the fourth level (source: analysis of information contained in LR publications)

In the strictest definition of the market for commercial vessels it would not be possible to eliminate any of these classifications. None of the ‘cargo carrying’ sector could be excluded from a generalised model of the “*commercial vessel”* market, and virtually all the miscellaneous side of the diagram in Figure A5.1 would also have to be included.   The classification “Other ship structures”, for example, includes yachts, which have already been discussed as being at least in part relevant to the market. Similarly, “non-propelled ships” may compete with the cargo carrying ships for capacity and cannot be excluded. Only two categories at the fifth level appear to be unsuited to the analysis of a market for *“commercial vessels”*, being patrol vessels under the ‘other activities’ classification and ‘naval auxiliary ship’ under ‘other ship structures’, both being naval type vessels and therefore generally subject to political decisions in terms of build location and acceptability of price[19].

In general, therefore, it is proposed to use the vessels included within LR’s taxonomy to define the products within a *“commercial market”*, with the limited exclusions noted above. Ships included in LR’s database will be grouped by common industry usage as described in relation to commercial data providers.

[19] The UK Government’s ordering of four replenishment tankers from DSME of South Korea on 2012 may appear as an exception to this conclusion. It should be kept in mind, however, that DSME is a warship builder as well as a commercial shipbuilder and the vessels will only partially be using commercial shipbuilding capacity. This order may also be seen as a test for the UK Government, rather than a permanent future commitment to the building of naval auxiliaries outside of the UK.

15. Appendix 6 – The development of economy of scale

A: The pursuit of volume

To demonstrate the progress of the pursuit of volume in commercial shipbuilding Figure A6.1 presents the output from the world's largest shipyards at the start of each decade from 1960, with output measured by both Gross Tons and number of ships delivered.

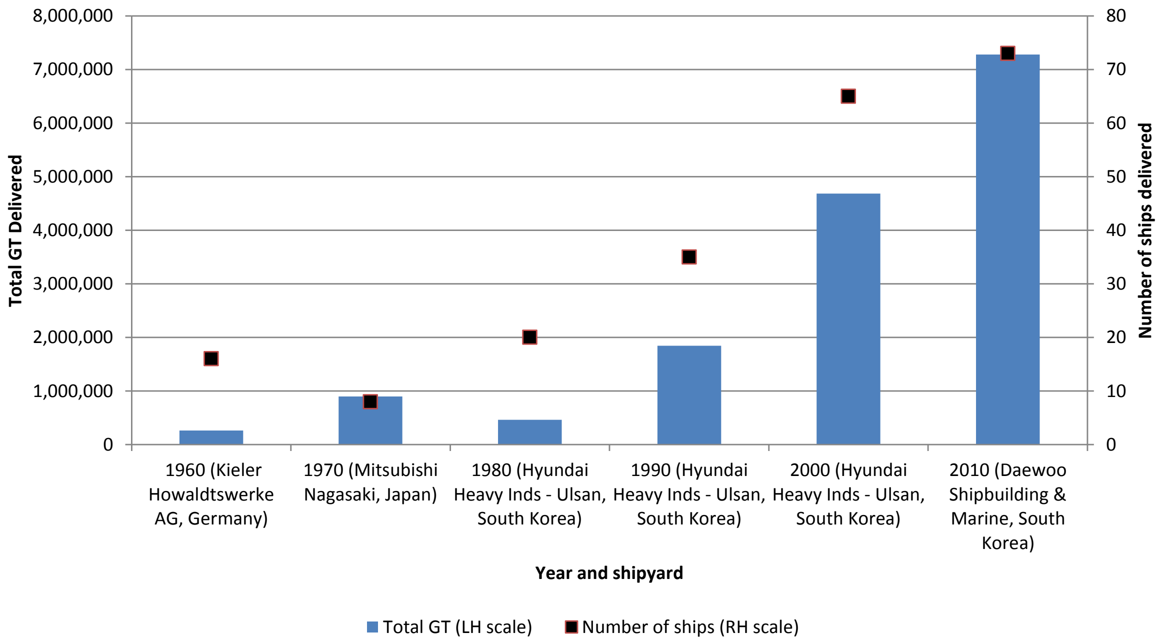


Figure A6.15.1 – Largest commercial shipbuilders by decade (output in the year indicated – data sourced from Sea-Web)

The movement of the market lead from Europe in 1960, through Japan in the 1970s to South Korea following 1980 can be seen in this Figure. What can also be seen is that the largest shipyard in 2010 produced 28 times the gross tonnage of the largest yard in 1960 and almost five times as many ships. It can also be seen that the pace of investment in volume picked up significantly after 1990, facilitated by the continuous growth in demand that developed between then and the market crash in 2008.

