The Potential of Big Data Analysis in the Shipbuilding Industry: A Way of Increasing Competitiveness

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Abstract

It is possible to exploit potentials of Big Data in the shipbuilding industry in order to increase efficiency and company performance. Big Data analysis will probably have a great impact on strengthening the competitiveness in the whole sector, providing various types of benefits and effective support to the decision-making system. Academics maintain that analysis methods and algorithms can offer specific guidelines to managers and practitioners in order to satisfy their information needs. Even though it is recognized that the techniques for Big Data analysis are relevant, only a few studies provide practical guidelines on how to apply these techniques in specific industries like shipbuilding.
This preliminary study aims to develop a *conceptual framework* of Big Data analysis based on the value chain approach. By using a *deductive methodology*, the framework is built taking into consideration four phases of the value chain in the shipbuilding industry – i.e. pre-production, design, production, and post-production. For its relevance, the study considers the *pre-production phase*, trying to classify data sources, analysis methods, and algorithms for the main activities of this node and also providing various suggestions to shipbuilding managers and practitioners. The researchers develop the framework by considering *secondary data* collected from the literature analysis.
Our results can successfully support decision making in shipbuilding companies, making processes and operations more cost-effective and helping companies be more competitive. Specifically, in the pre-production node this will lead to real-time demand forecasting and a more reliable estimation of initial production costs.

Keywords: Big Data, yachting industry, value chain

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1. Introduction

The adoption of Big Data and related technologies is considered as a strategic lever to increase competitiveness and boost the efficiency of companies in many industries.

The identification of industry-specific recommendations represents an important challenge for both academics and companies to support operational activities and make management decision making faster, more effective, and data-driven.

Owing to the shipbuilding sector's specificities and relevance in terms of gross domestic product (GDP) contribution, it is necessary to analyse this sector thoroughly in order to learn how one can properly apply Big Data analysis to it.

Specifically, for this industry scholars have conducted only a few studies focusing, for instance, on potentials of Big Data for vessels design (Liu *et al.,* 2017) and for the leisure boat market's overall efficiency (Merendino *et al.,* 2018).

In this research, the research team carries out an exploration and conceptualization of the connection between modern information systems and the shipbuilding sector to deepen the role of Big Data analysis in this specific industry.

This topic is particularly relevant, as professionals working in the sector requested an in-depth study with the objective of keeping their business profitable by exploring new opportunities arising from Big Data analysis.

The study aims to bridge the gap between Big Data (BD) application and real-world aspects, taking into account how one can apply and implement the Industry 4.0 paradigm implemented in a specific industry.

2. Research background and context

2.1. The sector at a glance

Within the shipbuilding industry, one can distinguish two main sub-sectors:

- ship construction and
- marine equipment.

This study focuses on the former, limiting itself to describe the latter as "all products and services supplied for the building, conversion, and mainte-

nance of ships (…). This includes technical services in the field of engineering, installation and commissioning, and ship maintenance" (ECORYS, 2009).

The shipbuilding sector is, therefore, very diversified and includes various types of vessels, which are related to several different market segments: (i) commercial shipbuilding (oil tankers, container ships and dry bulkers); (ii) cruise ship and ferries shipbuilding; (iii) leisure boating (including yachting and boats longer than 24 meters[1]), and (iv) the refit and repair industry. Currently, three East Asian countries, i.e. Japan, China, and South Korea, control commercial shipbuilding – the construction of seaborne vessels with the primary purpose of moving large quantities of goods, commodities, or people – with a combined 90% of global commercial shipbuilding and ship production evenly distributed among them. Europe and the U.S.A. are market leaders in segments (ii) and (iii), instead, with Italy playing an important role.

Western countries and Italy are specialized in building cruise vessels and are market leaders in premium price segments, specifically those concerning the production of yachts and leisure boats of various dimensions combined with the associated maintenance and refitting services [tab.1].

Tab.1 - Top nations by building volume (Global Order Book, 2020)

RANK	COUNTRY	TOTAL GROSS TONNAGE	NUMBER OF PROJECTS	AVERAGE GT
1	Italy	135,863	398	341
3	Germany	101,928	19	5,365
2	The Netherlands	84,051	72	1,167
4	Turkey	43,263	65	666
5	Norway	24,939	3	8,313

These market segments are characterized by a high degree of specialization, high-tech qualities, and complex production processes, in combination with orders for a limited number of vessels of the same type to be built.

In fact, Italy has a 41% market share in the yacht-building market segment owing to the growth and market consolidation of three leading Italian companies – the Azimut-Benetti Group, the Ferretti Group, and Cantiere San Lorenzo – and owing to an important network of small and medium-sized enterprises (SMEs) (CNA, 2019) [tab.2].

