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Malaysia Shipbuilding Industry: A Review on Sustainability and Technology Success Factors

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ABSTRACT

Shipyards are fixed facilities with drydocks and fabrication equipment capable of building a ship intended for personal or recreational use. The Malaysian shipbuilding and naval repair (SBSR) industry has evolved from the establishment of small shipyards in eastern Malaysia to the growth of larger-capacity shipyards. both in the East and West Malaysia. However, consistent patterns of delays in delivering to the customer directly reduced the company's profitability and financial results. This study will address issues to understand which resources are critical and important as a sustainable source of competitive advantage for SBSR.

1. Introduction

Historically, global shipbuilding leadership throughout the decades has changed by different industry players across the continents [44,51]. Amineh [6] affirmed from Britain to Japan, then to South Korea and finally to the emergence of a new global leader, China in 2015. Failure to embark on modernization of its shipyards and delay [20], too slow to implement new technologies [47] and adopt improved production management methodologies increased productivity [37], helped explain Britain's loss of leadership in the global shipbuilding industry.

Japan capitalized on its rapid economic growth following the Second World War. In addition to a well-coordinated government shipping and shipbuilding program, Japan succeeded Great Britain in the 1950s [5,37]. Over four decades, Japan dominated the industry and ultimately lost its global competitiveness due to aging and high labour costs, be inflexible and especially incapable of adapting to changes in the world market which required larger vessels [26]. In the mid-1990s, South Korea assumed leadership in global shipbuilding industry from Japan [8].

In the new economic cycle, Koreans have also faced escalating labour costs, resulting in higher steel prices owing to the differences between steel demand and domestic supply [15,37], and in addition the appreciation of the won has contributed to the reduced competitiveness of the Korean

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shipbuilding industry [16]. According to Ba *et al*., [11], China has taken the lead in the shipbuilding industry by 2010, committing to capacity building as part of the government-funded ambitious development and subsidy program [16], and by also having the advantage of competitive prices [46].

By becoming the world leader on the virtue of having the largest volume of production, China's success depended on the considerable support of the government and subsequently getting the volume of orders [6,21,26]. However, Eremenkov [18] argued that China's dominant position is not capable of competing with Korea on critical competitive requirements such as the ability to develop products and market. Korea is able to respond to a variety of customer demands, production technology and strategic developments in foreign markets [30,31].

2. Literature Review

A. Definition of Shipbuilding

Shipbuilding is defined as constructing ships and other floating vessels [4,21] and it normally takes place at a dedicated facility called a shipyard [42]. Solana [45] stated that shipbuilding and ship repairs activities, both commercial and military, are referred to as “naval engineering”. Accordance to North America Industry Classification System (NAICS), shipbuilding and repairing of US industry consists of establishments primarily engaged in operating shipyards.

Shipyards are fixed facilities with drydocks and fabrication equipment capable of building a ship, defined as watercraft typically suitable or intended for other personal or recreational use [36,37] Activities of the shipyard include the construction of ships, their repair, conversion and alternation, the production of pre-fabricated ship and barge sections, and specialised services, such as ship scaling [16]. On another perspective, the Ministry International Trade and Industry Malaysia categorized the industry as involving designing, building and constructing, repairing and maintaining, and converting and upgrading of vessels as well as marine equipment [24]. It is part and parcel of the marine transport sub-sector of the larger transport equipment industry that technically it serves the shipping industry in terms of building and supplying new vessels and maintaining existing vessels operated or owned by shipowners [16].

B. Shipbuilding Global Value Chain

The types of ships being produced can be classified based on the purpose, size, type of cargo etc. This classification of the types of ships are illustrated in the following Table 1.0.

Furthermore, for naval ships as according to Bame, uses classification of the types of ships by each purpose and responsibilities. There are aircraft carriers, submarines, guided missiles cruisers, destroyers, frigates, littoral combat ships, amphibious assault or transport dock ships, dock landing ships and special purpose ships such as costal patrol boats and mines countermeasures ships.

Essentially, these ships, as finished goods, are generally built in the shipyards using a lot of expertise and skill from various disciplines of people to design, build, and maintain a ship. According to Brun and Frederick [13], the shipbuilding process may be explained by using the value chain as an orientation framework. The sequence of the construction of ships as according to the value chain consists of three main phases; 1) Activities before production start; 2) Production; and 3) Post-production activities [47]. Fundamentally, the activities before start of production comprises mainly stages of design works and project management activities [15,28].