The output statistics in Figure A6.1 are, of course, affected both by the investment in shipbuilding capacity and the state of the market. The output at the start of each decade is, apart from the notable exception of the peak around 2011, at relatively low points in the market. It might be argued that a more rigorous analysis of the development of volume would compare the situation at the two peaks, comparing 1975 with 2011. This is done in figure A6.2.

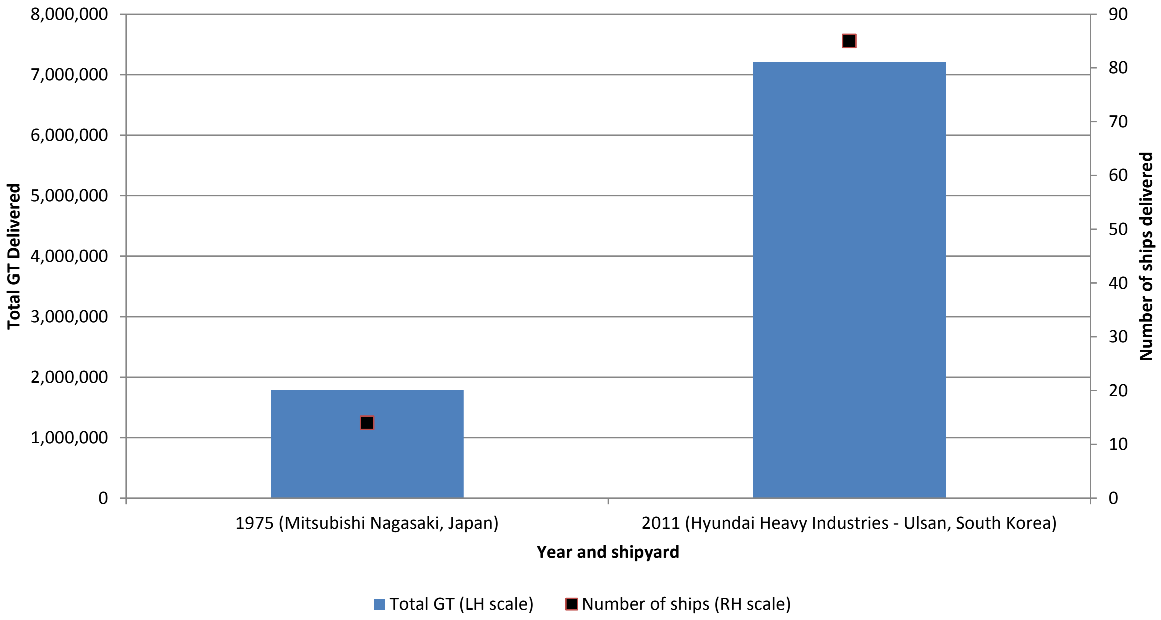


Figure A6.15.2 – Largest commercial shipbuilders comparing peak outputs in 1975 and 2011 (data sourced from Sea-Web)

The comparison of the peaks shows that the largest shipyard in the most recent peak produced four times as much tonnage and six times as many ships as the largest tanker factory[20] at the height of the previous peak. It may be argued that Mitsubishi Nagasaki's output of 14 VLCCs in 1975 was the furthest extent of the single product mass production factory in the modern era (ignoring wartime production in the United States).

