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Selection of the Most Challenges Criteria on Malaysian Shipyards Industry Using an Analytic Hierarchy Process Technique☆

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Abstract

The challenges faced by the Malaysian shipyard industry had led to the failure of local shipyards in catering to the demand of ship owners. The shipyard industry had recorded the least contribution (1.0%) to the world shipbuilding order book and had caused inconsistencies in the Malaysian shipbuilding ship repair (SBSR) industry's demand and supply market. The objectives of this study had been to identify the factors that had contributed to the challenges faced by the shipyard industry in Malaysia, and to rank them according to their priorities. The factors of these challenges had been identified by using the cause-and-effect analysis method and were further illustrated in the form of an Ishikawa diagram. Subsequently, an analytic hierarchy process (AHP) method was applied to determine the weightage of the priorities. The results had shown that 'Market' (41.66%) had been the most challenging aspect faced by the shipyard industry in Malaysia from all the five factors studied. As such, this research would help shipyard organisations to effectively prioritise these challenging factors as a way of sustaining their businesses and affecting the economic contribution from the shipyard industry.

Keywords: Shipyard Industry, Malaysian Ship-Building-Ship-Repair, Cause-and-Effect Analysis, Analytical Hierarchy Process, Maritime Studies.

1. Introduction

The shipyard industry in Malaysia had started to prosper since the early 1900s (Brooke Dockyard Revitalization Journey, 2014). Ships were manufactured and repaired in shipyards to accommodate the needs of local ship owners. The expanding global trade and the need for transport system had promoted the growth of this industry (Mickeviciene, 2011). According to MIGHT (2015), more than 70% of the vessels that were produced in Malaysia had been smaller boats that are used in rivers and coastal waters such as barges and harbour/river tug boats. Currently, there are ten major shipyards in Malaysia, with five in Sabah and Sarawak, four along the west coast and one on the east coast of Peninsular Malaysia (MIGHT, 2015). In 2013, the number of vessels produced in East Malaysia had been 203, while 31 were from Peninsular Malaysia. As a result, the production of vessels had given rise to about RM 5.6 billion of total revenue for both Peninsular and East Malaysia (MIGHT, 2015). However, despite its stature as a maritime nation, Malaysia had only contributed 1% of the world new building order book and was ranked 26th in the list of nations with the largest merchant fleet in 2013 (MIGHT, 2015).

Apart from competing with other shipbuilders in this region, the significant drop in the number of vessels exported from 113 in 2011 to 70 in 2013 had clearly shown a decrease in the demand. Many ship owners had preferred buying vessels from other countries to purchasing them locally because of the total cost difference (Nor, 2014). Moreover, they also conduct the repair and maintenance of vessels abroad as well, which leads to the issue of Malaysia's Cabotage policy, where ship-owners do not necessarily use the ships built in local shipyard to serve maritime business (Khalid, 2015).

Generally, shipyards encounter challenges when designing, manufacturing and repairing larger and more sophisticated vessels as they require higher capital costs, a larger work force and state-of-art facilities. The shipyard industry is fragmented due to the fact that a majority of the companies are still small-sized shipyards (MITI, 2016). Furthermore, shipyards would have to focus on the precise and complex designs of the vessels to ensure its marketability and productivity. For that reason, shipyards would have to increase their efficiency and productivity in meeting the domestic and global demand of vessels as well as to expand the business globally for it to be established as a leading SBSR (Ship-Building-Ship-Repair) industry. However, despite the steady growth of its national fleet and the shipping sector over the years, Malaysia still has some way to go towards achieving self-sufficiency in shipping. Therefore, this study aims to identify the challenges criteria faced by the shipyard industry in Malaysia and to rank them based on their priority so that improvements can be made on this particular industry.

2. Literature Review

Shipbuilding business has started to develop in Malaysia from the early 1912, which was during the establishment of Brooke Dockyard in Sarawak (Brooke Dockyard Revitalization Journey, 2014). The Malaysia SBSR industry was then set up with 120 registered shipyards, with 48 situated in West Malaysia and 72 in East Malaysia (Kupper and Chong, 2013). Some of the largest shipyards located in Peninsular Malaysia are Boustead Naval Shipyard in Lumut, Perak, Muhibbah Marine Engineering and Selat Melaka Shipbuilding Corporation in Port Klang, MSET Shipbuilding in Terengganu, Malaysia Marine and Heavy Engineering in Johor, while in Sabah and Sarawak, these include Labuan Shipyard and Engineering, Shin Yang Shipyard, Far East Shipyard and Weldan Marine Services. The map in Figure 1 shows the main shipyards that are located in Malaysia.

