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New approaches to shipbuilding capacity assessment

Karin Gourdon, Laurent Daniel, Takuya Adachi, Emilie Berger

Abstract

Accurate measurement of shipbuilding capacity is critical to inform market stakeholders of excess capacity issues. This report presents several approaches to improve the estimates of shipbuilding capacity. It shows how the use of average production would allow for smoothening the proxy of capacity in the yard-by-yard production approach. It discusses how firm level indicators, such as productivity, can also be considered. An analysis of productivity developments for a sample of shipbuilding firms shows that their productivity evolves in function of the market situation which, therefore, should be taken into account in the proxies of capacity based on yard production. Finally, the report studies how mergers and acquisitions of shipbuilding firms may impact capacity.

Keywords: Shipbuilding, Capacity, Productivity, Mergers and Acquisitions

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1. Executive summary

The objective of this paper is to develop a methodology and to collect capacity-relevant information at yard and company levels that allow the OECD to conduct an analysis of capacity and investment activities in the shipbuilding industry. This paper uses a sample of shipbuilding companies to study the impact of firm-level indicators on capacity. Moreover, it develops an analysis on the role of mergers & acquisitions of shipbuilding firms on their capacity. Finally, it discusses how the use of average yard production can allow improving the assessment of capacity.

Accurate measurement of shipbuilding capacity is an important objective, as it helps to inform and raise awareness of shipbuilding market stakeholders of the excess capacity situation. Moreover, it can lead to a better understanding of the detailed situation of capacity as well of its developments and drivers.

Given the impossibility to have all the information required to calculate the exact yard capacity, this paper in line with practice by shipbuilding market experts use proxies to estimate the shipbuilding capacity at global, regional, country, company, and yard levels. This paper uses the yard-by-yard "maximum production" approach as a proxy.

The "maximum production" approach does not capture the exact magnitude of capacity as it does not account for developments such as capacity closures or creations, productivity developments and other developments at firm or yard levels such as production volatility.

The methodology used to estimate capacity should notably account for the volatility of ship completions that can lead to over- or under-estimate capacity in some cases, especially for smaller yards. The "maximum production" approach is complemented by using production averages to reduce this possible estimation bias. This report shows that the use of average production allows improving the "maximum production" approach.

Firm-level productivity, companies' financial performance, and investment activities are factors that need to be taken into account to assess capacity more accurately by using a production function approach, company's profitability and indebtedness, and taking into account mergers and acquisitions in the shipbuilding industry. The paper shows that the productivity of shipbuilding firms evolves notably in function of the market situation which, therefore, should be taken into account in the proxies of capacity based on yard productions.

Financial performance indicates how strong and successful a company and an industry are. Financial health allows companies to explore and expand new business opportunities, to make new investments and to strengthen research and development activities. On the link between financial health and productivity, the economic literature suggests that companies with a higher degree of liquidity and access to external credit appear to have a better productivity performance. Consistently, more efficient firms tend to be more profitable.

Mergers and acquisitions (M&A) are often expected to have an impact on industrial sectors' consolidation and possibly on the reduction of production capacity. However, studies on the effect of M&As on consolidation show that M&A activity does not produce any significant effect on a production unit's exit decisions of the acquirer. Due to the limited number of mergers or acquisitions, it is not possible to draw conclusions on the effect of M&A activity on capacity in the shipbuilding sector. The paper shows, however, that the goal of the M&A deal is one of the key criteria that explains the impact of this deal on the capacities of the concerned companies.

2. Introduction

The shipbuilding industry along with other heavy industry sectors faces recurring overcapacity. Recent estimates of historical shipbuilding capacity reveal a decline of aggregate yard capacity since its peak in 2012. At the same time, the estimation results highlight that excess capacity in the shipbuilding industry will likely continue to exist until at least the year 2024 in the most optimistic scenario and until the year 2030 in the worst-case scenario. The extent of excess capacity is determined by demand as well as the willingness and feasibility for yards to reduce capacity and to refrain from new capital investments (OECD 2021).

This paper continues developing its approach aiming to assess capacity developments beyond estimating historical shipbuilding capacity only and to include factors internal to shipbuilding companies that affect potential output over time.

The complexity of the overcapacity issue requires a comprehensive examination of the large number of influencing factors and their interrelationships. To address this, the method proposed in this paper is intended to complement the OECD's previous work on historical shipyard production.

This paper carries out empirical work on determinants relevant to assessing capacity in the shipbuilding sector with a focus on i) firm-level productivity, ii) companies' financial performance, and iii) investment activities. The production function approach, used to evaluate capacity, takes into account the main input factors used by shipbuilding companies and involves estimating productivity over time, which at the firm level is assessed using four different measures. The second determinant, financial performance, is closely linked to productivity developments and is examined on the basis of selected indicators that provide information about a company's profitability and indebtedness. Complementing this, this paper examines the investment activities of shipbuilding firms, focussing on the characteristics of mergers and acquisitions in the shipbuilding industry and their impact on productivity developments.[1] Other factors also need to be taken into account including investments to meet environment and safety regulations when measuring capacity and specialities of yards such as shipbuilding methods or employees' working schedule.