Whilst a mass production single-product facility, such as Mitsubishi Nagasaki in the 1970s, is a seductive concept, given the potential productivity gains available from absolute standardisation of the product and development of production facilities to suit, it is not possible in reality that such a shipyard can be sustainable due to market shifts between products over time. Gains in productivity will be offset by under-utilisation in poor market conditions and flexibility to build a range of compatible ship types is therefore vital to achieve sustainable volume. To illustrate the dangers of over-specialisation, Figure A6.3 shows the total output of VLCCs from 1968 up to the

[20] Mitsubishi Nagasaki was series building only VLCCs in 1975 and could be said to be the inventor of this ship type, building the first crude oil tanker over 200,000 dwt, MT '*Berghus*', in 1967

present day, in terms of number of ships, with a reference line showing Mitsubishi Nagasaki's peak output in 1975.

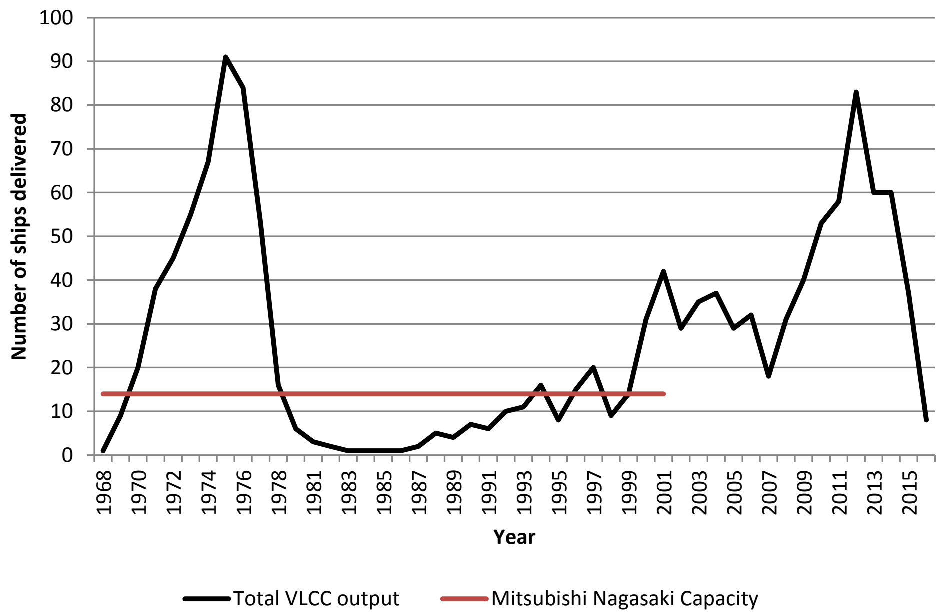


Figure A6.15.3 – Global output of VLCCs (data sourced from Sea-Web)

The production of VLCCs peaked during the initial phase of development in the 1970s, with 91 ships delivered in 1974 and Mitsubishi Nagasaki having about a 15% market share. The peak was short lived, however, with around six years of high demand between 1969 and 1976. Thereafter the market disappeared for around 15 years, providing very little and sometimes no demand for products from a dedicated VLCC factory. Following the crash in demand for tankers in 1978, Mitsubishi switched to being a more flexible shipyard, building a range of tankers, LNG carriers, bulk carriers and container ships. There is therefore illustrative of an economic imperative, due to the nature of the market, that a unit of shipbuilding capacity has to be flexible between products to adapt to market shifts and that comparison of likeness on the basis of ship type is not representative of the nature of the industry. Like products, each of which is compatible with a shipyard's capacity and determinants of competitiveness, have to exist for a shipyard to survive.

It would be wrong, however, to give the impression that the pursuit of volume implies that all shipbuilders have tried to achieve the highest levels of throughput as achieved in these largest shipyards. Very large shipyards are the exception rather than the norm in modern shipbuilding and it is likely that the very large size of modern market-leading yards may not be optimum, given the high cost of supporting such capacity in cyclical downturns. This is recommended for further study. In the five years of the peak of output from 2008 to 2012 the largest shipyard produced an output of over 82 ships per year whilst the average yard only 3.2 ships per year and the average value in the upper quartile of yards was 10.25 ships per year.   Perhaps most startlingly, 56% of shipyards delivered one ship or fewer per year over the peak period. It is of significance, however, that only 25% of these small yards (by output) have managed to win any orders in the post-crash period since 2008, compared to 68% of shipyards producing more than one ship per year. The average throughput of these more successful shipyards over the peak five years was just under 6 ships per year and they produced around ten times as much shipbuilding work (CGT), indicating a focus on more sophisticated ship types. This is illustrated in Figure A6.4, showing the average output in terms of CGT and number of ships over the peak period, along with average ship size represented by bubble diameter.