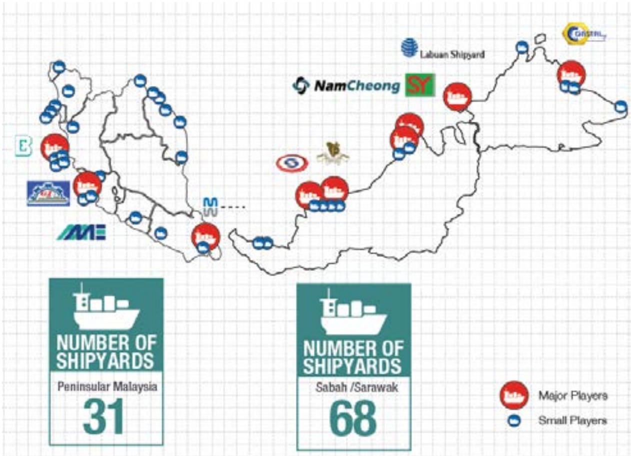

Figure 1: SBSR Industries in Malaysia

Source: MIGHT (2017)

The yards in East Malaysia own specialization in steel vessel of offshore supply vessels (OSV), tugs, barges and ferries (Khalid, 2014). The yards were more cost-effective, had high design capability and possessed more innovative building and material sourcing perspective due to its location (Khalid, 2014). While in Peninsular Malaysia, although the yards are capable in building both steel and aluminium vessels for the government and oil and gas sector, they are not as cost-effective as those built in East Malaysia. Nevertheless, Malaysia's strategic position had created a trade and investment position for many foreign countries to be part of its shipbuilding and ship repair industry (Nor, 2014).

The maritime industry is ranked 3rd in its contribution to the nation's economy with a revenue of RM 8.36 billion in 2013 generated from local yards (Khalid, 2015). The local production of vessels had been dominated by near coastal type and offshore vessels. 79% of the vessels produced by the local yards are exported to Asean countries as compared to the other regions (Grey, 2015). In 2013, around 35,000 number of workers had been employed in the SBSR industry and in that year itself, the industry had managed to produce RM 1.0 billion worth of vessels and floating structure as well as gaining the approval to implement two new projects that carry the value of RM 33.5 million (Khalid, 2015). Apart from ship repairing, Malaysia had also participated actively in the ship conversion business, which involves converting oil tankers from single hulled to double hulled as well as some to Floating Production, Storage and Offloading (FPSO) platforms (Kupper and Chong, 2013). Malaysia Marine and Heavy Engineering (MMHE) is the largest shipyard manufacturing and had delivered some of the biggest FPSO units in the world. These units were worth RM 69 million in 2011 and the conversion business was performed by MMHE at its facility in Pasir Gudang, Johor (Kupper and Chong, 2013). However, from 2005 to 2013, it was observed that the Malaysian shipbuilding industry had been focusing more on manufacturing near coastal and offshore vessels as shown in Figures 2 and 3 (Malaysian-German Chamberof Commerce and industry, 2014; MIGHT, 2015).

In 2010, Malaysia's former Prime Minister, Dato' Seri Najib Bin Abdul Razak had launched a new set of goal for our SBSR industry to achieve by 2020. The Malaysia Shipbuilding/Ship Repair Strategic Plan 2020 had aimed to boost the industry's competitiveness and to generate a $6bn turnover by the year 2020 (Grey, 2015). The vision from the plan was for Malaysia to become a major player from a small to the medium-sized shipbuilding market by substantially improving on the quality and value of the technological products and contributing to the nation's economy. The ship repair industry in Malaysia has set its aim to achieve 3% of the vessels to travel regularly along the Straits of Malacca route and another 80% of the offshore vessels navigating in South China Sea (MIMA, 2012). Our shipbuilding market had strived to improve the current value of 50% in the local market and 1.0% of the global market to 80% and 2.0% respectively in 2020 (MIGHT, 2015).

Among the targets set in the 6th Economic Transformation Programme of Malaysia had been to produce competitiveness in the vessel price market by developing a shipyard with state-of-art facility and to enhance the skills of shipbuilders in repair and maintenance to cater for the growing SBSR industry. A turnover of RM 7.05 million with the availability of 32,500 jobs in the shipyard industry was recorded in 2011(PEMANDU, 2013). This number had also attracted RM 6 billion worth of investments and the programme was also proposed to develop our country's offshore support vessel ability by training 160 engineers in the SBSR industry (PEMANDU, 2013). The training had been carried out by Boustead Heavy Industries Corporation Bhd. (BHIC) and Boustead Naval Shipyard.