The proposed work builds on the construction of a shipbuilding firm-level database that relies on a number of datasets, including the commercial Orbis database, a firm-level database of firm-level financial indicators created by the OECD's Trade and Agriculture Department (TAD) as well as the financial market platform Dealogic. The former two include key financial indicators, whereas the latter provides detailed information on acquisitions at the company level.

After a brief review of OECD shipbuilding capacity assessments to date (section 3), the paper presents the proposed empirical framework and methodological approach (section 4). Section 5 provides insights into the construction of the shipbuilding company-level database and ideas for the development of a comprehensive shipbuilding capacity

[1] In addition to the determinants presented, there are other factors that can impact economic capacity. For example, companies that benefit from public support may have higher productivity, profitability and/or lower debt levels. The relationship between government support and economic capacity is beyond the scope of this work, but requires further analysis.

database. This paper continues with a preliminary analysis of productivity trends in the shipbuilding industry in view of their important role in capacity assessments (section 6), and a comparison of several capacity assessments (section 7).

3. Past assessments of shipbuilding capacity

The OECD has significant experience in measuring shipbuilding capacity. Until 1999, the OECD sent yearly questionnaires to member governments and participating non-OECD economies to assess national shipbuilding capacity. This approach was discontinued because of concerns on the reliability of questionnaires due to the incomplete geographical coverage and some methodological weaknesses.

From 1999 until 2004, shipbuilding associations submitted to their national governments detailed information on shipyard facilities and production data, which in turn were forwarded to the OECD. The OECD then produced capacity evaluations based on an agreed methodology. Despite the improvements this new process brought along, it was discontinued because of technical problems related to the applied methodology in particular regarding the measurement of the productivity factors.

In 2011, the OECD in a discussion paper put forward an approach to estimate shipbuilding capacity that is based on the "maximum production" over a pre-defined time period either aggregated at the global level or at the individual yard level. This paper uses commercial databases for this analysis, such as Clarkson Research or IHS.

The "maximum production" approach takes into account new capacity developments when these capacity developments are reflected in observed deliveries of yards. For example, capacity expansions are captured if these expansions lead to deliveries that are higher than the maximum deliveries of the pre-defined period. Conversely, capacity reductions are captured if these are reflected in lower deliveries.

However, the "maximum production" approach may deliver an inaccurate picture depending on the type of shipyard. For shipyards that build a small number of ships, such as shipyards producing cruise ships, the "maximum production" approach could lead in certain circumstances to an underestimation or overestimation of installed capacity.

4. New approaches for assessing capacity in the shipbuilding industry

While the "maximum production" approach provides preliminary insights into the development of yard capacity, it is less able to capture capacity changes, since the choice of the period[2] used in the approach may be arbitrary. As a consequence, an important shortcoming of this approach is that it only captures changes in capacity when they are reflected in an increase or decrease in observed deliveries of yards. Factors internal to shipbuilding companies that affect potential output over time are neglected. These include, for example, productivity improvements achieved through different interactions between factors of production in shipbuilding firms, and the companies' financial health. To be more specific, productivity improvements refer to changes in the characteristics of human capital and capital stock, as well as the efficiency with which shipbuilding companies can convert these inputs, i.e., by learning-by-doing effects or changes in organizational structures (Sephard 2015; Grossman & Helpman 1990). At the firm level, intermediate inputs also matter, e.g. the extent to which firms use prefabricated components and equipment. A firm that is mainly assembling components bought from other firms could appear to be very productive if one only looks at human and physical capital. The input/output tables might allow to see whether intermediate inputs have become more important over time in the shipbuilding sector. Financial health of companies can affect potential output as it allows companies to explore and expand new business opportunities, to make new investments and to strengthen research and development activities. Therefore, analysing production inputs and financial indicators in greater detail is an essential complement to the "maximum production" approach and allows for a better understanding of capacity in the shipbuilding sector.

Further avenues could be explored that combine the "maximum production" approach, based on actual production data, with the proposed firm-level analysis, which focuses on productivity developments and companies' financial performance. An empirical impact assessment, e.g. on the impact of productivity performance on actual output, requires a comprehensive shipbuilding capacity database that links company level information with the yard level information.

4.1. Shipbuilding capacity and firm-level productivity

A production function relates the quantities of production factors used to the quantities of goods produced. Different forms of production functions are discussed in the economic literature.[3] For example, the Cobb-Douglas production function relates the inputs capital and labour with a technology parameter, so-called multi-factor or total factor productivity (TFP), to output. TFP is a good indicator of how efficiently firms can convert inputs into outputs. Changes in TFP reflect for instance the effects of changes in management practices, technological advancements, organisational change, general knowledge, network effects, spill-over effects from production factors, adjustment costs, economies of scale or the effects of imperfect competition (OECD 2019). It should be noted that the Cobb-Douglas production only looks at capital and labour as inputs and ignores intermediate inputs that are important if looking at gross output rather than value added as

[2] Moving three- and fifteen-years intervals are used.