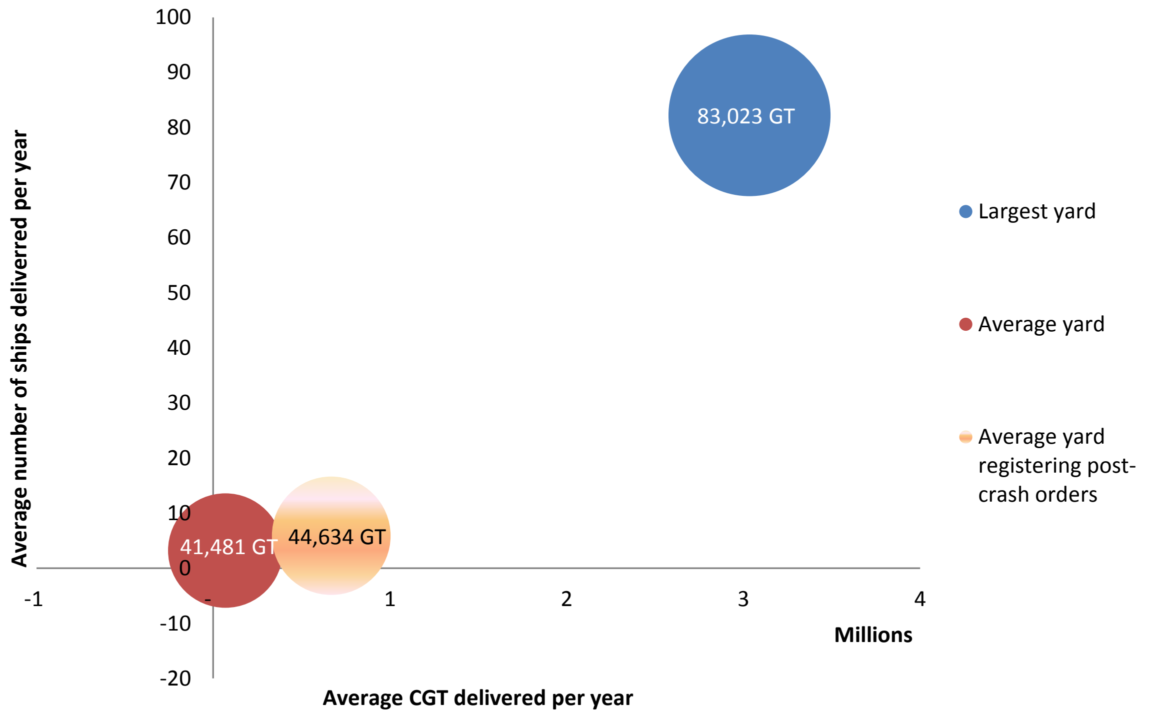


Figure A6.15.4 – Average annual output per shipyard over the period 2008 to 2012 (bubble size represents average ship size in GT – data sourced from Sea-Web)

Whilst very large shipyards remain the exception, the pursuit of volume (for most on a smaller scale) has been a general feature of the development of shipbuilding over the past fifty years. This is shown in Table A6.1, comparing the average output per year in the five years from 1960 to 1964 with the five years around the peak in the mid-1970s (1973 to 1977) and the five years discussed above.

Period	All yards (number of ships per year)	Yards taking orders post-crash only (number of ships per year)
1960 to 1964	2.0	NA
1973 to 1977	2.4	3.0
2008 to 2012	3.2	5.9

Table A6.15.1 – Average annual output for average shipyards producing vessels over 5,000 GT

It can be seen from this table that the average output for yards surviving the crash has doubled from the post-peak period in the 1970s.

The effect of economy of scale on competitiveness is two-fold. Firstly it enables investment, overhead and other general costs to be spread more economically over a larger workload. Secondly, it generates buying power for the shipyard particularly if the makers list, that is the list of equipment suppliers, is controlled. This allows the shipyard to develop a strong supply chain and enables the material cost to be reduced. .