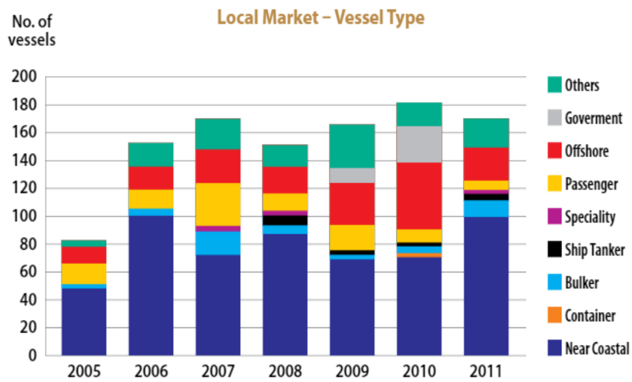

Figure 2: Production by Vessel Types

Source: Malaysian-German Chamber of Commerce and industry (2014)

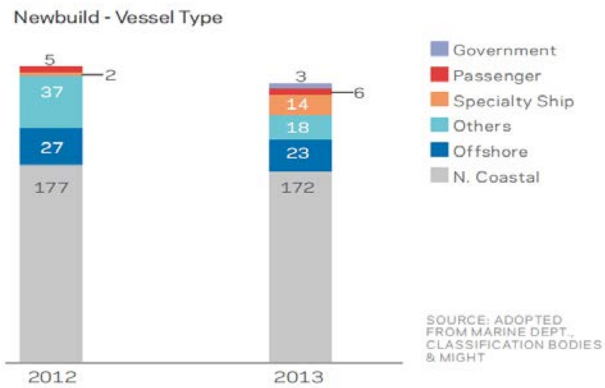

Figure 3: Production by Vessel Types

Source: MIGHT (2015)

2.1 Malaysia Shipyard Challenges

The countries in the ASEAN region are the main destinations for the export of Malaysian-built vessels. Newly-built vessels are also delivered to buyers in America, Africa and Europe.Malaysia's vessels are also sold to shipping companies in Australia, UK and other European countries via Singapore. In 2010, the decrease in the exports had indicated that the local shipyards had not been able to capture the foreign market due to the lower demand, which was mainly caused by the global economic slowdown. Nevertheless, the gross register tonnage for Malaysia export market had been on a steady level at an average of 50,000 GRT between year 2006 and 2011, as shown in Figure 4 (Malaysian-German Chamberof Commerce and industry, 2014).

Based on a six-year trend shown in Figure 5, 2011 had recorded the least number of imported vessels. This had demonstrated the confidence level placed on local ship owners of Malaysian-made vessels. However, the number of imported near coastal vessel in the last few years had been relatively high. This challenging situation had prompted the Malaysian shipbuilders to attempt capturing this market by responding the demand with locally-made products (Malaysian-German Chamberof Commerce and industry, 2014).

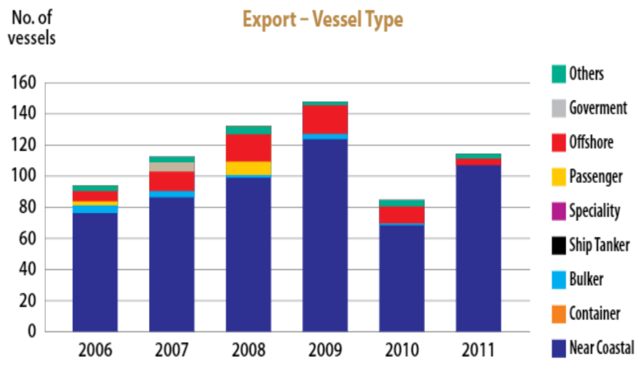

Figure 4: Export of vessels

Source: Malaysian-German Chamber of Commerce and industry (2014)

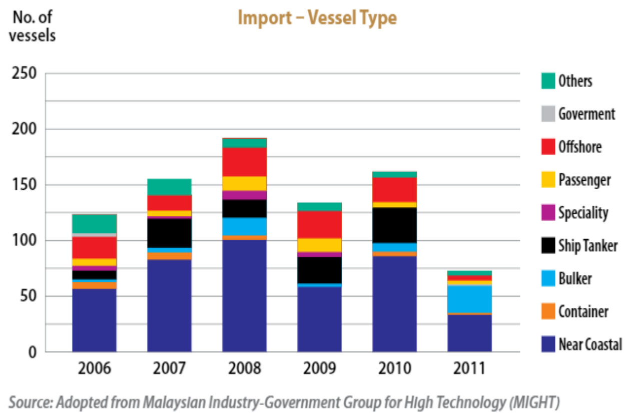

Figure 5: Import of vessels

Source: Malaysian-German Chamber of Commerce and industry (2014)

Competition between shipyards had also created a challenging situation for the shipyard industry in Malaysia, since this was not solely derived from the other local yards that are offering the same product and services. This is also compounded with the rising competition from yards in developing countries such as Vietnam and Thailand that offer low labour cost and harbour big ambitions to carve their names in the shipbuilding industry (Pike, 2014). Therefore, this competitiveness has prompted our local yards to work harder and to be more innovative in their design in attracting more ship owners.