Table 1
Classification of the Type of Ships

Types	Description
Container Ships	Vessel structured to hold huge quantities of containers.
Bulk Carrier	Ships that transport loose cargo in bulk quantities.
Tanker Ships	Specialized vessels carrying large amount of liquid cargo.
Passenger Ships	Ships used for transiting passengers.
Naval Ships	Ships designed for the military or naval establishment.
Offshore Ships	Vessels mainly used in oil exploration and construction at sea.
Special Purpose Ships	Build for specific purpose such as for fishing, dredging etc.

Note: Adapted from Raunek (2021), A Guide To Types of Ships from https://www.marineinsight.com/guidelines/a-guide-to-types-of-ships/.

In general, the design stages of ship construction began with the determination of the ship's mission requirements and the subsequent definition of the ship's parameters and characteristics [3]. Kunkera *et al*., [28] stated as part of this design phase, the client, particularly in the Navy, would generate client statements of requirements by establishing general service requirements. Following the preliminary design phase, the general layout of the ship's hull and equipment is performed [9] and during the subsequent design stage of the contract, the owner and the shipyard would make decisions regarding the specification of the hull shape and the selection of systems [39] and suppliers for the main equipment [47]. But finally, during detailed design stage is the most significant activities that hugely impact the construction of the ship. This phase includes determining the detailed arrangement of the compartments, equipment integration, impact characteristics and maintainability. Detailed design activities include essential early preparation for the production strategy and methodology, including decisions on building standards and impacted data management infrastructures [15,19,21].

C. Technology in the Malaysian SBSR Industry and its Significance

Over the decades, the SBSR industry in Malaysia has evolved from the modest beginnings of small shipyards in East Malaysia to the expansion of larger-capacity shipyards in both East and West Malaysia [38]. Naturally, the industry players are in both sides of the Peninsular coastal areas and also along the coast of East Malaysia. Today, there are 31 shipyards in Peninsular Malaysia and 68 shipyards in East Malaysia. 9 shipyards are major players in the local SBSR industry which 3 shipyards are located in the Peninsular Malaysia and the balance are situated in Sabah and Sarawak [35].

Looking at the size, the Malaysian SBSR industry was contributing to only a small fraction of the world market which order book in 2009 represents only 0.8% of the world order book value [16]. According to The Malaysian Reserve (2017), in 2010, the Malaysian SBSR industry generated revenue of approximately RM7.36 billion (USD2.33 billion) and provided 31,000 employments. Of the 252 ships newly constructed by local shipyards last year, only 72 ships, or 28%, were exported. Although SBSR industry was considered small and not at the forefront of the national economic activities in comparison with the shipping industry, in terms of its national strategic importance and many spill-over effects to other industries SBSR industry could generate, for a nation borders by sea, equally significant revenues in comparison to the shipping industry. This is due to the fact that SBSR industry directly supports the shipping industry, having the recognition by the OECD to be the strategic industry that generates employment, capacity, technology and other benefits which are contributing to the process of building the national economy.

In particularly, the Malaysia SBSR industry is strongly influenced by the government despite the primary notion that the shipping sector is driving the demand for vessel building and repair market. Public sectors including the government link companies are directly involved in determining the framework of which the industry operates, including in the segment which has the most technological-driven content which is linked to the national security and defense [34]. The Malaysian Industry-Government Group for High Technology (MIGHT) has recommended nine technology trends to be addressed by each key player in Shipbuilding and Ship repairing industry (SBSR), namely 1) Big data analytic; 2) Sensors; 3) Autonomous system; 4) Robotics; 5) Advance Materials; 6) Advance manufacturing; 7) Human Augmentation; 8) Clean energy; and 9) Blockchain. These technology trends must be embedded into every element of SBSR such as Design, Engineering, Workshop setup, Fabrication, and assembly, Outfitting and furnishing, Testing and Operations. It is always a priority for SBSR to focus the five elements as initiated by MIGHT. These five elements are: 1) Development of comprehensive blueprint for SBSR in Malaysia; 2) LNG fueled engine; 3) Solar and Wind Powered Ships; 4) Integrated Electric Propulsion; and 5) Shipbuilding robotics. However, in the shipbuilding of navy ships, some of these elements seemed inappropriate, i.e., solar and wind powered ships. There are pressures to build more sophisticated and high-tech ships with top-notch technology to ensure the capability of Malaysian Navy able to safeguard the sovereignty of our country. However, these technology enhancements do not suggest significant development in the issue of sequence in shipbuilding, but rather contributing into the better process of making, expediting construction of the ship and technology enhancements to the ship's specification and performance.

