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The efficiency of the top Mega yacht builders across the world: a financial ratio-based data envelopment analysis

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Abstract: This research provides an application of a non-parametric analytic technique (Data Envelopment Analysis, DEA) in measuring the performance of the mega yacht sector. It analyses the efficiency of the top mega yacht companies across the world in 2005-2013 by offering a model useful for comparing inefficient shipbuilders with the efficient ones. This paper adopts an output-oriented version of DEA based on financial ratios where inputs are not utilised. In order to handle missing data, we test and compare two different techniques: the deletion one and the multiple linear regression analysis (MLRA). We find that DEA can be a complement or alternative tool to ratio analysis to evaluate corporates' performance. We also find that the most efficient shipbuilders are those based in the most prosperous countries. Finally, the MLRA efficiency scores are more reliable and consistent with the firms' annual reports and financial ratios.

Keywords: Data Envelopment Analysis, Efficiency, Financial Ratios, Mega Yacht Sector

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1 Introduction

The mega yacht sector includes all large and leisure ships with a length exceeding 250 feet. The mega yacht sector represents an important industry around the world for many reasons. For instance, this sector plays a compelling role and remarkably contributes to the economies of a number of nations and of many other sectors, like port businesses and services, tourism, engineering, design and fashion (Bruni and Carcano, 2009). For instance, this sector contributed £273 m in gross value added (GVA) to the UK in 2016 (SuperYacht Business, 2016), €485 bn (£440 bn) to the European Union with an employment rate of 5.5 m people (Blonk, 2015). Estimations are that by 2020 the GVA will have increased to €590 bn (Blue Growth Strategy, 2017). Another factor that shows the importance the mega yacht sector around the world is partnerships that shipyards seek to establish with other companies in order to remain competitive and to tackle the substantial challenges that the mega yacht sector has experienced over the last decade (SuperYacht International, 2015). Since the global financial

crisis in 2008 the biggest shipbuilders have undergone substantial changes (Ritvala et al., 2014) in terms of ownership composition, alternative international partners, relocation of plants in developing countries and new M&As. For instance, some shipyards have established new partnerships with some of the world's top luxury brands, including Gucci, Hermès and Chanel, in order to increase the prestige of mega yachts (Smith, 2011) and to attract more customers. As a result, companies have implemented new corporate decisions in order to cope with global financial distress and to improve competition (Badiezadeh and Saen, 2014). The competition (Wu et al., 2014) amongst the largest mega yacht companies has increased due to these novel corporate arrangements, technological improvements and development of new ports' regulations (Gagliardo, 2008; Quagli and Ramassa, 2011). Until recently, mega yacht companies were more focused on growing the components of their assets in order to accomplish their goals for development; however, they are now more attentive to increasing their profitability (Merendino, 2013, 2014). This requires the determination and management of different factors that have a vital role in the profitability (Halkos and Salamouris, 2004) of mega yacht companies in the new competitive environment.

The objective of this study is to evaluate and compare the efficiency of the top mega yacht builders across the world during the period 2005–2013 by using financial ratio-based data envelopment analysis (DEA) approach. The period 2005–2013 has been chosen for two reasons. First, we want to consider an adequate period before and after the financial crisis in accordance with previous research (Costa, 2012); secondly, this is the time period for which most companies had made their financial reports publicly available, at the time we undertook data gathering. We want to show that financial accounting ratios and non-parametric techniques (like DEA) can be used as a complement to each other for the evaluation of companies' performance (Rouse et al., 2002). It is also generally accepted that the efficiency of a company is multidimensional in its nature (Paradi et al., 2011) and financial ratios are able to capture

this multifaceted dimension (Gibson, 2010). As Halkos and Salamouris (2004) stated "in order to provide reasonable conclusions from comparative performance of a subset of companies, it is fundamental that a comparison is conducted amongst companies operating in homogenous market". For this reason, we selected the biggest mega yacht builders across the world, as they operate with the same type of customers, designers, engineers and stakeholders in order to provide yachts exceeding 250 feet. The companies were selected on the basis of the top 30 global ranking published annually by Global Order Book which has been one of the main guides to the superyacht industry since 1992. This research offers an application of the output-oriented version of DEA based on financial ratios without inputs in the mega yacht sector. The modelling follows that of Fernandez-Castro and Smith (1994) that takes a modified DEA model to find efficient scores. Furthermore, although many studies adopting DEA to handle missing data apply the deletion technique (Halkos and Tzeremes, 2007; Fu et al., 2010; Demirbag et al., 2016; Dharmapala and Zaibet, 2006; Hua and Bian, 2008), a growing number of research has applied a particular approach, i.e., multiple linear regression analysis (MLRA). In order to find the most reliable results, in this study we employ and compare both techniques (deletion and MLRA).

The present study makes contributions to existing literature empirically and conceptually. First, we make an empirical contribution through our world-wide sample of large mega yacht companies. The selection of these shipyards is significant and novel in allowing us to analyse the efficiency of the mega yacht sector which is a growing industry operating worldwide. As regards methodological contributions, this research offers a compelling approach in applying DEA to evaluate the efficiency of shipyards, i.e., an output-oriented version of DEA based on financial ratios in which inputs are not utilised. This technique allows us to examine companies' performance and their financial ratios in conjunction with firm efficiency. Furthermore, this research offers an additional methodological contribution on how to handle missing data in a

sample of companies where DEA is utilised. In order to identify the best way to manage missing data, we test and compare two approaches: the deletion technique (Kuosmanen, 2008) and MLRA (Chen et al., 2014). While the deletion approach represents the traditional approach to dealing with missing data (Charles and Kumar, 2012), MLRA is considered an alternative method to manage all cases with missing values (Chen et al., 2014). We find that MLRA provides unbiased results (i.e., efficiency scores) which are in line with companies' annual reports and financial ratios.