The oil price can also severely affect our industry. The Malaysian Industry-Government Group for High Technology (MIGHT), a non-profit grouping, had estimated the oil and gas projects to contribute between 70% and 80% in the shipbuilding and ship repair (SBSR) annual revenue. If the trend of oil price continues to drop, this can affect the number of new builds and would pressurise local shipyards to offer the lowest margin in ensuring the continuity of projects on hand (Tan, 2015).

Malaysia does not have a national level of platform to discuss matters concerning the SBSR industry (MIGHT, 2016). The initiation of this platform would enable the stakeholders in the Malaysia's marine industries to gather and discuss issues, development, concerns, opportunities and challenges in the industry. The participants would also be able to exchange ideas and insights in the formulation of strategies, solutions and the way forward in boosting the growth and development of the SBSR industries. According to First Admiral Adjunct Prof. Dato' Ir. Ahmad Murad Omar, in the ship repair business, the local ship owners must be fully tap on the market provided by the government and preparations are needed to capture the highly lucrative double hull carrier conversion market (Omar, 2012).

Additionally, some yards do not establish their own shipping finance department (Shariff, 2012) and they depend entirely on advice and consultations given by bankers. As a result, shipyards are often faced with the complex requirements for bank loans. For that reason, one of the keys in encouraging performance improvement in the industry is to build appropriate incentives into contracts (Krieg, 2006). In the past, companies were eligible for Pioneer Status with an income tax exemption of 100% of their statutory income for a period of five years, or an investment tax allowance of 100% on the qualifying capital expenditure incurred within a period of five years.

Another issue that is faced by the shipping indutry is the factor of human resources. The local yards require a large number of workers to accommodate for the building of larger vessels. It is important that they have sufficient number of skilled and highly capable workforce such as technicians, designers, electricians, yard supervisors and engineers. Under the 11th Malaysia Strategic Plan, this issue had been highlighted and would be considered by our government to providing more structured training programmes to fulfil SBSR's workforce requirement (MIMA, 2012).

The next issue is on the management aspect, which is shown by the 0.8% decrease in the number of order book for the world market in 2009 from RM 8.4 billion in 2007 to RM 5.3 billion in 2009 (Jugovic, 2015). The delay in the order book and the oversupply issue had begun to take its toll on Malaysia's SBSR Industry. In 2010, the average annual demand for new vessels in Malaysia had been 300 with a total value of nearly $2.2 billion and 40 per cent of ships were built in Malaysian dockyards. By 2010, the yards would be congested with newly-built ships but there would be a decline in the demand of their services (Maierbrugger, 2013). The Malaysian maritime transport operators would not have the capacity, skill and technological capabilities to compete with the other shipyards from the Southeast Asia region. As a result, many local ship owners would have to rely on overseas shipyards in their order and in the repair and maintenance of their vessels.

Another challenge that is faced by the local shipyards is the material element. The lack of local and environmental-friendly technology in yards has brought up this element to attention. Due to the lack of supporting industries, local contribution of export quality ship is at an alarming condition (Zakaria, 2012). Producing innovative design plan of vessel and adopting new shipbuilding technologies are important for the marketability of locally-built vessels. Adaption of new technology from outside should be implemented in yards and developing of the research and development sector plays a role in building larger and more sophisticated vessel. High cost is spent in importing raw materials and services for the ship repair and building.

Thus, the SBSR 2020 strategic plan has laid out steps and goals in enhancing Malaysia's status and its capability of being an SBSR nation. These include establishing business-friendly policies to support the growth, strengthening the institutional framework, reinforcing the framework to ensure industry integrity and quality products; as well as attracting and preparing an adequate and skilled workforce (MIMA, 2012). All current and future challenges faced by Malaysian shipyards should be addressed towards achieving the ultimate goal of SBSR 2020.

3. Methodology

3.1 Cause-and-Effect Analysis (Ishikawa Diagram)

The cause-and-effect analysis is a method that involves listing all possible reasons and outcomes associated with a particular problem or situation and are assessed by using a diagram-based technique. The analysis method is a combination of the brainstorming technique and the revision of the historical incidents recorded, which graphically illustrates the relationship between a given outcome and all the factors that influence the outcome (Ishikawa, 1968; 1982; Ilie and Ciocoiu, 2010; Othman et al., 2016) as well as encouraging individuals or groups to participate in an investigation activity that enhances the body of knowledge (Basic Tools for Process Improvement, 2009; Tague, 2005; Othman et al., 2016). The main function of this method is to identify the possible root causes of a specific problem (Ishikawa, 1968; Tague, 2005; Othman et al., 2016).