[3] See Shephard 2015 for an explanation of the theory of cost and production functions. For the empirical analysis it is important to choose a production function that is both practical and takes into account the specifics of the capital-intensive shipbuilding industry.

shown in the OECD Productivity Manual (2001) and Measuring Productivity - OECD Manual.

Because more productive firms can increase their cost efficiency, TFP plays an important role in changes in production costs (OECD 2001). For example, the way production processes are structured and run (from the use of machines and labour to the way companies learn and eliminate technical and organisational inefficiencies), can affect how much output can be produced with the same amount of machinery. Instances where one company generates more output with the same amount of labour and capital inputs than one of its competitors may reflect changes in TFP. Growth in TFP is measured as a residual, i.e., that part of production growth that cannot be explained by changes in labour and capital inputs. It is usually measured as an index and in annual growth rates.

Labour productivity is one of the most commonly used measures of productivity, mostly due to its relatively low data requirements and ease of measurement. Labour productivity represents the total volume of value added or output produced per unit of labour. It gives insights into how productively labour is employed to generate value added or gross output. However, this productivity measure does not control for capital deepening, i.e., the increase of capital per worker, or for changes in the use of intermediate inputs. Increased labour productivity growth could, for instance, be associated with increasing capital intensity. Hence, assessing the efficiency with which not only labour inputs but also capital and intermediate inputs are used is a better measure of productivity than labour productivity or capital efficiency alone.

Shipbuilding is a capital-intensive industry. Despite the large amount of labour inputs, the major input factor for ship construction is the capital stock in the form of long-term assets, such as land area, building docks, quays, machines for steel preparation and cutting, and cranes (Gourdon 2019).[4] The capital intensity as the ratio of capital stock (i.e., gross fixed capital formation) to employment is much higher in shipbuilding than the average ratio in manufacturing. The most capital-intensive industries are nuclear fuel processing, petroleum refining, chemicals, and iron and steel, while at the lower end of industrial capital intensity are textiles and publishing. The productivity of the input factor capital can be assessed as a single factor productivity measure like labour productivity. It shows how productively capital is used to generate output. Capital productivity reflects the joint influence of factors like labour and intermediate inputs (OECD 2001).

It is important to note that, regardless of the sophistication of the measure, firms' productivity levels and dynamics may vary considerably, even within narrowly defined industries (see Bartelsman & Doms 2000). A wider range of outcomes may point to a greater degree of experimentation and learning by doing (see Bartelsman et al. 2010). At the same time, a large observed dispersion may point to the benefits of reallocating resources from less to more productive firms leading to aggregate productivity increases (see Hsieh and Klenow 2009). To obtain a better understanding of these issues, the distribution of productivity levels within the shipbuilding industry is included in the analysis.

4.1.1. Productivity indicators

The production function approach involves analysing shipbuilding companies' main input factors and productivity over time (see Table 4.1). Productivity at the firm level is assessed

[4] Some yards invest also in machinery for plate bending, automated welding, material transfer for panel fabrication, material control and distribution as well as IT systems for design development. In general these investment decisions are rather lumpy so that investments feature patterns of spikes.

using four different types of productivity measures, each of which relies on economic value added (EVA), which is defined as the sum of EBITDA[5] and labour costs (Gal 2013). Capital stock is constructed using the perpetual inventory method. Using Orbis data, the capital stock measure is calculated based on information on tangible fixed assets.

The productivity measures are as follows, in increasing order of complexity:

- **Labour productivity** as the ratio between EVA and number of workers. **Capital productivity** as the ratio between EVA and the real capital stock. These most basic productivity measures can serve as a baseline.
- **Solow residual** is what remains after deducting the contribution of the capital stock and labour to a firm's EVA. We take cost shares for each production factor from our sample, i.e., by dividing labour costs by EVA.
- **TFP residual from an ordinary least squares (OLS)** estimation of the production function. TFP is the difference between EVA and the contribution of each production factor, using the factor shares estimated in the production function. It must be noted that OLS can produce biased and inconsistent coefficient estimates.[6]
- **Wooldridge MFP** which is a productivity measure that accounts for the endogeneity problem of input choices. Estimates are based on a Cobb Douglas production function by drawing on the control function approach by Levinsohn and Petrin (2003) and by implementing it via the Wooldridge methodology (Wooldridge 2009). The implementation uses the *prodest* estimation command in Stata with staff and the capital stock as the 'free' and 'state' inputs, respectively. Intermediate inputs are used as a proxy variable for productivity, where intermediate inputs are taken as the difference between firms' revenue and EVA. MFP is the difference between EVA and the contribution of each production factor, using the factor shares estimated in the production function.

To complement measures of productivity and to analyse shipbuilding firms' main input factors in more detail, the following indicators are used:

- **Deflated capital stock in values** representing fixed assets, such as docks, quays, cranes, buildings, land area, machinery for steel cutting and welding and so on.
- **New investments** in capital stock in values and **number of docks** at the yard level. Capital stock investments feature long construction lags (e.g., yards and docks are not built within one day) making capacity investments slow (Gourdon 2019).
- **Labour statistics** including the number of workers.