The remainder of the paper is organised as follows: In the next section, a literature review of the mega yacht sector and similar DEA studies is presented. Afterwards, the DEA method is described. The methodology and the financial ratios used and the mega yacht builders included in the sample are presented next. The empirical results, including descriptive statistics, findings shown by using the deletion technique and MLRA, and the feasible targets are analysed. The final section discusses the conclusions and implications of this study, and a future research agenda is presented.

2 Literature review

2.1 Mega yacht: the sector

This industry has some peculiar features that make it a unique and interesting case to study. First, mega yacht builders are characterised by technological innovation and a high level of specialisation (Baan, 1996). This means that shipbuilders, to be competitive, should invest continuously in soft and hard innovation; where the former refers to product and process innovation (Amar, 2002) and the latter refers to marketing policies (Castelló, 2012), intangible investments (den Hertog et al., 1997) and organisational issues. Examples include fostering networking, improving management practices and customising services (Howells, 2000).

Secondly, the mega yacht sector is tightly connected with luxury that is ‘constantly on the move’ [Kapferer, (2008), p.96] and is ‘always changing its appearance’ [Mortelmans, (2005), p.504]. Mega yachts are expected to have:

a excellent quality

b very high prices

c scarcity and uniqueness

d aesthetics and polysensuality

e ancestral heritage and personal history

f superfluousness (Heine, 2012).

Finally, some scholars (Francesetti, 2008; Bruni and Carcano, 2009) argue that the mega yacht sector has an anti-cyclical nature, meaning that it is not affected by financial crisis cycles, because this luxury sector is strongly related to the number and the wealth of millionaires known as ultra high net worth individuals (UHNWIs) In fact, the number and the amount of their assets keep increasing despite financial crises, suggesting that recession does not impinge on the mega yacht sector. However, from an analysis of financial statements it emerges that the biggest shipyards across the world have witnessed either a loss or a significant reduction in sales triggering dangerous and worrying consequences especially after 2010 (Merendino, 2013, 2014).

Annually, Global Order Book releases the ranking of shipbuilders based on numbers and length of mega yacht orders (ShowBoats International, 2015). Table 1 shows the 2015 ranking. Italy has been playing a pivotal role internationally in this sector since 2001. Indeed, Italian

companies are ranked in the tops 3, and 10 out of 30 builders that are based in this country, meaning that it is the worldwide leader in terms of production of luxury ships followed by the Netherlands. In addition, East Europe, Turkey and China have recently been ranked in the top 30 mega yacht builders, meaning that they continue to grow and become more competitive.

Table 1 *Top 30 Mega Yacht Builders 2015*

2015 Rank	**Shipbuilders**	**Country**	**2015 Rank**	**Shipbuilders**	**Country**
1	Azimut/Benetti	IT	16	Christensen	US
2	SanLorenzo	IT	17	Cerri-Baglietto	IT
3	Ferretti Group	IT	18	Palmer Johnson	US
4	Sunseeker	GB	19	Sunrise Yachts	TR
5	Lürssen	DE	20	Privilege Yard	IT
6	Amels / Damen	NL	21	Abeking & Rasmussen	DE
7	Feadship	NL	22	The Italian Sea Group	IT
8	Princess Yachts	GB	23	Mengi Yay	TR
9	Heesen Yachts	NL	24	Oruçoglu	TR
10	Horizon	TW	25	Heysea	CN
11	Gulf Craft	US	26	Mondo Marine	IT
12	Fipa	IT	27	Dream Ship Victory	TR
13	Overmarine	IT	28	Perini Navi	IT
14	Alexander Marine	US	29	Hatteras	US
15	Oceanco	NL	30	Oyster Marine	GB

Source: Elaboration from Global Order Book 2015
Index of Countries: CN: China; DE: Germany; GB: Great Britain; IT: Italy; NL: The Netherlands; TR: Turkey; TW: Taiwan; US: United States.

As regards the demand-side of the mega yacht industry, the clientele is mostly represented by the so-called UHNWIs, those who account for net assets over $30 million excluding their main properties. In terms of their geographical origin, Russians, Asiatic and North Americans are the main super yacht owners with a fall of Latin Americans (Wealth-X Report, 2017) in 2017. It has been estimated that the number and the wealth will continue to increase over the next

future (Hodgson, 2017), implying that the mega yacht sector will continue to grow and flourish in the next few years.

2.2 DEA and mega yacht

Little research has been conducted to date about the efficiency of the mega yacht sector. Costa (2012) evaluates efficiency and productivity of intellectual capital in the Italian yacht sector, which represents the first attempt to study the efficiency in the mega yacht sector. Some studies (Tongzon, 2001; Cullinane et al., 2006; Ablanedo-Rosas et al., 2010) aim at analysing port efficiency that is indirectly connected with the mega yacht sector, since harbours should provide added services to mega yacht owners to attract them in order to increase and improve the performance of ports. Ablanedo-Rosas et al. (2010) examine the efficiency of Chinese ports by using multiple financial ratios and combining them into a single measure of efficiency. Their study utilises a DEA technique that is not so often applied to efficiency studies, i.e., DEA based on financial ratios without inputs. They find that the most efficient ports correspond to the highest ratios (e.g., current and quick ratios, and return on equity). However, there are few attempts to measure firms' performance by analysing financial ratios. In this respect, for example, Halkos and Salamouris (2004) and Yu et al. (2013) apply this non-parametric method (i.e., DEA) with no use of inputs by observing accounting ratios in two different competitive markets: commercial banking and the computer industry. It emerges that the role of financial ratios is paramount to analyse companies' efficiency, especially in competitive environments, because the combination of DEA and ratios is a powerful tool to measure quality management efficiency and to provide suggestions to improve inefficient quality management (Kuah et al., 2010), especially in complex and competitive sectors like the mega yacht one. For this reason, the present research analyses the top 30 mega yacht firms across the world during the period 2005–2013 by using the financial ratio-based DEA, which represents an alternative or

complement to ratios analysis for the evaluation of a firm's efficiency (Halkos and Salamouris, 2004).