Fig. 1. RMN 15 to 5 Transformation Program
Note: Adapted from RMN Sea Power Centre [41]. Copyright 2022 Naval News

D. Elements of Sustainability in Malaysian Shipbuilding Industry

By tradition, the main orientation of the shipyard has put priorities in the product design and engineering. It functions to develop the specifications which form the essential part of the product offering to the clients. Less emphasis was done on the aspect of developing design and engineering for the purpose of production or design works that are related to be used for production. This phenomenon was originated from the situation when by tradition the ship designers and engineers do not maintain their leading positions in shipbuilding or ship repair processes after completion of the product design process. Their main focus in on developing the product design and engineering specifications and later leaving it to Production Department to establish and figure it out the methods and processes for production, although the drawings were originated from design developed by the designers [7,47]. Furthermore, it is being observed that production engineering function may possibly become the most crucial part of the shipyard delivery system, either in shipbuilding or ship repair processes, incorporating the impacts in other major improvement areas such as supply chain and its related strategies, production capabilities enhancement, costing, price competitiveness etc.

To be precise, the interest of this study is in one the distinctive area of resources of the shipyard in DEFP's functionalities in the shipyard, or alternatively described as the capability to do design and engineering for assembly and production within the shipyard's delivery system. The selection of DEFP as the focus on this research was mainly due to its importance to the strategy and value-added stream to the shipyard's production delivery process

In conclusion, this study can confirm the notion that design/engineering for production (DEFP) is the source of the company's long-term competitive advantage. Subsequently, the company may be able to develop strategies to further invest in improving the resources associated with the DEFP function. The company can improve its role and function within the shipyard delivery system. It is anticipated that the depth of this study will enable the company or the shipyard to adopt a greater concentration of strategies to enhance this resource. The objective is to maintain the company's competitive position. As a result, the company may position itself well in advance of its competitors by being able to recognize the determinants of its sustainability and by continually developing and enhancing this function.

3. Methodology

The aim of this research is to study Production Engineering (PE) as a management process inherent in the company's organization. Furthermore, the objective of this study is to determine whether this resource, among the many resources held by the company, contributes directly to the company's competitive position. It can also play a vital role in developing the firm's sustainable competitive advantage in the local SBSR industry. In the context of shipyard production processes involving thousands of processes and sequence of operations, there are constraints of the production space in the bare ship. The fundamental purpose of this study is to assess the role of the management process between design/engineering and production in the construction of the ship and ship repair procedures in shipyards.

A. Case Study

This research focused on the relationships between the Design/Engineering and Manufacturing departments based on the qualitative approach to data collection. Yin [53] argued that to use preferably the case study method in situations when 1) the main research questions are 'how' and 'why' questions; 2) a researcher has little or no control over the behavioural events; and 3) the focus of the study is a contemporary phenomenon. Undoubtedly, the arising need to research multiple issues in the management processes that dealt with diverse engineering processes in the shipyard production system fits into the condition of case study methodology. Through a case study, the researcher was able to investigate the contemporary phenomenon in its real context, especially when the boundaries between the phenomenon and the context may not be clearly evident. Correlated to this notion, there was clearly a need to explore the root-causes of the issues of prolong delays in the delivery of ships in the shipyard despite many prior reviews by various consultants were carried out prior to 2013. The research was to establish the reasons of these delays in the shipyard (why) and investigate in-depth changes to the managerial processes of Design/Engineering that resolved poor performance of Production (how). Using the questions "how" and "why", the researcher will continue the explanatory mode in a case study method which has sought to address operational links over time.

B. Research Framework

The basic framework summarizes a series of process sequences, including layers and stages of the research process. This framework serves as a guideline for ensuring that research is on an acceptable track. The methodological framework, which is illustrated in Figure 1.1 exemplifies a structured approach from initial concept of areas of research (identification stage), development stage; consisting of the aim and objective of the research, the theoretical underpinnings and research methodology; the application stage, doing data collection and finally the refinement stage; data analysis, findings and write up of the study.