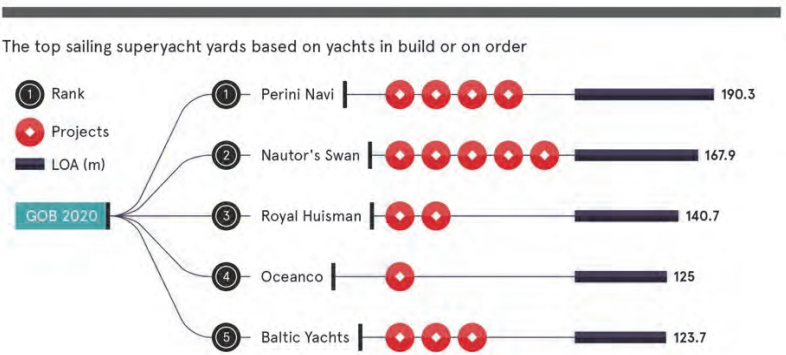
[1] The correct classification provides for superyacht (if the length is over 30 meters), mega yacht (over 40 meters), giga yachts (over 100 meters).

Tab.2 - Top 20 builders by length (Global Order Book, 2020)

RANK	COMPANY	GOB VISIT	TOTAL LENGTH (M)	NUMBER OF PROJECTS	AVERAGE LENGTH (M)	NUMBER OF PROJECTS 2019	2019 RANK
1	Azimut-Benetti	✔	3,535	101	35	97	1
2	Sanlorenzo	✔	3,061	87	35	77	3
3	Feadship*	✔	1,216	16	75.9	18	5
4	Sunseeker*		1,037	32	32.3	32	8
5	Lürssen*	✔	1,031	9	114.6	9	9
6	Amels-Damen	✔	930	14	66.4	16	7
7	Alexander Marine	✔	927	31	31.7	38	6
8	Heesen Yachts	✔	730	13	56.1	12	10
9	Horizon	✔	709	24	29.6	21	11
10	Overmarine	✔	514	12	42.9	11	13
11	Baglietto-CCN	✔	430	10	42.9	10	15
12	Heysea Yachts		400	11	36.2	11	16
13	Bilgin Yachts		392	5	78.3	4	NEW ENTRY
14	Turquoise Yachts		390	6	64.9	5	NEW ENTRY
15	Oceanco	✔	351	3	117.0	5	12
16	Gulf Craft	✔	344	9	38.1	8	20
17	Cantiere delle Marche	✔	341	9	37.7	9	19
18	Palumbo	✔	339	8	42.3	9	14

Italian companies acquired this leading position by avoiding competition based on costs with Eastern Asian players, trying instead to compete on quality and adopting a strategy of customization and differentiation [fig.1].

Fig. 1 - Top five sailing builders (Global Order Book, 2020)



Nevertheless, although Italy's competitive positioning is on segments with high added value, other global players enter the luxury and leisure boats market. Consequently, Italy's position, despite being still dominant, is threatened by Eastern competitors shifting up toward more complex vessel segments (Mickevicien, 2011).

Furthermore, the presence of SMEs among Italian shipyards makes competition with Asian shipyards tougher although SMEs are more flexible and

can innovate more easily. Mickevicien (2011) argues that one can regard this last point as an advantage for Italian firms even if SMEs do not have enough financial resources and are characterized by the highest wage level.

Other studies, however, highlight that Italy is not the best-performing country in terms of efficiency, especially after the financial crisis of 2008. According to Merendino *et al.* (2018), British and German companies registered the highest efficiency score in the mega-yacht segment after 2010. This evidence emphasizes that there is significant room for improvement in terms of efficiency for Italian shipbuilding companies, even considering that the Global Order Book rank, which is based on the number of orders for mega yachts as well as the length of the mega yachts, actually does not reflect firms' efficiency.

As it is not possible to compete on labor cost, the Italian industry has to advance not only in superior products concerning ship safety, design, efficiency, and environment protection but also in innovative processes intended to increase production productivity.

Particularly, the main challenge shipbuilding firms face is how to protect their competitive advantage in this market segment over time by reducing production costs without losing quality; how to boost the coordination between the yard and all the subjects and subcontractors involved in the production process; how to enhance product customization; and how to provide maintenance and refitting services in a timely manner or in advance (e.g., predictive maintenance).

To maintain their market position and to increase their productivity and competitiveness, ceteris paribus, Italian companies may adopt the intelligent manufacturing paradigm by focusing on Big Data applications and related technologies to support both operational activities and strategic decision making. On the topic of intelligent manufacturing, the literature refers to a revolutionary innovation in production organization and a business model that originates from an important integration of manufacturing technology, information systems, and technologies (Liu *et al.,* 2017).