3 DEA

DEA is a non-parametric approach aimed at measuring the relative efficiency of decision-making units (DMUs) performing the same or similar tasks (Charnes et al., 1978). Different variations of DEA have been developed; among them the most widely applied are DEA-CCR (Charles et al., 1978) and DEA-BCC (Banker et al., 1984). The main idea is that DEA compares units (branches, companies, departments) taking into account resources used and output (goods and/or services) provided. Thus, the DEA model discerns between efficient and inefficient units (Cooper et al., 2007) resulting in a fundamental tool for managers to evaluate the inefficiencies within the company and then to implement strategies to improve the productivity of inefficient units, increasing profitability and diminishing operating costs (Sherman and Zhu, 2006).

In order to evaluate the efficiency of mega yacht shipbuilders, the present study adopts the financial ratio-based DEA model, particularly the Fernandez-Castro and Smith's (1994) and Halkos and Salamouris's (2004) approaches where, in contrast with the original DEA model proposed by Charnes et al. (1978), inputs are not specified. The main idea is that 'inputs are considered similar and equal' [Halkos and Salamouris, (2004), p.205] for all companies since they perform in the same market for goods (viz. mega yachts). Accordingly, Fernandez-Castro and Smith (1994) state that when DMUs operate in the same market or sector, selling the same products or services, "the inputs to the firms can be considered immaterial, as they can be assumed to equal for all [...] The interest of the analyst is then in finding the companies which secure what are in some sense the 'best' financial ratio (output) amongst the firm observed" [Fernandez-Castro and Smith, (1994), p.241]. Indeed, from this perspective financial ratios

reflect and encompass inputs. It follows that the DEA model adopted in this research is focused on outputs (i.e., financial ratios).

The output-oriented and financial ratio-based DEA model is defined as follows (Halkos and Salamouris, 2004; Ablanedo-Rosas et al., 2010): there are *n* DMUs, where each *DMUi* (i=1,2,....,*n*) generates *q* outputs *yij* (j=1,2,....,*q*).αi is the DEA coefficient associated with *DMUi*. The DEA model is the following linear program for each company:

Max λ_0

Subject to

$$\sum_{i=1}^{n} \alpha_i = 1$$

$$\sum_{i=1}^{n} y_{ij}\alpha_i \geq y_{i0}\lambda_0 \qquad j = 1, 2, \ldots, q$$

$$\Lambda_0 \geq 0,\ \alpha_i \geq 0 \ .i = 1, 2, \ldots, I)$$

The efficiency score for the each DMU is given by $\Phi_0 = \frac{1}{\lambda_0}$ and it is positive and less than or equal to 1. DMUs with Φ_0 equal to 1 are considered as efficient; whereas DMUs with Φ_0 score less than one are deemed as inefficient.

Traditional DEA literature (Charnes et al., 1978; Banker et al., 1984) states that all inputs and outputs should be positive and certain. However, scholars have been trying to relax the restriction of the DEA model and to handle missing data by adopting different typologies of methods, viz. the deletion technique (Kuosmanen, 2008), multiple linear regression (Chen et al., 2014) or the fuzzy approach (Kao and Liu, 2000). The present research applies and

compares two approaches for handling missing data, i.e. the deletion technique (Kuosmanen, 2008) and multiple linear regression analysis (Chen et al., 2014). The deletion approach is utilised since it is the traditional approach to cope with missing data (Charles and Kumar, 2012); and multiple linear regression analysis is applied because it represents a general method that can handle manage all cases with missing values (Chen et al., 2014).

Specifically, this study adopts the following phases.

Phase A. All those DMUs for which it is not possible to retrieve financial statements or financial ratios from databases for the entire period analysed are deleted from the sample.

Phase B. With the remaining DMUs, we verify whether financial ratios are presented for each year. In the case of a DMU that does not have any data for one or more years but has it for the remaining years, we delete this DMU for that particular year. The reasons a company (DMU) has missing data for a given year are that either the financial statement is not published for that year or the company is established after that year. For instance, The Italian Sea Group was established in 2013, so the only financial statement available is for 2013; for this reason, The Italian Sea Group DMU is deleted from the sample from 2005 - 2012.

Phase C. All ratios for all remaining DMUs are checked. We delete the DMU where it is not possible to calculate its ratios because they would have been biased; e.g. the Fipa's ROE in 2013. Fipa registered a loss (negative nominator) in 2013 and has negative equity (negative denominator) resulting in a positive ROE that is biased and inconsistent.

Phase D1. By taking the above steps, the resulting sample is composed of both DMUs with all financial ratios for the entire period under analysis and DMUs with some financial ratios missing for some years. In order to manage this missing data and consistent-with the literature (Scheffer 2002) we delete DMUs even in the case where they exhibit some missing financial ratios for one year.