[5] EBITDA is defined as earnings before interest, taxes, depreciation and amortization.

[6] As put forward in Gal 2013:8: "endogeneity arises because as productivity changes, optimizing firms react by adjusting their inputs and productivity also directly affects value added".

Table 4.1. Capacity determinants at the firm level, production-function approach

Capital stock	Value
	Number of docks[7]
	Investments
	Productivity
Labour	Number of workers
	Productivity
Multi-factor productivity	TFP residual
	Wooldridge MFP

Note : Intermediate outputs could also be added in case data is available.

4.1.2. Financial performance

Financial performance indicates how strong and successful a company and an industry is. Financial health allows companies to explore and expand new business opportunities, to make new investments and to strengthen research and development activities. On the link between financial health and productivity, the economic literature suggests that companies with a higher degree of liquidity and access to external credit appear to have a better productivity performance (Anwar & Nguyen 2011). Consistently, more efficient firms tend to be more profitable (Bottazzi et al. 2008).

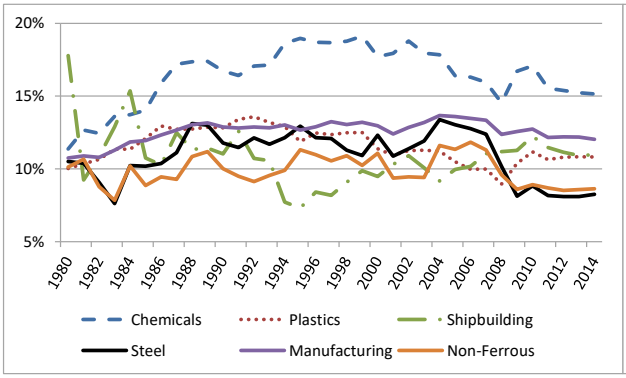
Financial health can be measured in a variety of ways and no single measure should be used to define financial performance. EBITDA gives an indication of the company's operational profit, as it considers sales and operating costs but excludes changes in working capital, capital expenditures, taxes and interest. Another widely used measure of a company's operational performance is the ratio between EBITDA and sales. Indicators of financial performance can be derived from income statements of publicly traded companies or from national accounts data. By comparing gross operational surpluses to total output, national accounts data can provide an estimate of an industry's overall productivity (OECD 2015).

Panel A of Figure 4.1shows the development of aggregate profitability across different industries for the period 1980 to 2014, according to national accounts data (OECD 2015). It shows that the financial performance of the shipbuilding industry has been worse than that of several other industries and, since the mid-1980s, worse than that of the overall manufacturing sector. Information drawn from publicly traded companies' income statements confirm this picture, suggesting that shipbuilding companies have underperformed when compared to companies in other industries between 1992 and 2014 (Panel B of Figure 4.1).

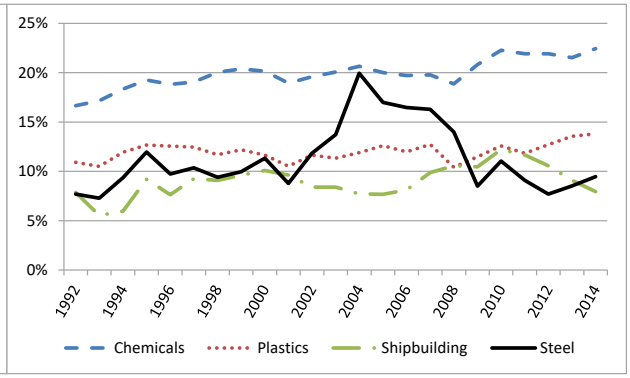
[7] The information is drawn from Clarkson's World Shipyard Monitor.

Figure 4.1. Evolution of profitability across selected industries

A. Gross operating margin, 1980-2014



B. EBITDA/Sales, 1992-2014



Source: IHS (gross operating margins) and OECD calculations based on Factset (EBITDA on Sales), as cited in OECD 2015.

The underlying causes of the shipbuilding industry's weak performance compared to other industries warrants further investigation. Recent research on this matter is scarce. Deepening the focus on the financial health of shipbuilding companies is also important because of the link between profits and productivity as well as the likely impact of excess capacity on industry profitability. Against this background, analysis of financial performance at the firm-level provides further insights into capacity developments in the shipbuilding industry.

Financial performance indicators

Selected indicators of financial performance that are informative about a company's profitability and indebtedness are the following:[8]

- **EBITDA/Sales**: The ratio between earnings before interest, tax, depreciation and amortisation (EBIDA) and total revenue. EBITDA indicates a firm's operating profitability. It provides a good measure of core profitability because it excludes depreciation and amortization. The ratio to total revenue allows for comparability of core profitability between firms. A below zero ratio indicates that companies are making losses.
- **EBIT/SALES**: The ratio between EBIT and sales is an alternative measure of operational profitability that takes into account depreciation and amortization.
- **Cash-flow scaled by total assets** is a measure of profitability that takes into account depreciation and amortization as well as taxes. Along with EBITDA, this gives insights into how a company finances short-term capital.
- **Free Cash-flow to sales** is an additional profitability indicator. This variable provides information of firms' capacity to generate cash after investments and covering costs with replacing capital (depreciation and amortisation). Free cash flow is the amount of cash that a firm generates and is available for either paying out dividends to shareholders or retaining as cash holdings for use in future periods (revealing expectations about future market).