The innovation of information systems and a proper use of all the available data generated by different sources offer a promising solution to deal with these challenges and to implement this paradigm. In fact, many studies reveal that BD and the use of analytics to support information systems significantly enhance the company's decision making as well as its performance and processes optimization (Brynjolfsson *et al.*, 2011). Furthermore, potentials of BD are demonstrated in many sectors, including the manufacturing sector (Manyika, 2011).

2.2 BDA and IIOT: The key for increasing competitiveness

Data collection and analysis are fundamental not only to any information system but also to support both operational activities and the management decision-making process. The scale, complexity, and capacity of an information system relates closely to available data and the means to process the data.

Big Data (BD) brings about radical changes in various aspects of human society and the business world is certainly affected in a manner that commentators have described as a data revolution (Wang *et al.*, 2015; Manyika, 2011). Although scholars and practitioners have generally recognized the importance of BD, it is an abstract concept and many definitions have been proposed with the objective of capturing its main characteristics and its possible applications. The TechAmerica Foundation (Mills *et al.*, 2012), for instance, defines Big Data as "a term that describes large volumes of high velocity, complex and variable data" that requires advanced techniques and technologies to enable the collection, storage, distribution, management, and analysis of the information This definition expands upon the main features of Big Data that Laney, had summarised as the three V's: huge Volume, high Velocity and huge Variety, with the later addition of a fourth V, uncertain Veracity (Laney, 2001; Schroek *et al.*, 2012; White, 2012). In 2011, an IDC report *'Extracting values from Chaos'* (Gantz *et al.*, 2011) stressed the importance of BD analysis, which should be designed to extract economic value from very large volumes of a wide variety of data. Such definition highlights the most critical problem in dealing with huge amount of data, which is how to discover values from large datasets from different sources and with different structures of data. Indeed, the main obstacle ISs and firms are facing consists in managing enormous quantities of data and various pieces of information, together with acquiring the capacity to selectively turn raw and unstructured data into gold nuggets (Tsai *et al.*, 2015).

Nowadays, even if the amount of data digitally gathered and stored is wide and rapidly growing, such high volumes of data are of little use if they cannot be purposefully analyzed in order to extract insightful information that can be applied in decision making and in business processes. Davenport (2006) argues that it is crucial for businesses to compete on analytics, which consists in "the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decision and actions."

Big Data Analytics (BDA) comes as a promising methodology to generate operational and business knowledge at an unprecedented scale and specificity by analyzing and mining BD (Xhafa & Barolli, 2014; Cloud Security Alliance, 2013). Regardless of size or business domain, academics agree that BDA can transform business models and improve the competitiveness of enterprises greatly. In fact, Big Data analysis can be regarded as a competitive differentiator (Fan *et al.*, 2014) as emerged in a business survey done by Massachusetts Institute of Technology (MIT) and IBM. In the survey, it was detected that the top performing companies (versus the low performing ones) are more likely to be sophisticated users of analytics – descriptive, predictive, and prescriptive (Lavalle *et al.*, 2011). The potentials of BD are supported by McKinsey & Company who pointed out the positive effects of Big Data in a report on productivity and competitiveness, analyzing the U.S. healthcare system, U.S. retail, and global manufacturing (Manyika, 2011). Furthermore, Global SAP (2012) provides a number of successful BD applications, for example, the fraud detection system of American Airlines, the fraud detection system of AOK Hessen and the system adopted by the State of São Paulo to identify untaxed earnings. The research highlights that BDA achieves up to a 6% productivity boost; likewise, another study carried out by IBM indicated that the organizations leveraging Big Data will outperform their competitors by more than 20% (Forsyth, 2012). Moreover, BDA can be adopted to determine supplier and customer satisfaction (Xiang *et al.*, 2015) and also to predict power consumption in manufacturing processes (Shin *et al.*, 2014).

The role and potential of analytics can be matched by several fundamental related technologies, such as cloud computing and the Internet of Things (IoT), especially in the manufacturing industry. IoT and particularly the emerging Industrial IoT (IIoT), a sub-paradigm of IoT, focus on industrial applications and realize information exchanges connecting different objects in the real word like radio-frequency identification (RFID), sensors, bar code readers, mobile phones, and enabling companies to have more information and control over their internal – for example, physical and human – and external resources. As such, BDA and IIoT technologies complement each other and set up a sort of double helix (Wang *et al.*, 2015) that may be adopted to increase companies' internal efficiency, output, and productivity, primarily for small and medium-sized enterprises (Gandomi *et al.*, 2015).

Marchini *et al.* (2019) highlight how IoT technologies and process digitalisation provide benefits in terms of cost reduction, product quality control, and production optimisation.

Furthermore, BD can play an important role also for SMEs through an impact on company planning and control activities (Cupertino *et al.,* 2018).

Lastly, Castellano *et al.* (2017) show how the adoption of data mining tools can effectively improve the managers' strategic skills even when they do not hold similar competencies, highlighting the existence of a positive effect in spreading awareness of potentials of BD technologies.