Phase D2. An alternative approach of deletion applied in Phase D1 is used in order to manage missing data. In particular, in the case of the few DMUs with missing financial ratios for one or more years, Chen et al.'s (2014) approach is adopted, i.e. Multiple Linear Regression Analysis (MLRA). The latter is a statistical method, which predicts the values of a dependent variable given a set of explanatory variables (Pindyck and Rubinfeld, 1998). The MLRA approach (Chen et al., 2014), used to estimate missing values, is developed as follows:

***Step 1*.** The variable with missing values is considered as the dependent variable and the remainder as independent ones; proceed to Step 2.

***Step 2*.** If a DMU has other independent variables with existing missing values, they are excluded from the analysis; otherwise to obtain the regression equation MLRA is used (then proceed to Step 3). If all values of remaining independent variables of the current DMU are missing, it is necessary to replace the dependent variable of the current DMU with the mean of the variable excluding the DMUs with missing values (then proceed to Step 3).

Step 3. The predicted values using the regression equation in Step 2 are calculated; go back to Step 1 until all missing values are estimated.

Consequently, the present research compares results by applying both the deletion method in Phase D1 and MLRA in Phase D2. It follows that in the case of the former, a drop in the number of DMUs has occurred. Furthermore, Phase D2 represents an alternative to Phase D1.

A potential problem arises because some ratios may register negative values. Since some companies in the sample exhibit negative financial ratios (e.g. ROE, ROA) a constant value is added to every negative value in order to transform them into positive (Yildirim and

Philippatos, 2007; Pasiouras et al., 2009; Ablanedo-Rosas et al., 2010) and '*to ensure that the reference group of DMUs performs no worse than a reference* […]' shipbuilder '*on the ratio where the DMU$_0$ in the study has negative performance*' [Ablanedo-Rosas, (2010) p.353].

2. Methodological Approach: Sample and Variables

The present research deals with the top 30 mega yacht builders across the world by using financial ratio-based DEA which examines simultaneously multiple financial ratios by combining them into a single measure of shipbuilders' efficiency. This study analyses the top shipbuilders published by the Global Order Book 2015 during the period 2005-2013.

It is worth pointing out that it is not possible to expand the period of analysis, because financial statements are not available. By using Orbis and Fame to retrieve financial statements and financial ratios, financial statements of 17 companies have been analysed; the remaining 13 shipbuilders that do not have them available[1)] are deleted from the sample (Phase A)[i]. Secondly, 6 out of 17 companies do not exhibit any data for one or more years, which means they are deleted from the sample (Phase B). Indeed, for a given year, the financial statement of a given DMU is not available, resulting in the deletion of this unit. Furthermore, 3 out of 17 companies exhibit biased values of ratios; thus, when they present biased data they are deleted from the sample (Phase C). For instance, in 2010 Cerri exhibits a positive ROE due to both negative numerator (loss) and denominator (equity). By using DEA as a method, our results are able to identify if and how the financial crisis has affected performance and efficiency of the shipyards.

Due to the complexity of analysing the shipbuilders' financial performance, the variables (i.e. outputs) analysed are financial ratios. Financial ratios are highly significant for mega yacht companies, because they offer organisations a standardised method for comparing

their performance, investments, finance, costs and revenues with the other competitors worldwide. Additionally, given the fast-paced mega yacht environment, financial ratios will give further impetus to companies and competitors to adjust or rectify some corporate decisions or investments, including opening new plants or yards in a different country than the headquarter. Financial ratios can be categorised into four basic types: profitability ratios, activity ratios, liquidity ratios and leverage or solvency ratios (Vickers, 2006). For each of these categories, we have calculated at least one ratio has been calculated to measure the efficiency score, resulting in seven different ratios. It follows that a more comprehensive view of the companies is obtained, since all the categories of ratios have been analysed.

PROFITABILITY RATIO

1. Return on Equity (ROE) = income/book value of shareholders' equity[ii]. It shows the ability of management to use shareholders' resources to generate net income (Arditti, 1967; Easton, 2004; Baker and Powell 2009).

2. Return on Assets (ROA) = net income/assets. It indicates the company's ability to generate net income by using its assets (Bettis and Hall, 1987; Gibson 2010).

ACTIVITY RATIOS/TURNOVER RATIOS

3. Inventory Turnover = cost of goods sold / Inventory. It measures managers' ability to maintain the right level of inventory during a certain period of time (Saunder and Cornett, 2003; Hill et al., 2014).

LIQUIDITY RATIO

4. Current ratio = total current assets/total current liabilities. It measures the ability of a company to pay off its current liabilities in the short term (Libby, 1975; Chen and Yuan, 2004; Gibson 2010).

5. Quick ratio = (cash + accounts receivable)/current liabilities. It represents a variant of current ratio, by considering that inventory is not as liquid as cash and accounts receivable (Beaver, 1968; Gallagher and Andrew, 2007).

LEVERAGE RATIO/SOLVENCY RATIOS

6. Debt ratio = total liability/total equity. It examines the balance between debts (including loans, mortgages, etc.) and equity (Anderson et al., 2004; Gibson, 2010).

7. Solvency ratio = total liabilities/total assets. It evaluates the relationship between the total liabilities and total assets (Beaver, 1966; Patra, 2006).

3. Empirical Results

Table 2 describes these financial ratios for all companies from 2005 to 2013. The descriptive statistics refer to Phase D1, meaning that they are calculated considering both negative values and observations without any missing data.