It would follow that the larger the shipyard the greater the competitive advantage that could be gained from these sources, provided that sufficient work can be maintained to utilise the expensive capacity developed. This caveat identifies what might be regarded as a 'double-edged sword' characteristic of the strategy, given the variable nature of demand in the largest sector of the market. The vulnerability of such strategies relates to the imperative to keep capacity occupied in a market downturn or to fill newly developed capacity and this mechanism was at the core of the EC's arguments in the WTO case. The conflict between investment to reduce costs and the need to minimise costs in a downturn, in other words to minimise the overhead and financing burden that remains once output has turned down, has been well known for a long time. Pollard and Robertson in their book on British shipbuilding between 1870 and 1914 state about shipbuilding at that time: *"British yard owners were able to take advantage of their more highly skilled workforces by investing only in equipment that was absolutely necessary to manipulate the large, heavy, and hard components of modern ships, and by refusing to purchase as many labour-saving machines as German and American builders did. Thus the conservatism of the British was motivated not by a shorter time horizon or an irrational distrust of innovation, but by an awareness (which the less experienced German and American builders did not share) of the* [cyclical] *hazards of the industry"* (Pollard and Robertson, 1979, p. 29). Whether this was a wise strategy in the long run is highly debatable, given the long slow demise of the British industry after this time and given that skilled labour costs tended to rise significantly as the market rose, diminishing the advantage of the strategy in the long term. As pollard and Robertson state of this problem: *"The difficulties were never satisfactorily resolved"* (*ibid*.). The most successful strategy has possibly been the strength between diversified sectors of industrial conglomerates, as for example seen in the 'Chaebol' of South Korea (Joon Soo Jon, 2002, p. 558). When shipbuilding is in need of support it is possible that other sectors of the group may be able to provide this because they may be at a stronger position in their own business cycle. Professor Joon Soo Jon says in this book: *"The flexibility inherent in the within-group transfer of resources to the benefit of shipbuilding operations has been important to the success of Japanese and South Korean Shipbuilders"* (*ibid*.). Even this strategy has its problems, however, for example in the role that the bankruptcy of Daewoo Motors played in the weakening of the entire group in the late 1990s, the shipyard DSME also subsequently becoming insolvent.

B: Standardisation of the product

Despite the progress of the past fifty years there persists an element of misunderstanding of the nature of the product of the commercial shipbuilding industry, particularly amongst those not directly involved in the industry. Specifically this relates to a belief that ships are in some sense 'unique' in terms of product, differentiating shipbuilding, for example, from automobile construction where mass production leads to production runs of thousands of quasi-identical products. As Glen puts it: "*many ships, although built to a basic design, will be tailored to a shipowner's specific need. In a world of mass manufacturing, this creates a distinct limitation to the opportunity of cost reduction through the repeated assembly of identical designs, thus limiting a potential source of production economies"* (Glen, 2006).

The benefits of standardisation have long been known. Sturmey noted in his 1962 book on the decline of the British shipping industry, that one of the contributory factors was that British shipowners insisted on buying unique ships from British shipyards, ignoring the fact that standard ships could be purchased more cheaply from abroad: *"Standardization of tramps, bulk carriers and tankers has been largely neglected by British shipowners and shipbuilders, despite the knowledge that such standardization could cut costs"* (Sturmey, 1962, p. 401). Despite this the contrary view, that ships are largely one-off project-builds, is still widely held. In an article in the Naval Architect Magazine in October 2010, the 'Head of Business Capture, AVEVA NET Solutions' (the market leading supplier of computer design software for commercial shipbuilding) stated: *"Shipbuilding is distinct from most other manufacturing industries. Firstly, vessels are almost always unique, enormously complex and hugely expensive to create. Secondly, these one-off products are designed and constructed to breathtakingly short timescales, involving vast material supply chains, production facilities and manpower logistics"* (Gwyther, 2010). Certainly there are sections of the industry where vessels are predominantly unique, for example in the construction of some warships or dredgers, but this view of commercial shipbuilding in the modern era is far from giving an accurate representation of the global commercial shipbuilding industry.