[8] Indicators draw on variables put forward in OECD 2015.

- **Cash stocks scaled by total assets**: This is an indicator of firm's immediate liquidity. Firms may have higher cash stocks to face expected negative shocks in the future or to take advantage of future investment opportunities (if external finance is difficult to obtain).
- **Debt to EBITDA** reveals firms' ability to service debt. Healthy firms should have a ratio below 3. The indicator is only meaningful for positive values of EBITDA, thus for all companies making losses this indicator is not computed. An alternative indicator was constructed as the ratio between average DEBT and average EBITDA over all firms for a given year.
- **Ratio between total debt and total assets** indicates the percentage of a company's assets that has been financed through debt. Accordingly, it measures the degree of leverage of a firm. It includes both short-term and long-term debt.
- **Solvency ratio** is the ratio between shareholders' funds on total assets. This ratio helps to determine a company's ability to pay its long-term debt and other debt obligations. A solvency ratio higher than 20% is considered to be financially sound.
- **The share of short-term debt on total debt** indicates whether a company is focusing on financing for operational issues. The ratio varies between zero and one and will depend on the extent.
- **Investment in fixed assets normalised by total assets**. Investment is defined as additions to plant, property and equipment.
- **R&D expenses** provides an indication of whether a firm is making efforts to innovate.

4.2. Shipbuilding capacity and investment activities

M&As are transactions in which the ownership of existing companies is transferred or consolidated with other entities in order to achieve strategic and financial goals. Instead of establishing new plants or increasing the scale of existing ones, successful companies can grow by acquiring or integrating other firms. At the same time, less productive parts of the company can be scaled down or closed down. As a consequence, M&As could be one of the channels through which restructuring processes are initiated within the industry and can help to alleviate overcapacity.

M&As may support the reduction of overcapacity by enabling companies to find synergies, to close and consolidate operations by shifting resources from less productive to more productive plants. Within the company, knowledge spill-overs, capital diffusion and reallocation of assets to more productive facilities is possible. The economic literature indicates that M&As are usually carried out by large and highly productive multinational enterprises (MNEs) and that target companies' productivity increases after acquisition (Helpman et al. 2004). For the economy as a whole empirical evidence suggests that M&As facilitate the exit of unproductive plants as they increase competitive pressure in market, inducing other less efficient businesses to exit and/or reduce inefficient operations (Andrade et al. 2001; Jovanovic & Rousseau 2002; Breinlich 2008). Evidence indicates that M&As may promote financial restructuring, with higher stock returns and gains in share prices being recorded after an alliance occurred. The extent to which M&As may facilitate restructuring is affected by market and regulatory conditions. This includes regulations for entry and exit, access to finance or labour market conditions (OECD 2020).

At the same time, there are other reasons to pursue M&As, which may ultimately not lead to capacity reductions, and in some cases may even exacerbate overcapacities. These include, for example, firms with cash reserves that purchase underperforming assets during an economic downturn in anticipation of selling them profitably in a market upswing in

the near future. Improved access to finance can be an additional incentive for companies to conduct M&As, as larger business units tend to face fewer financial constraints. In cases where financial management reasons are at the main focus of conducting M&As, they may be less effective in reducing overcapacity (Carreira & Silva 2010). M&As may also increase financial challenges due to very large companies being more prone to moral hazard problems. Further, horizontal M&A activities could eventually result in increased sectoral concentration, of which reduced competition, slower productivity growth, less innovation and oligopolistic behaviour are all possible outcomes. Since benefits tend to be more concentrated in highly concentrated markets, corporations are also more inclined to engage in lobbying activities (OECD 2020).

Box 1. M&A activity and capacity in the shipbuilding sector

Investigating the characteristics of M&A deals in the shipbuilding industry can be informative to policy makers as it permits to understand whether instances of acquisitions have evolved according to specific patterns over a given period of time and jurisdiction, and what the possible reasons for this are. Research on M&A activity and capacity seems to indicate that the reason for which companies pursue and undertake M&A activity is a determining factor for the impact that M&As have on capacity. The relationship between capacity and investment activities, as well as the fact that there is little empirical evidence on this matter for the shipbuilding industry to date, makes it relevant to further research into the possible effect of M&A activity on shipbuilding capacity.

Despite scant empirical analysis on M&A and capacity, industry experts and stakeholders often describe the following dynamics for M&As deals and capacity development in shipbuilding economies.

M&A activity in shipbuilding tends to be aimed at :

- Conglomeration;
- Allowing large companies to enter new markets/ market segments and develop strategic alliances with up- and downstream enterprises or;
- Encouraging small and medium-sized enterprises (SMEs) to restructure their business scope and specialise in niche areas.