The cause-and-effect analysis had been applied in various field of studies such as quality management (Ishikawa, 1982; Tague, 2005), quality improvement tool (Hekmatpanah, 2011), risk determination (Ilie and Ciocoiu, 2010), risk assessment (Othman et al., 2016), nursing practice and management (Phillips, 2013) and the safety of industrial automation (Russo and Turk, 2007). As such, this technique had been chosen and is deemed to be suitable for assessing the potential challenges of Malaysian Shipyards Industry.

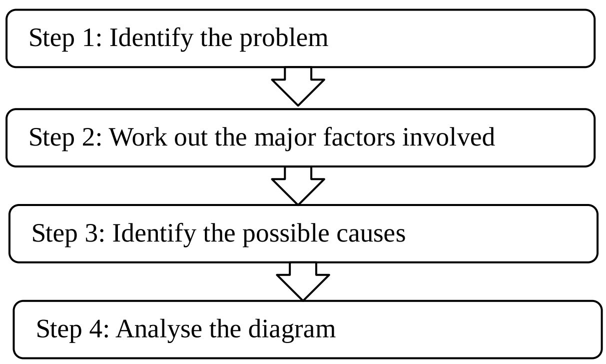

Figure 5: Steps to use Cause-and-Effect Analysis

Sources: Ishikawa (1982), Tague (2005), Othman et al. (2016)

The 4 basic steps of conducting the cause-and-effect analysis are shown in Figure 5. The first step is to identify the problem area that needs analysis. Where appropriate, identify who is involved, what the problem is and when and where it occurs. Next, work out the major factors that are involved in the occurrence of the problem. These may be systems, equipment, materials, external forces and people. Then, identify all the possible causes. Find the contributing factor of each cause and the diagram is expanded by finding more factors that are related to one another (Tague, 2005; Othman et al., 2016). When a cause is large or complex, then it may be best to break it down into sub-causes. In this stage, an Ishikawa diagram is created to show the possible causes of the problem. Lastly, investigations and surveys are carried out to test which possible cause has the most contribution to the problem (Ilie and Ciocoiu, 2010; Othman et al., 2016).

3.2 Analytical Hierarchy Process (AHP)

The AHP is a multi-criteria decision-making approach, which is based on the process of hierarchizing a system to carry out a wide-ranging evaluation and the final selection of one of the contributors to the particular problem. The method is a theory of measurement using both quantitative and qualitative data (Saaty, 1980; Saaty, 2008; Cabala, 2010).

This approach basically points out a set of elements, which are mutually related in the system that is being analysed. These elements form a particular hierarchy, which is crucial for the existence and survival of many systems, both natural and human-made. The system analysed will form a multi-layer arrangement, where the layers are differentiated by internal structure and functions. The functions of elements on a lower level are subordinated to the functions of elements on a higher level. The proper functioning of the higher levels would depend on the proper functioning of the lower levels (Saaty, 1980; Saaty, 2001; Cabala, 2010).

A structural hierarchy approach indicates the relationships between the component parts of complex systems, where these relationships are understood as an arrangement in terms of structural properties. In this case, the organisation and analysis of complex decisions utilise the mathematical structure of consistent matrices for determining the weight values (Merkin, 1979; Saaty, 1980; 1994; Abdul Rahman, 2012). It also enables the comparison of criteria with respect to a criterion in the nature of the pair-wise comparison mode (Abdul Rahman, 2012).

The AHP approach has been widely applied in several areas, such as strategic decision making (Bhushan and Kanwal, 2004; Abdul Rahman, 2012), engineering education (Drake, 1998; Abdul Rahman, 2012) and risk analysis (Dey, 2003; Abdul Rahman, 2012). The qualified judgements on pairs of attribute *Ai* and *Aj* are represented by an *n x n* matrix A as shown in Eq. 1 (Abdul Rahman, 2012; Abdul Rahman et al., 2018).

$$A = (a_{ij}) = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \quad (1)$$

where i, j = 1,2, 3…, *n* and each *aij* is the relative importance of attribute *Ai* to attribute *Aj*. The weight vector indicates the priority of each element in the pair-wise comparison matrix in terms of its overall contribution to the decision-making process. This weight value can be calculated by using Eq. 2 (Abdul Rahman, 2012; Abdul Rahman et al., 2018).

$$W_k = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{a_{kj}}{\sum_{j=1}^{n} a_{ij}}\right)(k = 1, 2, 3, \dots, n) \quad (2)$$

where *aij* stands for the entry of row *i* and column *j* in a comparison matrix of order n. Next, the consistency of the pair-wise comparison has to be evaluated. This consistency process can be done by using a consistency ratio (CR). The CR is designed in such a way that a value greater than 0.10 indicates an inconsistency in the pair-wise comparison. However, if the CR is 0.10 or less than that, the consistency of the pair-wise comparisons is considered reasonable (Cabala, 2010; Abdul Rahman, 2012; Abdul Rahman et al., 2018). Further details of the calculation process can be referred to Anderson et al., (2003), Cabala, (2010) and Abdul Rahman et al., (2018).