In making this very general claim for the 'one-off' nature of the product in shipbuilding, Gwyther is echoing a long-held view of the industry. The 'Geddes Report' by the UK Shipbuilding Inquiry Committee published in 1966 describes in a section titled '*The kind of* industry' the conflict between craft and industry in shipbuilding and states that *'ships, like buildings, are mostly 'one off'* jobs'(Geddes, 1966). The standard industry textbook from fifty years ago quoted previously, Hardy and Tyrell, echoed this view, notwithstanding '*liberty ships"* and *'T2'* tankers that are noted as an exception: "*It must be remembered that seldom – except in the case of* *oil tankers – are more than six exact sister ships needed. Therefore the highly specialized assembly-line establishment may find difficulty in operating at maximum efficiency*"(Hardy and Tyrrell, 1964, p. 4). Things started to change during the 1970s and in the 'Booz-Allen' report commissioned by the UK government into "*British Shipbuilding 1972"*, an update to the previously mentioned 'Geddes Report', it was stated that *"Standard designs, particularly for large ships in the oil and bulk trades, are becoming increasingly acceptable to shipowners"(Booz-Allen and Hamilton International BV, 1973)*. It is true to say that up to the 1980s standard products were the exception, rather than the rule, and were sufficiently unusual as to be branded with generic names to identify the series. Examples include IHI's '*Fortune*' bulk carrier (61 built in total) and '*Freedom*' general cargo ship (178 built in total), and the highly successful '*SD14*' general cargo liner from Austin and Pickersgill, UK (208 built in total). Analysis of fleet data from Sea-Web reveals that of 943 ships over 5,000 GT built in 1975, only 10% (95 ships in total) were of a recognised standard design of this type, with the longest series over the year being 10 '*Santa Fe*' general cargo liners from AESA of Spain and 9 '*SD14*'s from Austin and Pickersgill. Such charismatic names are rarely used in the modern era but the use of standard designs has become more common. Analysis of Sea-Web data reveals that 28% of the 2,557 commercial vessels delivered in 2012 (1,848 ships in total) were of a branded and named standard design. Even where there is no named standard, however, standardisation is now the norm in much of commercial shipbuilding, particularly for larger ships. For example, between 2007 and 2014 Daewoo Shipbuilding and Marine Engineering of South Korea delivered 59 VLCCs, all of which have length and beam of 333m x 60m and deadweight about 320,000 tonnes. Hyundai Heavy Ulsan delivered 46 VLCCs also with these dimensions and Hyundai Samho a further 37. Other Korean yards have delivered smaller numbers of VLCCs with almost identical dimensions. Whilst these vessels are not specifically named as standards and there may be minor variations between ships, they constitute effectively quasi-standard ships that conform to size classes required by the shipping industry and conforming to the parcel sizes that shippers require for their trades.

The development of strong size classes has been a significant feature of the shipbuilding boom of 2000 to 2008, differentiating it from the previous boom that peaked in the mid-1970s. This is demonstrated in Figure 6.5, which shows the spread of designs of crude oil tankers from shipyards in market leader Japan in 1975, at the peak of the previous cycle, with those of shipyards from market leader South Korea at the peak of the recent cycle in 2010.