The ROE mean witnessed its highest level in 2008 (21.05%) and has registered a positive trend since 2005; whereas during the recovery period (2009-2013) the ROE mean dropped considerably, especially in 2011 when it was -34.14%. This means that in the pre-crisis period (2005-2006) and at the crisis peak (2007-2008) the top shipbuilders performed better than during the recovery period (2009-2013), because the negative effects of the global recession emerged a few years after the peak (2007-2008). Indeed, after this period mega yacht

orders decreased significantly due to the change in the type of luxury goods UHNWIs were purchasing (from leisure boats to jewellery, art and vintage cars). ROA assumed the same trend as ROE, meaning that firms' ability to generate net income by using their assets deteriorated in the last five years of the analysis.

Current and quick ratios have the same positive trend for the period analysed. However, the former decreased in 2013 while the quick ratio increased, because the inventories reduced and companies registered more cash and equivalents, and accounts receivable, than during the years before. This may be due to three factors: more mega yachts were sold, as witnessed by a slight increase in ROE in 2013; some plants and superfluous assets were disinvested resulting in an increase in cash and accounts receivable; shipbuilders obtained new internal funds from shareholders (equity) and restructured their debts with financial institutions. Indeed, the debt ratio decreased in 2013, meaning that firms were improving their financial position.

Table 2 Descriptive Statistics

	2013	2012	2011	2010	2009	2008	2007	2006	2005
ROE									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	-10.16	-22.28	-34.14	-7.90	-30.40	21.05	13.96	17.38	12.86
Median	0.23	2.29	0.56	3.70	8.93	21.00	12.77	15.42	3.88
Standard Deviation	48.51	103.02	116.99	48.22	138.90	27.23	22.38	21.71	26.78
Max	59.58	54.46	64.50	68.30	29.89	90.77	54.29	53.30	68.73
Min	-166.70	-413.13	-482.32	-153.85	-572.78	-33.66	-42.60	-32.30	-49.67
ROA									
Number of observations	14	16	17	15	17	16	16	15	15
Mean	-1.38	1.23	-1.02	-3.82	-0.12	7.82	5.57	6.04	4.85
Median	0.16	1.79	0.01	0.47	0.58	4.44	3.26	3.03	1.98
Standard Deviation	10.00	10.20	9.92	15.86	9.19	9.99	7.39	8.37	10.36
Max	13.45	18.80	14.09	18.11	13.56	40.38	21.62	32.73	39.65
Min	-24.32	-20.82	-30.19	-46.04	-28.91	-2.64	-5.67	-4.06	-9.55
INVENTORY TURNOVER									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	12.84	4.67	3.30	7.40	4.77	4.51	5.72	4.71	2.83
Median	3.04	3.65	3.21	2.82	1.55	3.28	3.69	3.15	1.81
Standard Deviation	33.51	5.49	2.53	14.77	7.14	4.02	7.03	4.67	2.70
Max	133.13	20.00	8.40	60.38	29.56	12.62	28.55	19.71	10.73
Min	0.21	0.20	0.02	0.38	0.57	0.25	1.00	0.87	0.04
CURRENT RATIO									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	1.26	1.61	1.55	1.89	1.42	1.29	1.29	1.19	1.20
Median	1.16	1.02	1.28	1.31	1.27	1.15	1.10	1.06	1.08
Standard Deviation	0.55	1.39	1.01	1.52	0.98	0.42	0.56	0.45	0.39
Max	2.56	6.60	4.42	6.66	4.96	2.12	3.06	2.66	2.35

Min	0.66	0.65	0.34	0.63	0.45	0.59	0.48	0.78	0.81
QUICK RATIO									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	0.68	0.57	0.62	0.84	0.54	0.50	0.66	0.55	0.51
Median	0.63	0.64	0.59	0.46	0.39	0.38	0.45	0.47	0.46
Standard Deviation	0.41	0.32	0.51	0.86	0.36	0.37	0.55	0.41	0.38
Max	1.59	1.09	2.33	3.15	1.16	1.38	2.22	1.74	1.65
Min	0.17	0.10	0.01	0.09	0.08	0.08	0.14	0.10	0.14
DEBT RATIO									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	3.42	3.10	5.53	4.24	7.59	2.61	2.93	8.37	9.27
Median	2.04	2.24	1.68	1.98	1.39	1.75	1.53	2.99	4.02
Standard Deviation	5.67	2.44	10.35	7.14	19.98	3.07	3.86	17.67	16.10
Max	22.32	10.64	43.72	30.31	86.45	11.74	13.10	75.63	66.33
Min	-3.78	0.37	0.15	0.42	0.34	0.00	0.00	0.08	0.06
SOLVENCY RATIO									
Number of observations	14	16	17	15	17	16	16	16	15
Mean	47.43	52.02	80.88	42.81	44.07	35.76	34.99	35.79	31.80
Median	40.94	47.20	45.67	42.70	40.77	26.61	26.15	25.13	23.23
Standard Deviation	28.82	35.81	132.39	30.74	31.81	25.32	24.89	37.93	33.16
Max	120.78	148.79	584.83	125.44	100.77	85.51	84.45	165.86	136.30
Min	-4.48	-9.40	-5.64	-3.30	1.16	7.86	7.55	0.01	0.02

Table 3 shows the efficiency score for each shipbuilder between 2005 and 2013 after the deletion of DMUs that present missing data (Phase D1). The first column of the table represents the DMUs rank; this enables us to compare the results obtained by applying MLRA. Furthermore, for each year, the second column presents the companies' names and the third one the efficiency scores.