4. Research Finding

In this section, the cause-and-effect analysis method and the analytical hierarchy process (AHP) technique had been combined to analyse the factors and sub-factors before they are being ranked in preference order.

4.1 Stage 1 – Determine the goal of the study

The fundamental goal of this study is to identify and rank the factors affecting the Malaysian shipyard industry that are based on their priorities.

4.2 Stage 2 – Identification of problem

The main issue of this study is to determine the reasons local shipyards had failed in catering to the demand of ship owners. Even with the prospering global trades and shipping businesses, the local shipyard industry is still struggling to meet the demand in building bigger ships at a specified time. Using the cause-and-effect theory and (See Figure 5), the challenging factors were identified and had been categorized into five main criteria, which includes: Market, Manpower, Money, Material and Management as discussed in Section 2.1.

The evaluation parameters are divided into two levels, which are the main criteria and the sub-criteria and is shown in Figure 6. Each main criterion is divided into three sub-criteria, which makes it a total of fifteen sub-criteria. The overcapacity in shipping/offshore structure, competition from more cost effective foreign yards and the slower demand for yards' products and services have been identified as the sub-criteria for the market factor. Manpower on the other hand, is divided into labour drain from SBSR industry to other industries, lack of adequately skilled labour and poor project management skills. As for the money factor, the sub-criteria includes huge capital cost and rising production cost, lack of incentives for SBSR industry players and the complex requirements for bank loans. Next, the material criteria had been divided into modernizing/ automate/ adopt new technologies, the high cost of imported raw materials and services plus the less sophistication of locally manufactured and produced equipment. Lastly, the overdependence on local contracts, inefficient supply chain and too many yards offering same products/services had been defined as the three sub-criteria for the management factor.

4.3 Stage 3 – Data Collection Process

The structured questionnaires had been distributed to several experts from the few selected shipyard organisations in Malaysia. However, based on the surveys, only ten questionnaires had been selected to be used in the analysis process since only the ten questionnaires had fulfilled the requirements of the survey.

As this study had used the expert sampling technique, the experts were selected from individuals that are specialised in the specific area being investigated (Etikan and Bala, 2017). These experts had been selected based on several specific criteria in order to get a high reliability data.

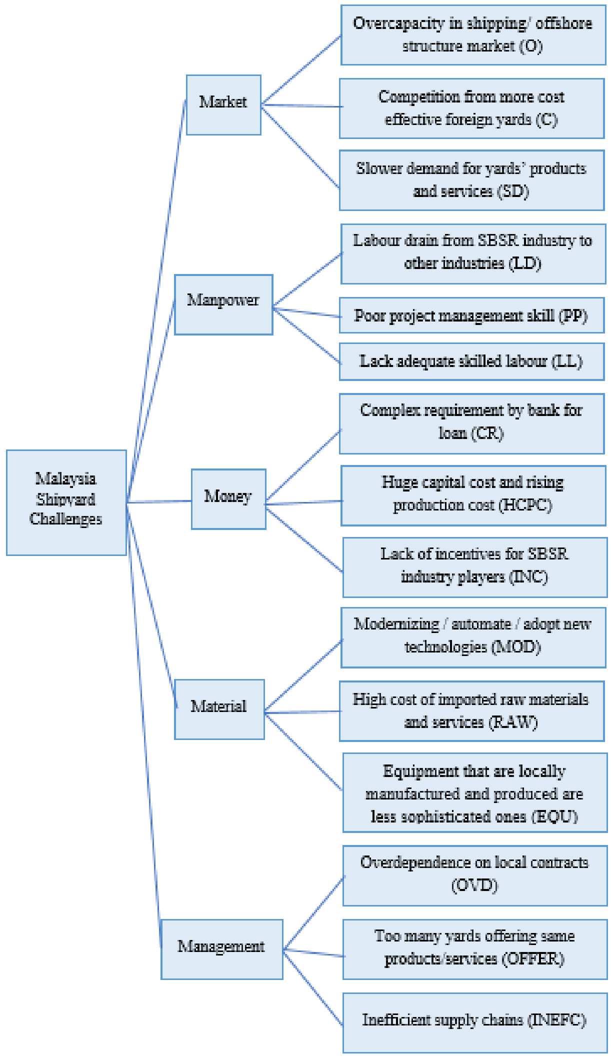

Figure 6: Cause-and-Effect Analysis (Ishikawa Diagram) on Challenges faced by Malaysian shipyards

Therefore, the criteria of experts' selection for this study had been: 1) Background: Decision-makers (engineers, managers, etc.), 2) Working Experience: Serving the shipyard industry in Malaysia, and 3) Years of Experience: Must be more than 5 years. With respect to the sampling technique and criteria, only experts that had fulfilled the above requirements were chosen for this study. The details of the experts are indicated in Table 1.