These operations are expected to raise companies' productivity and competitiveness in the market. As such, governments of several shipbuilding economies specifically promote M&A and restructuring to target the structural problem of overcapacity and increase value added to the industry (Yang & Yu 2011; Jang et al. 2019).

However, even if an M&A deal is targeted at relieving overcapacity, there is no guarantee that 1) it will be successful in reducing capacity and 2) that the M&A deal itself will succeed. High uncertainty and challenges are embedded in the implementation of a M&A deal and in practice, many M&A cases fail to create synergies and establish the necessary capability, adding another level of complexity to the relationship between M&As and capacity (Cho et al. 2017).

Companies can also be incentivised to undertake M&A deals in response to market pressures, developments in the shipping sector or other related industries or general economic trends. As a consequence of the economic downturn and very low levels of new orders after the 2008 global financial crisis, some shipbuilding companies were pushed into M&As to stay profitable in the market (TradeWindsW 2016). M&A deals between national shipbuilding companies can also take place as a response to consolidation in other national shipbuilding economies and the (perceived) risk of losing global market share, with the risk that this worry over losing potential market opportunities could result in companies not undertaking the restructuring work necessary to reduce overcapacity (Jang et al. 2019).

Some experts and stakeholders also highlight the fact that M&A deals may be employed as a tool to invest in companies that are facing financial difficulties. In this case, consolidation is not aimed at improving a company's financial performance through higher competitiveness in the sector but instead takes place as a measure to "bail out"

underperforming firms or firms that would exit the market on their own (The Wall Street Journal 2013; Lloyd's List 2020). If confirmed by more in-depth data analysis, this could be an example of M&A activity failing to result in a reduction of overcapacity (or even exacerbate it).

Determinants and two-fold method

The description of **M&A deals' characteristics** focuses on the following aspects:

- Number of annual M&A deals in a given period and economies;
- Types of actors involved, i.e. role of company-cooperation (joint-ventures);
- Characteristics of the investor and target firms (e.g. ownership, firm size, technology);
- Geography of M&A transactions, i.e. origin of acquirers and target companies;
- Nature of M&A transactions, i.e. cross-industry or within-industry transactions;
- Total value of M&A deals in a given year and by economy, which allows to compare M&A transactions by value and in relation to other economies.

Two-fold method to examine the possible **effect of M&A transactions on shipbuilding capacity:**

- The descriptive approach envisages providing statistics on a company's production capacity according to their participation in the M&A market. Ideally, production capacity would be determined at the level of yards and their production facilities. As this is not feasible at this stage due to non-publicly available data, production capacity is approximated using shipbuilding companies' productivity levels. Indicators of productivity are described in section 4.1. of this paper. Companies that are active in the M&A market are defined as those having performed at least one acquisition in the period of interest. With this in mind, average productivity levels can be compared between M&A active and non-active shipbuilding companies. Comparison of M&A transactions in relation to a given year and to other economies also permits analysis on how the relationship between M&As and productivity levels (if present) evolves over time. Taking into account the geography and nature of M&A transactions allows further study on how any eventual relationship between M&A and shipbuilding companies' productivity levels changes across different types of deals (domestic vs cross-border, horizontal vs vertical) and different characteristics of companies involved.
- The econometric approach tests the effect of an M&A event on productivity dynamics. To do so, companies are identified if they have been active in M&A deals ("treated group") at some specific point in time and companies that have not been involved in any M&A activity ("control group"). Isolating the M&A effect from other factors that might have an impact on productivity requires that the shipbuilding companies in both groups share very similar key characteristics (for example, the number of employees, financial health, ownership).[9] Using a so-called difference-in-difference estimation, the econometric exercise aims to analyse companies' productivity development in the aftermath of an M&A event.[10] In particular, the difference between the average productivity development of the *treated* and *control group* in a given period is used to measure the impact of a M&A.

[9] To identify the effect of M&A activity on shipbuilding productivity, one has to consider other factors that could theoretically have an impact, such as market conditions.

[10] The econometric approach is based on OECD 2020.

5. Productivity developments in the shipbuilding industry

Productivity growth is driven by a number of factors. Investments in new machinery and equipment, R&D, information technologies or human capital can lead to greater efficiency in production processes. The introduction of new technologies increases competition among producers with older technologies, which is likely to result in a redistribution of output and higher aggregate productivity levels in the industry.

The productivity analysis is based on the commercial Orbis database, which is provided by the Bureau Van Dijk, as well as from the firm-level database of financial indicators created by the OECD Trade and Agriculture Department (TAD). The analysis contains information on six large shipbuilding companies from four major shipbuilding economies, including Germany, Italy, Japan, and Korea. For all the companies, continuous information is available for the five-year period between 2013 and 2017, allowing a comparison of different productivity indicators for this sample.