Table 3 Efficiency scores – Deletion technique (Phase D1)

	2013		2012		2011		2010		2009		2008		2007		2006		2005	
1	Sunseeker	1,000	Sunseeker	1,000	Sunseeker	1,000	Sunseeker	1,000	San Lorenzo	1,000	San Lorenzo	1,000	Amels	1,000	Lürssen	1,000	Lürssen	1,000
2	Ferretti	0.53	Privilege Yard	0.132	Fipa Group	0.373	Cantieri Apuania	0.246	Admiral Tecnomar Tyg	1,000	Ferretti	1,000	Heesen	1,000	Admiral Tecnomar Tyg	0.007	Heesen	0.26
3	Admiral	0.129	Admiral	0.071	Amels	0.088	San Lorenzo	0.217	Cantieri Apuania	0.857	Amels	1,000	Fipa Group	1,000	Heesen	0.005	Ferretti	0.244
4	Oyster Marine	0.074	Cerri	0.051	Admiral	0.086	Admiral Tecnomar Tyg	0.173	Mondo Marine	0.755	Baglietto	1,000	Baglietto	0.895	Oyster Marine	0.005	Admiral Tecnomar Tyg	0.226
5	Amels	0.066	Oyster Marine	0.039	Privilege Yard	0.083	Fipa Group	0.157	Amels	0.436	Cantieri Apuania	1,000	Cantieri Apuania	0.882	Ferretti	0.003	Sunseeker	0.097
6	Cantieri Apuania	0.055	Cantieri Apuania	0.038	Oyster Marine	0.076	Amels	0.124	Ferretti	0.399	Cerri	0.986	Mondo Marine	0.828	Sunseeker	0.003	Fipa Group	0.086
7	San Lorenzo	0.052	Ferretti	0.037	Cantieri Apuania	0.061	Privilege Yard	0.08	Fipa Group	0.37	Fipa Group	0.827	Oyster Marine	0.807	Fipa Group	0.003	Baglietto	0.028
8	Mondo Marine	0.049	San Lorenzo	0.036	Heesen	0.049	Perini Navi	0.078	Sunseeker	0.343	Mondo Marine	0.689	Ferretti	0.781	Azimut-Benetti	0.001	Perini Navi	0.028
9	Heesen	0.048	Overmarine	0.031	San Lorenzo	0.047	Ferretti	0.077	Perini Navi	0.268	Oyster Marine	0.612	Cerri	0.581	San Lorenzo	0.001	Princess Yachts	0.027
10	Azimut-Benetti	0.044	Princess Yachts	0.027	Overmarine	0.043	Oyster Marine	0.077	Cerri	0.191	Overmarine	0.594	Sunseeker	0.549	Princess Yachts	0.001	Cerri	0.027
11	Princess Yachts	0.041	Azimut-Benetti	0.025	Ferretti	0.041	Mondo Marine	0.076	Azimut-Benetti	0.146	Heesen	0.503	Perini Navi	0.413	Overmarine	0.001	Overmarine	0.025
12	Perini Navi	0.041	Amels	0.025	Perini Navi	0.037	Overmarine	0.073	Oyster Marine	0.123	Sunseeker	0.486	Privilege Yard	0.269	Baglietto	0.001	Azimut-Benetti	0.024
13	Overmarine	0.026	Heesen	0.022	Princess Yachts	0.028	Heesen	0.048	Baglietto	0.122	Perini Navi	0.46	Overmarine	0.245	Cerri	0.001	Mondo Marine	0.024
14	Cerri – Baglietto	0.019	Perini Navi	0.02	Cerri	0.025	Azimut-Benetti	0.047	Privilege Yard	0.116	Azimut-Benetti	0.316	Azimut-Benetti	0.243	Cantieri Apuania	0.001	Cantieri Apuania	0.021
15			Mondo Marine	0.018	Azimut-Benetti	0.023	Princess Yachts	0.037	Princess Yachts	0.109	Princess Yachts	0.288	San Lorenzo	0.207	Mondo Marine	0.001	San Lorenzo	0.014
16			Baglietto	0.012	Mondo Marine	0.019			Heesen	0.1	Privilege Yard	0.214	Princess Yachts	0.207	Perini Navi	0.001		
17					Baglietto	0.003			Overmarine	0.076								

Results show that only one shipbuilder proves to be efficient between 2010 and 2013, and between 2005 and 2006, respectively Sunseeker (UK) and Lürssen (DE). Furthermore, during the period 2007 – 2009, efficient shipbuilding companies increased from two to five, e.g. San Lorenzo (IT) and Amels (NL). Two conclusions can be drawn. First, during the period 2007-2009 more than half of the efficient companies are Italian shipbuilders, confirming the leadership of Italy in terms of both mega yacht orders and efficiency (Costa 2012; Merendino, 2014). Secondly, during the peak of the financial crisis (2007 and 2008), a greater number of efficient shipbuilders can be observed, while during the recovery period all companies witness a worsening of their performance, as confirmed in the descriptive statistics (Table 2). Indeed, during 2010-2013, only Sunseeker, which is the largest volume mega yacht builder in the UK, is the most efficient among the top shipbuilders across the world.

Table 4 shows the efficiency scores for each shipbuilder between 2005 and 2013 after using the approach of Chen et al. (2014), i.e. multiple linear regression to estimate missing values (Phase D2).