Table 1: Details of Experts

Experts	Designation	Years of experience
Expert 1	Engineer	More than 5 years
Expert 2	Engineer	More than 5 years
Expert 3	Project manager	More than 10 years
Expert 4	Project manager	More than 10 years
Expert 5	Shipyard manager	More than 15 years
Expert 6	Engineer	More than 5 years
Expert 7	Engineer	More than 5 years
Expert 8	Shipyard manager	More than 15 years

Expert 9	Shipyard manager	More than 15 years
Expert 10	Project manager	More than 10 years

The experts are stated anonymously due to privacy and confidentiality protection as agreed by the authors and the experts.

In this data collection process, the experts were required to compare the criteria based on their assigned importance on the given challenges of the shipyard industry by using the pair-wise comparison method. The comparative judgment of the experts for each criteria and sub-criteria stated in the questionnaire was based on the numerical assessment scales as shown in Table 2. The inputs were then analysed using the AHP technique to calculate the relative vectors and their relative importance weight values.

Table 2: Numerical Assessment

Numerical Assessment	Linguistic meaning
1	Equally important
3	Weakly important
5	Strongly important
7	Very strongly important
9	Extremely important
2,4,6,8	Intermediate values between the two adjacent judgments

Sources: Saaty (1980), (2008), Cabala (2010)

4.4 Stage 4 – Data Analysis Process

4.4.1 Analysis of the main criteria

Step 1

Firstly, record the value given by each respondent for all the comparison and form a matrix for each respondent. It is necessary to derive weight value for each criterion to identify the best and consistent result by the experts. Next, compute the values given by each respondent and divided by the number of respondents. This will be the geometric mean of ten respondents. For example:

The importance of criterion 'Market' is compared relatively with 'Manpower' based on the numerical assessment in Table 1. Expert A had given a value of 5, followed by expert B=7, expert C= 3 until respondent J. All the values given are then added up and divided by 10 (total number of respondent).

Mean = (5+7+3+5+9+5+3+3+7+7)/ 10

= 54/10 = 5.4

This was done for all the criteria and a matrix of *5 ×5* is formed in Step 2 by showing the average ratio values of all ten respondents.

Step 2

By using Equation 1, the matrix 5 × 5 is formed, the average mean values for each row is added and presented, which is shown in Table 3 (See Appendices A). The diagonal elements of the matrix are 1. The total value for each criterion is then used in Step 3 to compute the weight value.

Step 3

The weight value for each criterion is calculated by using Equation 2. The value of each row in the sum should be equal to 1. The weight value determines the ranking of each criterion. For example, the weight value of the criterion "Market" is calculated as follows:

$$w_{mrkt} = \frac{0.41375 + 0.41831 + 0.56040 + 0.36720 + 0.32310}{5} = 0.41660$$

Table 4 (See Appendices B) shows the weight value ranking of the main criteria in determining the challenges faced by the shipyard industry in Malaysia.

Step 4

Each criterion's weight value is multiplied with the total value of rows for the corresponding criteria from Step 2 to obtain sum maximum for all the criteria.

$$\lambda_{max} = 2.4169(0.4166) + 12.9092(0.08998) + 6.7812(0.1807) + 12.2539\ (0.08669) + 4.1467(0.22612) = 5.396$$

Then, to ensure the level of data consistency, the consistency index (CI) can be computed as follows:

$$\textit{Consistency Index} = \frac{\lambda_{max} - n}{n-1} = \frac{5.396-5}{5-1} = 0.099$$

The matrix is checked for its consistency. It is necessary for the consistency ratio to be equal to or less than 0.1. If it fails to meet the required value, then the answers to the comparison evaluated by the experts would be re-examined for better consistency. The random index value is shown in Table 5.

Consistency Ratio = Consistency *Index* / *Random Index (RI)* = 0.099/1.12 = 0.088 < 0.1 (acceptable)

Table 5: Value of Random Index (RI)

n	2	3	4	5	6	7	8
RI	0	0.58	0.90	1.12	1.24	1.32	1.41

Source: Saaty, 2008

Steps 1 to 4 are then used to calculate for all the sub-criteria in hierarchy level 2. They were then ranked according to their weight values and the result is presented in Figure 7.

Step 5

Lastly, step 5 involves the calculation of a normalised weight value, which is used to rank all fifteen sub-criteria. This is done by multiplying the weight value of each main criterion with the corresponding sub-criteria. A similar calculation technique is applied for computing the weight and consistency ratio values of all sub-criteria. To find the overall ranking of sub-criteria, it is necessary to find the normalized weight value for each sub criteria. This can be done by multiplying (i) each weight value of main criteria in hierarchy Level 1 with (ii) corresponding weight value of sub- criteria (ii) in Level 2. The results are (iii) shown in Figure 7.