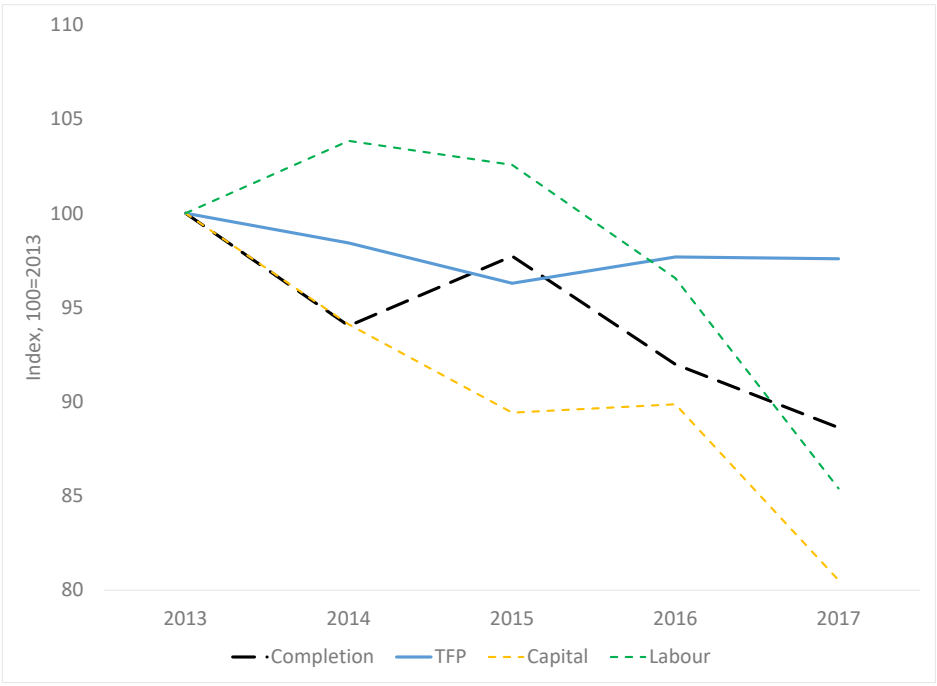
This paper calculates Total Factor Productivity (TFP) for the above six companies and compared it with developments of net property etc. (Capital), number of employees (Labour), which are indicators of capacity, and with the world completion in CGT (Completion). It is shown in the Figure 5.1.

During the period 2013-2017, Completion experienced a siginificant drop (more than 10%), while TFP moderately decreased. To understand this situation properly, this paper focuses on the changes in capacity during this period. The purpose was to ascertain whether, during this period, the six companies concerned had constant capacity but maintained production regardless of market conditions, or whether there were also changes in the capacity of them during this period and, as a result, there was little change in their productivity.

As a result, the paper confirmed that there was also a change in the capacity of the six companies during this period and, consequently, that there was not much change in productivity. Capital and Labour indexes appear to be partly correlated with completion.

Shipbuilding companies may adjust their production factors in terms of capital and labour in line with changing market conditions. From this perspective, using the very long-term “maximum production” as shipbuilding capacity may be misinterpreted. However, it is important to note that the present analysis used a small and short-term sample due to the limited amount of data available. There is room for this analysis to be improved in the future when the data is supplemented.

Figure 5.1. Comparison of developments of Completion, TFP, Capital and Labour



Note: Total-factor-productivity is based on the Wooldridge estimation.
Source: OECD calculations based on Orbis 2021, TAD 2022, and the Clarksons World Fleet Register.

6. Comparisons of capacity assessments

This section shows that the measure of capacity at yard level can vary in function of the methodologies used.

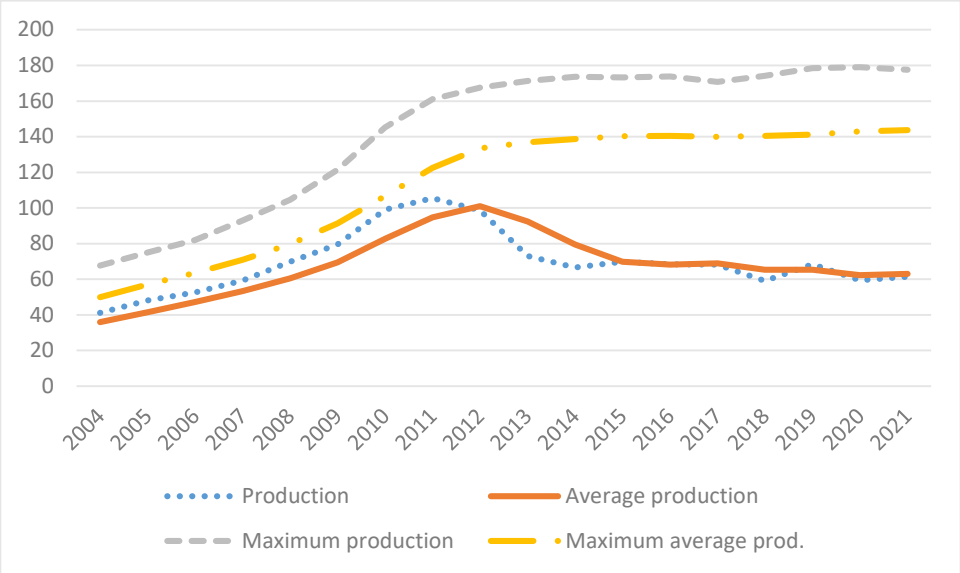
6.1. Yard-by-yard maximum average production approach

The "maximum production" is highly sensitive of the duration of the period in which the maximum is calculated. Moreover, the "maximum production" of the past years for evaluating the capacity of a specific shipyard might deliver an inaccurate picture depending on the type of shipyards. For shipyards that build a small number of ships, such as EU shipyards producing cruise ships, the "maximum production" could lead in certain circumstances to an underestimation or overestimation of installed capacity.