However, as emerged in an online survey of 154 global executives conducted by Harris Interactive (Global SAP, 2012), there is a bit of confusion about what Big Data is. The inquiry highlights how executives differ in their understanding of BD, pointing out the existence of significant room for improvement in spreading awareness of the strategic value of BD and related technologies. Although the phenomenon has different intensity among countries, many sectors (e.g., healthcare and manufacturing) have lagged behind in the adoption of advanced information systems capable of managing and extracting information from vast amounts of data, thus losing competitiveness and market share. Particularly, Italy appears to have significantly lagged behind as highlighted by the Big Data Analytics & Business Intelligence Observatory of the Polytechnic of Milan (Buffo *et al.*, 2019). The largest Italian firms display evident heterogeneous behaviours: 60% of them exchange data with external environments and appear to be able to integrate data coming from different sources in different formats. On the other hand, four firms out of ten rely on internal data. Delving deeper into the four firms' data structure, one can find that 76% of the utilised data come from transactional data, thus emphasizing a sizeable delay in the capacity to find new and diversified sources—such as public data banks or data providers—and in the ability to improve their performance by exploiting their own data.

3. Research method

In this study, the research team adopts a *qualitative method* in order to gather insightful information to build a conceptual framework of BD analysis in the shipbuilding sector.

The research is carried out by using a deductive methodology based on a literature analysis. Secondary data are collected and organized in an organic framework that provides useful guidelines for shipyards and practitioners.

As the connection between modern information systems and the shipbuilding sector is a relatively recent topic, there are only a few studies that analyze BD potentials and applications referred to in the shipbuilding industry, especially with regard to the leisure boats market.

Specifically, the research team considers only publications about the shipbuilding sector, Big Data, and information systems in this study to gather secondary data in order to build the conceptual framework.

The literature collection is based on the *narrative review method*, according to which no specific protocols and standards guide the review. Narrative or traditional literature reviews are particularly useful to summarize a body of literature about a recent and wide field of research.

Furthermore, differently from conventional systematic reviews that address narrowly focused questions, narrative reviews also provide interpretation and critique and the narrative reviews' key contribution is providing the reader with a deeper understanding (Greenhalgh *et al.*, 2018).

The data collection method is, moreover, based on a literature search that includes the querying of scholarly databases with keywords, such as "shipbuilding," "big data," "Information systems," and backward or forward searches on the basis of relevant articles discovered (Webster and Watson, 2002).

Furthermore, the process of data collection is not focused on a systematic analysis of a large number of papers but follows the procedure Vom Brocke *et al.* (2009) suggest for writing a literature review that is based on analyzing specific papers chosen for relevant reasons. In fact, the authors suggest that only five research papers are required for a review as long as they contain sufficient information.

Lastly, our findings are organized according to the *value chain approach*.

3.1. Purpose and structure of the research

This preliminary paper considers the opportunities arising from the adoption of Big Data analysis in the shipbuilding industry, taking into account the specificities of the sector and trying to provide practitioners with a better understanding through a framework of potentially insightful guidelines.

In Section 4.2 the value chain approach is introduced in order to build the conceptual framework for Big Data analysis in the sector. Specifically, the research is focused on which data and detailed algorithms could be used to significantly improve the efficiency of the *pre-production phase*, the first and crucial node of the industry's value chain. Lastly, the expected results summarize the evidence collected and highlight the potentials of BD with a more accurate scrutiny of *demand forecasting* and *sales support*. In this last section, a number of analysis methods and algorithms are listed.

4. BDA and the shipbuilding industry

The 2008 financial crisis has led to a significant reduction of ship order quantities and shipbuilding tonnages, thus putting the global shipbuilding industry under serious stress. In fact, the market competition pushes firms to develop their products with improved quality (Aramja *et al.*, 2015) and companies have to do it in a faster and more cost-effective manner. Due to market globalization and lower labor costs in Asian countries (i.e., Korea, China), Italian and European firms now face fierce competition, which can be managed by making important innovations and by establishing new forms of cooperation. In this context, Big Data analysis is a promising solution since it allows for a more efficient production process and for real-time sharing of information between subcontractors.

Italian shipbuilding companies' competitive advantage can be protected by implementing innovations and by developing the self-styled Nautica 4.0, exploiting the potential offered by the BD analysis. In order to deal with this challenge in the shipbuilding industry, shipbuilding companies can adopt analytics to support planning and control systems and to encourage greater coordination between companies in the production network and with subcontractors (from furniture to nanotechnology).