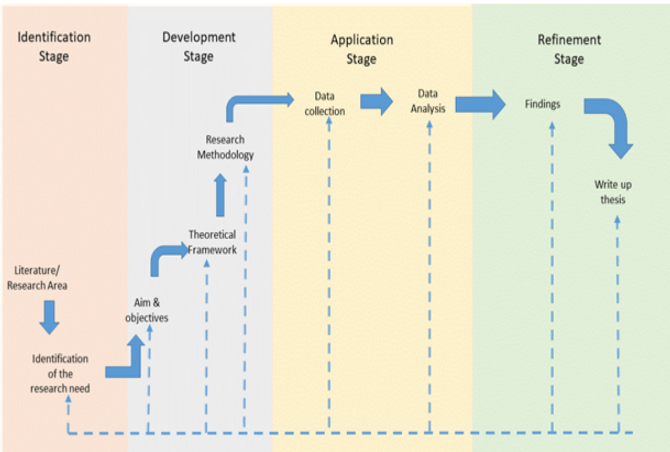

Fig. 2. Study Framework
Note: Adapted from Tobi and Kampen [50]. Copyright 2016 The Author(s) Springer

In the first phase of the research, the context of the study will be based on the operations of a Malaysian naval shipyard. Taking the advantage of researcher's background knowledge in this particular industry settings and personal experience in project and quality management of this area of interests, the problem of the industry will be identified. A clear result of many cycle of projects, to cite a few, in the shipyard beleaguered with repeated delays of delivering projects [1], gradually decreasing profit margins both in shipbuilding and ship repair business segments and critical needs for asset replacement program [12], production optimal resource efficiency [46] and ineffective production system including engineering and planning dysfunctionalities [34] will be identified.

C. Observation Design

Awang [10] and Sabah *et al*., [43] states that using the observation method of data collection, the researcher will identify their respondents and record the required data based on what they observe. The data obtained reflect the real behavior of the respondents. Researchers obtain a clearer picture and a better sense of situations for their study. Therefore, the researcher will be better placed to make an appropriate recommendation about the underlying phenomena of the study. As it is in the interest of organizational processes, observation is used as a primary tool to help document what is taking place in this context. It is useful tool because 1) It gives direct access and insights into complex social interactions and physical settings; 2) It gives permanent and systematic records of interactions and settings; 3) It can be context sensitive and ecologically valid [49]; 4) It uses very varied techniques; yielding different types of data and with the potential to widely applied in different context; and 5) It can be used to address a variety of research questions [27]. Subsequently, in this study, observation will be used to triangulate with other methods such as interview in order to verify findings derived from one source of data to another and thus increasing reliability.

In this study, research will be involved in the observing interfaces and management processes between Design/Engineering and Production both in ship repair and shipbuilding. The researcher will take field notes on the behaviour and activities of the management personnel. Field notes will form files, whether they are unstructured or semi-structured. These data will be saved in Microsoft Powerpoint or Word format and uploaded to ATLAS.ti as core data for analysis.

D. Interview Design

Qualitative interviews are a useful tool for collecting data across a variety of methodological approaches and can therefore be used to answer a number of research questions. According to McGrath *et al*., [32], qualitative research interviews are best when the researcher strives to understand the subjective perspective of a phenomenon by the interviewee. rather than generating generalized understandings of a large group of people. Dumez [17] argued that the interview design and question phrasing will influence the depth and freedom with which a subject can respond. The degree of the structure imposed in an interview will vary along the three types of interviews: structured, semi-structured and unstructured. Structured interviews enabled interviewer to ask respondent the same questions in the same way, that questions may be phrased in such a way that a limited range of responses is limited to one the pre-coded responses. In contrast, semi-structured interviews used open-ended questions. It seeks to define the topic under investigation and provides opportunities for the interviewer and interviewee to discuss some topics in more detail [22]. Moreover, the interviewer can use cues or prompts to encourage the interviewee the question further and the interviewer also has the freedom to probe the interviewee to elaborate on the original response or to follow a line of inquiry introduced by the interviewee.