Table 4 Efficiency scores – MLRA (Phase D2)

	2013		2012		2011		2010		2009		2008		2007		2006		2005	
1	Sunseeker	1	Sunseeker	1	Sunseeker	1	Sunseeker	1	Abeking & Rasmussen	1	San Lorenzo	1	Amels	1	Lürssen	1	Lürssen	1
2	The Italian Sea Group	0.262	Abeking & Rasmussen	1	Abeking & Rasmussen	1	Abeking & Rasmussen	0.295	Baglietto	1	Amels	1	Fipa Group	1	Admiral tecnomar tyg	0.009	Heesen	0.181
3	Admiral tecnomar tyg	0.085	Privilege Yard	0.546	Privilege Yard	0.546	Cantieri Apuania	0.246	Admiral tecnomar tyg	1	Abeking & Rasmussen	1	Abeking & Rasmussen	1	Oyster Marine	0.006	Ferretti	0.17
4	Oyster Marine	0.074	Cerri	0.5	Cerri	0.5	San Lorenzo	0.217	San Lorenzo	0.319	Cantieri Apuania	1	Cantieri Apuania	0.852	Heesen	0.006	Admiral tecnomar tyg	0.158
5	Amels	0.066	San Lorenzo	0.33	San Lorenzo	0.33	Admiral tecnomar tyg	0.174	Cantieri Apuania	0.302	Cerri	0.914	Mondo Marine	0.761	Feadship	0.006	Sunseeker	0.067
6	Cantieri Apuania	0.055	Oyster Marine	0.325	Oyster Marine	0.325	Fipa Group	0.157	Mondo Marine	0.287	Fipa Group	0.807	Cerri	0.589	Fipa Group	0.004	Fipa Group	0.06
7	San Lorenzo	0.052	Admiral tecnomar tyg	0.324	Admiral tecnomar tyg	0.324	Lürssen	0.142	Ferretti	0.243	Feadship	0.482	Ferretti	0.581	Ferretti	0.004	Feadship	0.027
8	Mondo Marine	0.049	Lürssen	0.288	Lürssen	0.288	Amels	0.124	Amels	0.164	Mondo Marine	0.436	Sunseeker	0.573	Sunseeker	0.003	Perini Navi	0.02
9	Heesen	0.048	Cantieri Apuania	0.288	Cantieri Apuania	0.288	Privilege Yard	0.08	Fipa Group	0.129	Ferretti	0.433	Oyster Marine	0.382	Baglietto	0.003	Princess Yachts	0.019
10	Azimut-Benetti	0.044	Amels	0.218	Amels	0.218	Perini Navi	0.078	Sunseeker	0.113	Baglietto	0.403	Feadship	0.378	San Lorenzo	0.002	Cerri	0.019
11	Princess Yachts	0.041	Azimut-Benetti	0.215	Azimut-Benetti	0.215	Ferretti	0.077	Cerri	0.093	Perini Navi	0.34	Heesen	0.334	Perini Navi	0.002	Overmarine	0.018
12	Perini Navi	0.041	Perini Navi	0.207	Perini Navi	0.207	Oyster Marine	0.077	Perini Navi	0.088	Sunseeker	0.325	Perini Navi	0.297	Mondo Marine	0.002	Azimut-Benetti	0.017
13	Abeking & Rasmussen	0.04	Fipa Group	0.206	Fipa Group	0.206	Mondo Marine	0.076	Privilege Yard	0.064	Oyster Marine	0.272	Baglietto	0.26	Cerri	0.002	Mondo Marine	0.017
14	Ferretti	0.034	Feadship	0.193	Feadship	0.193	Overmarine	0.073	LÜRSSEN	0.06	Azimut-Benetti	0.195	Overmarine	0.259	Cantieri Apuania	0.002	Baglietto	0.015
15	Feadship	0.032	Mondo Marine	0.188	Mondo Marine	0.188	Feadship	0.059	Oyster Marine	0.055	Overmarine	0.17	Azimut-Benetti	0.217	Princess Yachts	0.001	Cantieri Apuania	0.014
16	Overmarine	0.026	Ferretti	0.185	Ferretti	0.185	Heesen .	0.048	Azimut-Benetti	0.05	Heesen	0.165	San Lorenzo	0.212	Overmarine	0.001	San Lorenzo	0.01
17	Cerri – Baglietto	0.019	Overmarine	0.175	Overmarine	0.175	Azimut-Benetti	0.047	Feadship	0.048	Princess Yachts	0.142	Princess Yachts	0.202	Azimut-Benetti	0.001		
18			Princess Yachts	0.172	Princess Yachts	0.172	Princess Yachts	0.037	Princess Yachts	0.038	Privilege Yard	0.111	Privilege Yard	0.135				
19			Heesen	0.146	Heesen Yachts	0.146			Heesen	0.036								
20			Baglietto	0.08	Baglietto	0.08			Overmarine	0.031								

It emerges that by adopting these two different approaches to handling missing data, some changes may occur in the efficiency scores. Ferretti and Fipa, which are the second companies registering the highest efficiency score with the deletion approach, drop to the lowest part of the ranking with the MLRA. The latter is likely to be more accurate measure and in line with companies' performance. Indeed, Ferretti registers an excessive value of inventory turnover (133.13) and the average of all companies is 12.84 implying an ineffective buying and an investment with a rate of return of zero. FIPA registers the lowest level of ROE (-482%), a negative ROA (-8.16%), a low inventory turnover (0.5) and a low solvency ratio (1.8) compared with other companies analysed[iii]. Furthermore, it is plausible to assume that by adding new observations to the sample, the sample becomes less biased and these newly added firms appear to be more efficient than the sample obtained by using the deletion approach. For instance, in 2009 the companies having the highest efficiency score in 2009 through the deletion technique are San Lorenzo and Admriral; however, by adding three more companies, San Lorenzo is replaced by Aberking & Rasmussen and Cerri but still remains in the top rank.

During the financial crisis peak (2007-2008) and 2009, the number of efficient companies increased, whereas before the recession and during the recovery period the efficient companies are one and two. This is due to the fact that during the recovery period the shipbuilders have tried to react to a decrease in mega yachts' orders by disinvesting in plants, changing ownership composition, and replacing directors and managers. These radical strategies require time before their positive effects can impact on companies and on financial reports.