BDA allows firms to find hidden patterns and correlations between data, it analyzes time series, it determines seasonal trends and behaviors, it simulates economic scenarios, and it helps in segmenting customers. Furthermore, many BDA applications prove to be useful to the design phase by implementing the intelligent and collaborative design approach (Liu *et al.*, 2017). Thus, a proper use of analytics helps managers make faster and better decisions by enriching the kind of information and knowledge provided by the information systems, such as MIS, DSS, and EIS.[2]

Moreover, analytics represents a strategic lever to create value and to stimulate the competitiveness of the whole sector. Furthermore, the use of analytics can support the production process and operational activities, enabling the automation of the production flow and with continuous compliance checks regarding the processing specifications. The literature has also discussed sustainable manufacturing and sustainable practices, such as waste minimization and energy efficiency through monitoring or technology (Despeisse *et al.*, 2013). After an organization applies a form of BD analysis,

[2] MIS refers to Management Information System, DSS to Decision Support System, and EIS to Executive Information System.

other benefits, such as better-aimed marketing, perfectly tailored business insights, and recognition of sales and market chances, can be anticipated too.

4.1 The value chain approach for BD analysis in the shipbuilding industry

The potential of BD analysis in the manufacturing industry is expected to have a positive impact through improved demand forecasting, supply chain support, developed production operations, and web-search-based applications (Chen *et al.*, 2014). Many scholars provided their contribution to identify analytic methods for Big Data. To deal with BD, Gandomi *et al.* (2015), for instance, presented a number of detailed analytical methods, such as text analytics, audio analytics, video analytics, social media analytics, and predictive analytics. However, although applications and techniques for BD analysis are relevant and many experts have contributed in this field, it remains rather difficult to provide useful advice on how to apply these tools in specific industries. Indeed, BD analytics and IIoT technologies can be adopted at various organizational levels and the possibility of extracting economic value from their use depends on the specific areas and processes to which they are applied. This implies that each industry requires specific suggestions for BD analysis since there are significant differences among sectors.

For this reason, the research team takes the shipbuilding industry's value chain into account in order to identify the main tasks involved in each node, the methods that can be adopted for each of them, and the kinds of data and algorithms that can be used. According to Porter (1985), a value chain is a defined sequence of actions that companies undertake, with the sequence of actions creating a common value system for the creation of a particular product or service. This chain describes various processes aimed at achieving an increase in the value of the company's products. Adopting the value chain approach is particularly useful to have an overview of the business area for the targeted company or industry.

Porter proposed a general value chain that firms can utilize to examine all of their activities and to analyze their interconnections. This tool provides a useful understanding of the sources of value for each manufacturing firm. The author divides the activities common to all businesses into primary activities – i.e. logistics, operations, marketing and sales, service – and support activities – i.e. procurement, human resource management, technological development, and infrastructure. Several previous studies adopted the value

chain approach to understand the advantages of data analysis related to specific manufacturing industries, particularly the steel industry (Sowar *et al.*, 2011) and the automotive industry (Patil *et al.*, 2015). Generally, consulting firms have carried out these studies.

In keeping with a study about Korean shipbuilding, as far as the general value chain characterization is concerned, four main value nodes are identified for the shipbuilding industry (Brun *et al.*, 2017):

(i) the pre-production phase that includes many tasks, such as dealing with customers, estimating production costs, and sales and marketing activities;
(ii) the design phase that concerns the initial design, the basic design, and the production design;
(iii) the production phase, i.e. the manufacturing phase, *stricto sensu*, in which many activities, such as assembly procedures and the outfitting of the boat, are included, with this phase ending in the delivery; and
(iv) the post-production phase that includes all the after-sales services, i.e. predictive maintenance, refitting, e-navigation, et alia.

4.2 Framework and data analysis features/specifications

The paper attempts to propose a conceptual framework for Big Data analysis in the shipbuilding industry. The framework is developed starting from the value chain of the industry [fig.2] and is focused on the pre-production phase.

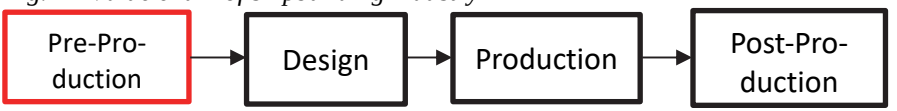
Pre-production services all relate to the tasks that need to be completed prior to commencement of manufacturing. Generally, regardless of the specificities of each industry, pre-production refers to project planning, cost minimization, negotiations, contracts, and audit. In line with the literature and the peculiarities of each firm, it is possible to identify and include other main tasks in this node of the value chain.

The pre-production node of the value chain is, in fact, fundamental to increase the efficiency of the whole shipbuilding production process and allows firms to optimize the allocation of financial resources. For the shipbuilding sector, two crucial steps in this phase are demand forecasting and (ii) sales support – and BD analysis can play an important role in making both activities more efficient. Furthermore, focusing on this node is important for firms in so far as new trends emerge in the industry, such as the difficulty in financing new orders (Brun *et al.*, 2017).