A relevant question is to consider taking an average capacity figure (i.e. average production over a period of time) in the estimation of shipyards' capacity.

This paper extracted a comprehensive dataset of ship production in gross tonnes by yard from the IHS database Sea-Web. The paper then calculated the average production by yards of the last three years. It then calculated the "maximum production" and "maximum average production" by yards for the last 15 years. Finally, these figures were aggregated for all yards in the world for each year between 2004 and 2021. The figure below shows the trends of these four data series.

Figure 6.1. Estimated global yard capacity using maximum production and maximum average production (in gt)



Source: IHS and OECD Calculations

Several conclusions can be drawn from these calculations:

- Ship production reached a maximum in 2011 at 105.5 million gt, 4% higher than the "maximum average production" reached in 2012 at 101.1 million gt. Average production is on average 2% lower between 2004 and 2021 than production showing both the volatility of ship production and the concentration of production at some yards during selected years.
- The proxy of capacity measured by "maximum production" increased by 10% from 161.0 million gt in 2011 when the peak of production was reached to 177.5 million gt in 2021. This shows that the aggregation of "maximum production" figures by yards does not provide an accurate estimate of capacity given the fact the actual capacity of yards in the world decreased following the decrease of ship demand.
- The proxy of capacity measured by "maximum average production" increased less (by 7%) from 133.5 million gt in 2012 when the peak of "maximum production" was reached to 143.7 million gt in 2021. This shows that the aggregation of "maximum production" figures by yards does not either provide an accurate estimate of capacity. However, the average production avoids some of the double counting that simple production creates.
- "Maximum average production" is on average 22% lower between 2004 and 2021 than "maximum production" showing also that using average production improves the estimate of capacity by eliminating the double counting of ship production with the simple "maximum production" approach.

In total, using average production seems to improve the proxy of capacity from the "maximum production" approach. However, these estimates seem to remain inaccurate given the inertia of these proxies which are still mainly based on the 2011 peak of ship production.

6.2. Capacity assessment using the concept of active yards

Danish Ship Finance, in its Shipping market reviews[11], presents estimates of the global shipbuilding capacity based on the notion of active yards. Actives yards are yards that have delivered at least one ship in the last two years. According to Danish Ship Finance, there were 275 active yards in 2021 globally, which are part of 195yard groups, with an estimated capacity of 53 million cgt, which is 6% lower than in 2020, when the active yard capacity amounted to 57 million cgt.

6.3. Manpower by job categories and production equipment indicators

Design capacity is calculated in function of the size of the production facilities in a given yard as well as the production methods. This is calculated using production equipment including the size of docks and berths, as well as manpower by job categories, employees' working schedule and shipbuilding methods. However, while this methodology would be the most accurate, it cannot be used in practice given the lack of data. Most shipbuilding companies do not make this information publicly available. Moreover, many yards frequently modernised their production facilities and methods, which modifies the information needed for the measurement of design capacity.

Although data on manpower by job categories and production equipment are not available for all yards, it is still possible to use information on those yards for which information is

[11] Shipping Market Reviews by Danish Ship Finance are available at https://www.shipfinance.dk/research/shipping-market-review/

available to fine tune the proxies of capacity presented in Sub-Sections 6.2 and 6.3. For instance, shortage or excess of labour force or production equipment compared to required labour force or production equipment for a given proxy of capacity presented in Sub-Section 6.1, could be taken into account to modify the final estimate of capacity.

7. Conclusion

The comparison of developments of ship completions, TFP, capital and labour (Section 5) shows that, in recent years, shipbuilding companies adapted to market fluctuations by adjusting their assets and labour. Assessments of shipbuilding capacity with the "maximum production" approach, assumes that all maximum assets and workforces are preserved, which is not compatible with these developments.

The "maximum production" (15 years) and "maximum average production" (15 years) are very far from the production (actual). In view of the previous paragraph and given the inertia of these proxies that are still based on the 2011 peak of ship production, using the "maximum production" (15 years) and the "maximum average production" (15 years) as a proxy for shipbuilding capacity might be inaccurate.

The average production (3 years), which could adjust for the unevenness of completion in a single year, might work better to some extent as a proxy for shipbuilding capacity, assuming that companies adapt quickly to the demand situation.

However, it is important to note that this paper is based on the very limited amount and kind of data and there exists room for this document to be improved in the future when data is supplemented.

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