Moreover, during the period 2004-2013 the lowest efficiency scores are mainly associated with Italian companies, apart from Princess Yacht that registers the worst score in 2010. This is deeply at odds with the Global Order Book rank stating that Italy is the country

that registers the highest mega yacht orders in the world. This suggests that while Italy is the leading country in terms of the number of mega yachts produced, on the other hand it has the least efficient companies among the top mega yacht builders. On the other hand, the English and Germany shipbuilders are able to invest their resources efficiently during the recovery and pre-crisis periods, respectively.

The companies that experience change in ownership are Ferretti, Sunseeker, Hessen, Admiral tecnomar and Cantieri Apuiana. From our analysis, it emerges that even after its acquisition by a Chinese company, Sunseeker is the most efficient shipbuilder. On the other hand, Ferretti and Hessen present a lower level of efficiency, especially after the acquisition by the new shareholders in 2011 and 2008 respectively. This may mean that the M&A was a paramount strategy to save these company but it does not seem that these companies are efficiently managed. As regards Admiral tecnomar and Cantieri Apuiana, in 2013 they merged to form The Italian Sea Group. Even though their efficiency scores did not increase after the M&A, the new group of companies reached the second position in efficiency in 2013. This suggests that, in this instance, the M&A helped the two companies to perform better at a time when all the other competitors were witnessing a worse performance.

6 Discussion and conclusions

In this study, an application of DEA to the biggest mega yacht firms was performed, by using financial ratios as output measures in the suggested model for the time period 2005–2013. Two approaches to handle missing data were used, namely the deletion technique and MLRA. Finally, from the analysis we calculated the optimal ratios (output) level for inefficient companies in 2013.

Some interesting implications emerge from this analysis. First, this research shows that managing missing data through MLRA (Phase D2) is more accurate and reliable than using the

deletion techniques (Phase D1), because the efficiency scores are in line with financial reports and their related financial ratios. In fact, Ferretti was categorised as the second most efficient company in 2012 through the deletion approach, even though it witnessed a negative trend in all ratios; on the other hand, by running MLRA it registered a low efficiency score, positioning the company in the lowest part of the rank. Therefore, MLRA results are more reliable than the deletion technique. Indeed, the deletion technique may provide biased results (i.e., efficiency scores), which are not sustained by companies' reports and financial ratios.

Second, the 2015 Global Order Book rank, which is based on the number and length of mega yachts orders, does not reflect companies' efficiency. It means that shipbuilders receiving the highest orders numbers of mega yacht are not necessarily performing efficiently. For instance, our study shows that Azimut-Benetti and Ferretti, the top shipbuilders across the world in terms of mega yacht orders, may be not the most efficient companies.

Third, Italy is not the best performing country in terms of efficiency. Indeed, Italian shipbuilders appear to be efficient between 2006 and 2009, before the financial crisis affected the mega yacht sector. After 2010 British and German companies register the highest efficiency score. That is an interesting result, because it seems that the efficiency trend of these shipbuilders reflects the economic structure of their own countries. Indeed, the UK and Germany are the most powerful economic countries within the European Union (Knowles, 2013). It follows that if Italian companies want to keep abreast with English and German shipbuilders, they should invest their resources more efficiently by comparing their strategies to those of the more efficient companies (e.g., Sunseeker, Abeking and Rasmussen).

Fourth, the results confirm that the mega yacht sector is not anti-cyclical, i.e., it is deeply affected by the financial crisis as shown by the descriptive statistics (Merendino, 2016). For instance, ROE and ROA have witnessed a negative and declining trend during the period

analysed. Although the quick ratio registers a positive trend in the last year (2013), its value is low enough (below 1) for us to consider companies to be at risk of not being able to repay current liabilities in the short run, resulting in insolvency risk.

Finally, the DEA approach is a valuable method that allows companies to compare their performance with those of their competitors and to verify the level of performance they should reach to become efficient as their competitors.

This research suffers from some limitations relating to the number of DMUs. We focused on the biggest shipbuilders across the world; future research could calculate efficiency scores for small-medium mega yacht companies. Another limitation is connected with the missing data. In order to overcome this issue, two techniques are applied and compared, namely the deletion approach and MLRA, in order to avoid biased results by applying only one technique.

This research is based on a unique study focusing on the analysis of efficient and inefficient mega yacht shipbuilders across the world. It is in line with the studies of Berger and Humphrey (1997) and Halkos and Salamouris (2004) in the application of financial ratios in DEA. It shows that financial ratio-based DEA gives insightful information for shipbuilders' management. In particular, it represents a complementary tool for managers to evaluate the performance and efficiency of their firm and competitors. Indeed, it provides each shipbuilder with a firm-benchmark that it can follow in order to increase its performance and efficiency. Future research could take into consideration other traditional financial ratios and accounting variables, such as EVA (economic value added), in order to measure the value and efficiency of a firm. Finally, future research could adopt an input-output DEA model by considering not only financial data but also information related to the board of directors, CEO turnover, employees, the organisational structure of shipyards and the number of national and international plants.

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[i] We have checked other databases, including Bloomberg and Datastream, but no suitable data is available. We, therefore, contacted by email or over the phone all the companies for which data is unavailable; some of them did not reply or unable to share their financial statements or ratios.

[ii] Given the different taxation rates adopted by the countries of our sample, we have calculated ROE by taking into consideration the income before taxation; by doing that our results are not affected by the diverse tax rates within our sample.
[iii] Data available on request.