In this sense, applying BD analysis to demand forecasting and sales support can be a lever for a better resource management.

In order to develop the framework, the following steps will be applied. After having identified the target node of the value chain, the main analyses of the shipbuilding industry's pre-production phase are determined. Then, using literature analysis, the main techniques are identified and, lastly, a number of suggestions concerning the algorithms are provided.

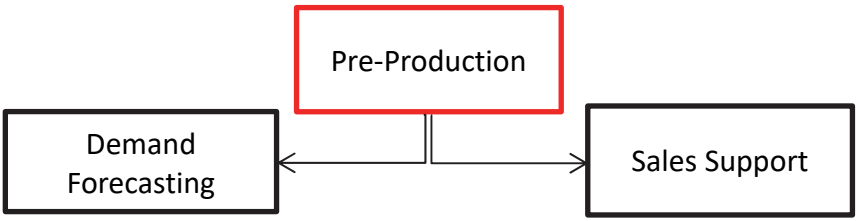
Fig. 2 - Value chain of shipbuilding industry



Shipbuilding is an order-made production industry, with sales management and demand forecasting expected to be two strategic tasks to keep the business profitable, especially in a context characterized by financial constraints and increasing global competition. As such, demand forecasting and sales support belong to the pre-production step. Big Data analysis can support these two tasks to be timelier and more accurate [fig. 3].

Demand forecasting is crucial in this sector primarily because of the supply structure, which is rigid and reacts slowly to market change, thus generating the risk of not being able to match the demand on time. Another trend evidenced by the report on Korean shipbuilding is overcapacity (Brun *et al.*, 2017), which can be managed by accurate demand forecasting. Furthermore, in order to increase ship orders, technology advancements should be analyzed so as to anticipate and stimulate future preferences that are very relevant in an industry such as shipbuilding – especially in leisure and luxury boats. Specifically, demand depends on many factors, namely the size and age of the current fleet, the expectations about market growth, ship-repairing costs, and capacity and changes in regulations and technological changes (Bruce *et al.*, 2013). Many demand forecasting models have been created in several sectors but there is little evidence of their use in the shipbuilding industry. For instance, Daewoo Shipbuilding and Maritime Engineering (2015) developed a model based on economic indicators and navigation data. Big Data analysis can be used to improve demand forecasts – and technology trends (Song *et al.*, 2013; Park *et al.*, 2016; Lee *et al.*, 2019) and traditional client estimations can be adopted as analysis methods for the purpose (Kim *et al.*, 2016).

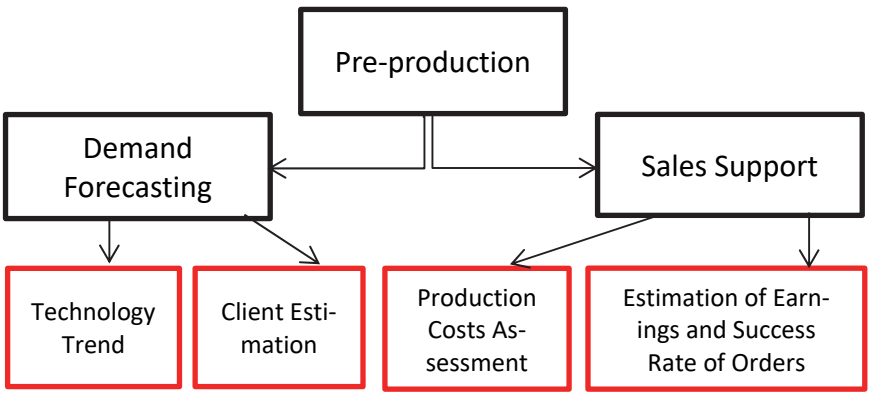
Fig. 3 - The two main tasks (category of analysis) of the pre-production phase



Sales support is another crucial task in this sector because orders are not stable and there is a need to support the marketing and sales divisions in dealing with the investment the firm should undertake to realize a new product. Sales support can be analyzed using other analysis methods, such as the production costs assessment (Kim *et al.*, 2016) and the estimation of earnings and success rate of orders (Sohn, 2011).

These two methods integrate data from similar past transactions with the customers' actual requests. BD analysis in this field is useful to eliminate the subjective component and to generate an estimation based on data from different sources (internal/external, structured and unstructured) [fig.4].