4. Research Findings

The approach to deliberate and explain the results and the analysis that will be structured based on the methods used. that is, in the order of the report format which will be the observation and interviews with the relevant company staff. With respect to research design, the purpose of data collection was to search for answers to the RQ. It is an explanatory study on the contribution of DEFP to the competitiveness of the company. The RQ established for the study will be organized and put into a matrix to match against the subsequent findings in order to present a better flow of the rational and sequence in answering all the RQ.

A. Data Analysis

All interview and observation data are uploaded in ATLAS.ti. Quotations will be developed and subsequently assigned coding. The codes are then grouped into themes, similar to the results obtained with the manual process. Consequently, through the relationships of the network groups to be established and a model should be identified. Thereafter, a new sustainable competitive advantage code will be created, as the end results from combining the flows of all networks.

B. Theme and Significant Statement

To summarize, this part will elaborate in detail the flow, conducted and collection of data from the framework previously being designed. The main data collected will be from interviews as well as from observations. The raw data will then be converted into transcripts which will become the inputs of ATLAS.ti as a platform for the qualitative data analysis application software.

The findings and findings from this case study will be used to identify functional deficiencies in shipyard operations in the form of a DEFP. Subsequently, through transformation, DEFP can become an important resource for the company's strategic position within the local SBSR industry. The results of DEFP as a precious, scarce, imperfectly imitable and substitutable resource will be elaborated in greater detail according to the themes.

5. Discussion and Conclusion

For many periods in the shipyard, a concerted effort was made to address the issue of delays in ship delivery, whether it was an MRO or a shipbuilding project. Successive management consultant companies were hired to arrive at the solution to the problem, but none came up with a complete and thorough solution fits in to the environment inside the shipyard. The pressure and threats to affect change increases by passes of time, mainly in the form of severe penalties due to the delay in delivery and ultimately touching on the fundamental issue of company continuing concern as a profit-making enterprise.

After consultation with MIGHT, the government agency responsible to assist the SBSR industry undergoing transformation, the Korean consultants were engaged full time with the company with the approach to do transformation together with the people of the shipyard. They were expected to provide their expertise in transforming the Malaysian shipbuilding industry. Now the transformation is performed by leading engineers with many years of experience in shipbuilding and ship repair and not by a consulting firm that does not have extensive experience in the operation of a shipyard. More importantly, the organizations with resilient supply networks are assured of increased firm productivity [14].

The transformation agenda is implemented in many critical areas of shipyard management, especially in project management, design, engineering, and production. In addition, this research concentrated on the domain of DEFP. In the beginning of the research, the literature review pointed out in which area and framework of DEFP to arrive at the foundation of this study in order a sequence of logical analysis could be accurately being pursued. Another aspect that requires special attention is the MRO. It is important to focus on digital data management as suggested by Wang *et al.*, [52]. The vendors participation in the shipbuilding is very important. The strategic collaboration between vendors and foreign manufacturers, suppliers and OEMs in order for offsets program and technology transfer can be enhanced [2].

The causes of delays of the delivery of ship are being established in direct connection to the dysfunctional of DEFP. Through transformation drive, DEFR is created and nurtured to a resource critical to the performance of the shipyard. Based on the expected findings of the study, DEFP qualifies to be the resource that is valuable, rare, imperfectly imitable and no substitutability. Therefore, based on the case study, the pattern of adoption of DEFP in the organization of Ship Repair and Shipbuilding and correlating it with the shipyard performance is expected to be clear. Consequently, DEFP may make a significant contribution to the shipyard's continued competitive advantage. The role of DEFP to focus on quality aspect is important as well. Total quality management (TQM) practice, for instance, can ensure continuous quality improvement as suggested by Jamalludin *et al*., [25].

The findings of this study may suggest the relevance and growing importance of DEFP as a shipyard asset, especially when the evidence from the findings may indicate a huge difference in results in the adoption of DEFP between ship repair and shipbuilding. If this is the case, it will point to a profound divergence in strategic thinking between two production entities. The former is open to a change, but the latter would opt for the status quo. Design and engineering constitute an "engineering wall" apart from production. The study may indicate a strong conclusion suggesting DEFP as the resource that would not be entirely outsourced by the shipyard, other than design or production. Otherwise, the shipyard would lose its character and core resources that differentiate it from other shipyards. a resource that is difficult to copy and cannot be copied in its entirety from one to the other. In summary, this finding could form the basis for any review or consideration of a future capital expenditure program for the shipyard.

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