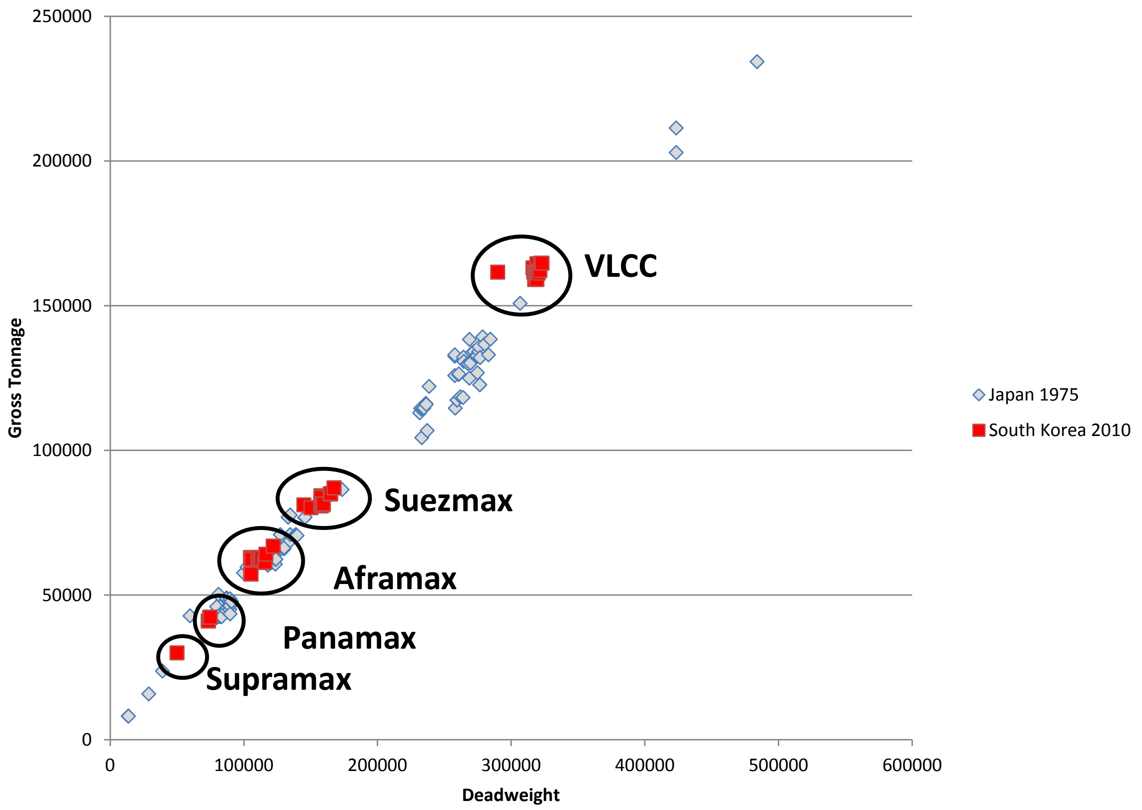


Figure A6.15.5 – Comparison of the spread of crude oil tanker designs from market leaders at market peaks (data sourced from Sea-Web)

The almost limitless spread of designs from Japanese yards in 1975 is contrasted with the tight clustering of types delivered by Korean yards in 2010, showing coherence in design between yards as well as within yards.

How this quasi-standardisation of products relates to the concept of ‘like product’ within the context of the SCM agreement is addressed specifically in this dissertation. It is worth touching further on one important aspect at this stage. Whilst the function of a ship built within a shipyard will vary according to its type, for example oil tanker compared to container ship, the interim products from which those two types are made, in particular the steel interim products, need not vary significantly. As Bruce and Garrard term it: “*One of the key features of design for production is the use of standards, for example for steel”*(Bruce and Garrard, 1999). This concept is generally termed ‘group technology’ in shipbuilding. This is described in SNAME's standard work on ship production as follows: *"The vast majority of shipbuilding involves the simultaneous production of multiple products of different types with some significant variation within product types. A key to this type of production is to recognise that even given product variety and variation, there is a high degree of similarity between most ships' intermediate products. Intermediate products are the sub-products that are produced and then concatenated through multiple production stages to create a final product"(Lamb and Society of Naval Architects and Marine Engineers (U.S.), 2003, p.25-5)*.

A good example of this principle can be found in the production of a stiffened flat panel, the fundamental unit of production in the construction of all ships. Fabrication of a panel essentially involves the welding of a number of flat plates together, followed by the welding of stiffening structure to the resulting panel. Such a panel will vary in scantlings (i.e. material thicknesses), overall shape and dimensions, the number of cut-outs and their shape and position and the size and arrangement of stiffening members. From the point of view of operatives on the panel production line:

- The overall shape and dimensions, providing that they are within the capacity of the production line, are of no consequence as the plates are cut automatically and provided they are laid in the correct orientation the panel dimensions will be correct.
- The cut-outs are of no consequence as they also are cut automatically when the plates are cut.
- The arrangement of stiffening members is of no consequence as the positioning of members is marked automatically by the cutting machine and, providing that the correct stiffeners are provided to the panel line cut-to-shape and are aligned to the correct lines, the panel arrangement will be correct.

The final use of the panel is also of no consequence to its production, whether it is for use in a tanker or a bulk carrier, for example. The stability of this part of the production process has led to significant potential for automation of panel production in shipyards.

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