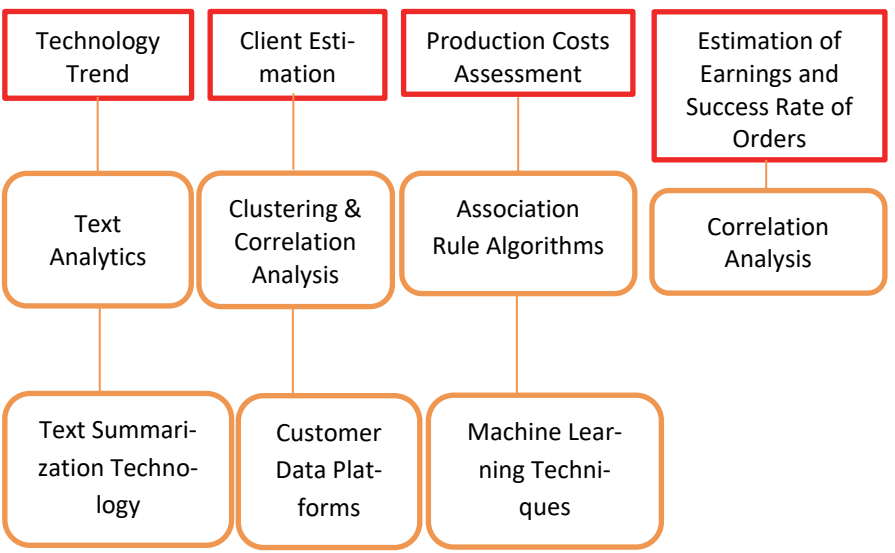
Fig. 4 - Analysis methods for demand forecasting and sales support



The algorithms that can be adopted are listed in many previous studies (e.g., Gandomi *et al.*, 2015). Text analytics and text summarization techniques, for instance, can be used in the technology analysis or applied to ship patents or papers in order to identify possible real-time trends and the technologies that will be demanded more in the future. For a proper client segmentation and for the estimation of potential customers, predictive analytics

like clustering or correlation analysis can instead be used to define customers, for instance, regarding the kind of ship they could be interested in or by the probability to place an order. Moreover, the implementation of customer data platforms (CDPs) in the cloud allows firms to segment customers in real time, taking advantage of predictive algorithms and machine learning techniques (Buffo *et al.*, 2019). These platforms are used to gather all the available data for each client (i.e., data from past transactions, demographic data, and behavioural data) to implement more targeted marketing strategies. Production costs can be estimated by integrating data from past records with the peculiarities of the ship order using association rules (AR) algorithms and other machine learning techniques (e.g., neural networks). Lastly, for the earnings and success rate of the orders, regression techniques like the correlation analysis can be adopted in order to analyze the relationships between bid conditions and the success/earning rate, thus trying to determine the most favourable bid conditions for the company.

Fig. 5 - Algorithms and tools for each analysis method identified



5. Findings

The results expected from adopting this conceptual framework of BD analysis in the pre-production node of the shipbuilding industry's value chain are taken into account for each identified analysis method related to the two

main analyses, i.e. demand forecasting and sales support. Tabb. 3a and 3b highlight the whole framework, also taking into consideration the expected results for each data analysis technique.

5.1 The technology trend

Analyzing technology trends by using text analytics applied to patents, literature, and papers related to emerging technologies allows managers to predict future market trends and to anticipate future demand for boats. Text analytics can be applied to identify relevant keywords based on term frequency. For instance, by carrying out this analysis shipbuilders can find the relevance of green technologies, deriving from this insight a potentially increasing demand for green ships and engines.

5.2 Client estimation

Managing customers and increasing their satisfaction in order to retain their loyalty to the company is fundamental in an industry like shipbuilding. Thus, the application of clustering and correlation analysis techniques together with the implementation of customer data platforms (CDPs) are effective to classify customers in homogeneous groups to carry out more accurate marketing strategies, considering the specificities of each cluster. Client groups can be defined using various characteristics, such as the size of the ship, the willingness to pay, or the probability to place an order. Moreover, customer estimation allows companies to be ready to meet the requests of each customer segment, supporting the demand forecasting purpose.

5.3 Production costs assessment

Matching traditional historical data from past transactions with the specificities demanded in the new order can help firms better estimate the production costs. Particularly, owing to the AR algorithms, one can obtain cost information from similar past transactions or processes that can be adapted to the new order with the objective of estimating the production cost more appropriately. In fact, using the association technique allows the firm to support sales activity by identifying costs and setting prices appropriately.

5.4 Estimation of earnings and success rate of orders

One can define the terms and conditions of an offer more accurately by using correlation analysis on data related to negotiations of similar previous orders. By adopting data analysis techniques, shipbuilders can obtain the best economic terms – without making the negotiation fail – based on the analysis of the profits and the success rate of previous orders, thus avoiding proposing or accepting unfavourable terms. This kind of analysis will help the sales staff set the optimal bid terms.

Tab. 3a – Conceptual framework for Big Data analysis in the pre-production node (demand forecasting)

Demand Forecasting			
Methods	Algorithms and applications	Data	Results
Technology trend analysis	Text mining Text summarization techniques	Data concerning ship technology (patents, papers, et alia) Unstructured data in various formats	Real-time identification of technology trends (frequency of keywords found) Identification of future market trends and opportunities
Client estimation	Clustering CDPs	Customer data (socio-demographic, behavioral) Unstructured data	Segmentation of customers in homogeneous groups (e.g., by type of ship/ probability to place an order)

Source: Lee, 2017.

Tab. 3b – Conceptual framework for Big Data analysis in the pre-production node (sales support)

Sales Support			
Methods	Algorithms and applications	Data	Results
Production costs assessment	AR algorithms Machine learning techniques	Data concerning previous similar transactions Specificities of the actual ship order	Information on cost of past similar orders Identification of components or resources used in previous orders.
Estimation of earnings and success rate of orders	Correlation analysis	Customer data (socio-demographic, behavioral) Unstructured data	Relationship between past bid terms (similar orders) and earnings/success rate of the negotiation

Source: Lee, 2017.

5.5 Implications

Big Data analysis and the identification of industry-specific tools can support operations and decision-making processes in manufacturing industries. Particularly, BD analysis represents a strategic lever for shipbuilding companies, especially for those small and medium-sized companies that show significant room for improvement. The adoption of specific methods and algorithms related to specific business tasks allows companies to make processes and operations more cost effective and helps them be more competitive. Specifically, in the pre-production node this will lead to more accurate demand forecasting, a more reliable estimation of production costs, and an effective sales support. Providing such a framework would help shipbuilding managers and practitioners focus on practical applications of BD analysis used in their sector. They can find practical guidelines that should be refined and implemented in order to stimulate innovation and real organizational changes in their companies. Moreover, optimizing processes and increasing internal efficiency through BD analysis can help organizations make signif-

icant savings. Resources can, thus, be reallocated to the research and development of new ship prototypes or for strengthening integration between the various subcontractors and the shipyard. Lastly, the ambitious purpose of Nautica 4.0 can be achieved, inter alia, by spreading awareness of the relevance of Big Data analysis among the management of the shipbuilding industry.

6. Conclusions, limitations, and future research

The conceptual framework provided in this study is useful to clarify potentials and possible applications of Big Data analysis in the shipbuilding sector. Especially, the paper proposes a framework based on the *value chain approach* and is specifically focused on the first node: the pre-production phase. The other three value chain nodes are identified, but the discussion of how Big Data analysis relates to these phases is left to future researches. The authors of this paper identify two main tasks in the pre-production phase where BD analysis can play an important role in improving performance: demand forecasting and sales support. For these tasks, the authors provide and summarize specific methods of analysis derived from the literature and algorithms, also taking into consideration the type of data required and the expected results. This conceptualization can be extended to the other nodes of the shipbuilding industry and can be replicated in other manufacturing industries too. Moreover, the framework could be refined owing to semi-structured interviews carried out with domain experts of the Tuscan nautical district. The paper has to be considered as a first step to deeply investigate the potentials of BD analysis applied to the shipbuilding industry.

Further research is required in this field to analyze, for instance, the perception companies have of these tools and the presence of skills that are suitable for implementing and managing BD analysis systems. In fact, case studies to identify management challenges and to discuss examples of success will be carried out as a first step for further research.

It is likely that only few firms try to keep up with new technologies while most firms adapt slowly. This relates not only to the innovations in the supply chain but also to the skills of managers and employees who have to be trained to collect and manage BD properly. If this were the case, there would be possible gains for the whole sector by spreading knowledge and facilitating spill-overs.

Ultimately, the objective of this paper is to be a stepping stone to a deeper

understanding of the great capabilities of BD. By providing an accurate review and a thorough critical assessment, the authors hope this paper stimulates further research that could raise even more awareness about the subject and possibly trigger such potential for a specific industry.

Due to the scarcity of literature available on the topic, a relatively small sample of studies is taken into analysis in this research. Although Vom Brocke *et al.* (2009) suggest that a review requires only five research papers as long as they contain sufficient information, the limited number of researches considered does not allow to *generalize* our findings.

Furthermore, the qualitative approach adopted cannot be replicated, as the literature collection bases on the *narrative review method* according to which no specific protocols and standards are required to guide the review. Although this approach is useful to gather information about a recent and wide field of research, the *subjective component* plays a role in the data analysis process. The subjectivity of the research can be mitigated by integrating quantitative or mixed-method studies in future research.

Furthermore, this analysis can be integrated by analyzing the role and potential of Big Data analysis in the other three nodes of the value chain (design, production, and post-production) in order to offer a complete overview of the research topic.

As this study is a first exploration of the capabilities of Big Data, it can certainly benefit from a vast array of further research, all the more so since it is already clear that Big Data analysis can bring significant gains.

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