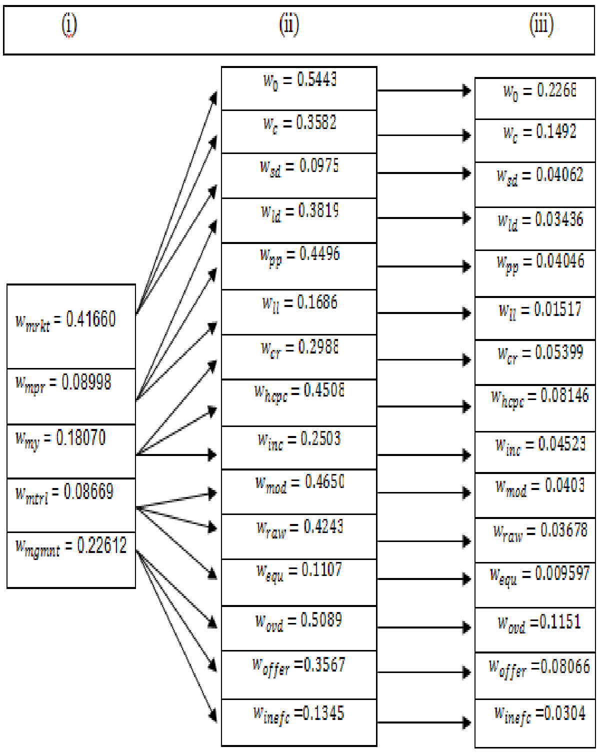

Figure 7: Normalised weight value of sub-criteria

4.5 Stage 5 – Findings and Discussion

After the analysis is made to the collected data using the analytical hierarchy process technique, the results of the study are summarised as shown in Figures 8 and 9. Figure 8 and Figure 9 indicate the prioritization of the main criteria and sub-criteria that is based on their weighted percentages. The values indicated in Figure 8 are the weights of comparison between the main criteria in the given challenges of the shipyard industry in Malaysia. Meanwhile, the values that are indicated in Figure 9 represent the normalised weights of comparison between all the sub-criteria that had contributed to the challenges of the shipyard industry in Malaysia.

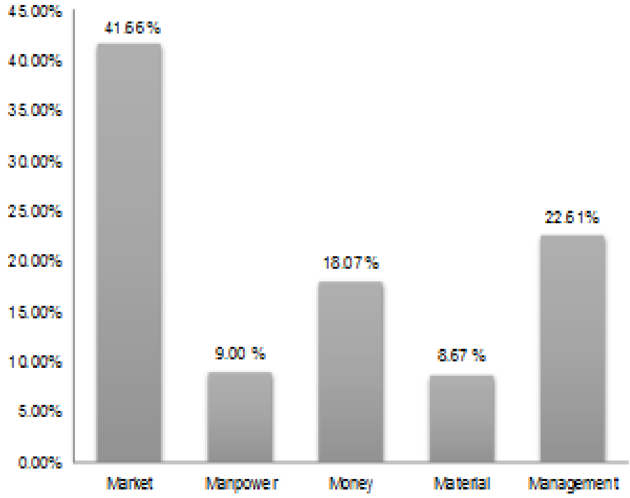

Figure 8: Prioritization of main criteria

In Figure 8, all the main criteria had been compared to determine its importance in contributing to the challenges faced by Malaysian shipyards. Based on Figure 8, the criterion of 'Market' had the highest rank with a percentage of 41.66%, which was then followed by the criterion of 'Management' that showed a percentage of 22.61%. The criterion of 'Money' had a percentage of 18.07%, while 'Manpower' had recorded 9.00%, and lastly, 'Material' with an 8.67%. Based on the results of main criteria, the criterion of 'Market' had played an important role on influencing the shipyard activity in Malaysia.

The normalised weights of all sub-criteria were summarised for the purpose of ranking in the preference order, which is shown in Table 6. The sub-criteria were ranked based on their weighted percentages after they had been normalised using the AHP technique. All of the normalised sub-criteria were then illustrated in Figure 9 to show their contribution to the challenges faced by the shipyard industry in Malaysia.

Table 6: Normalized value in percentages of sub-criteria

Sub-criteria	Percentage (%)	Rank
Overcapacity in shipping/ offshore structure market (O)	22.68	1
Competition from more cost effective foreign yards (C)	14.92	2
Slower demand for yards' products and services (SD)	4.06	8
Labour drain from SBSR industry to other industries (LD)	3.44	12
Poor project management skill (PP)	4.05	9
Lack adequate skilled labour (LL)	1.52	14
Complex requirement by bank for loan (CR)	5.40	6
Huge capital cost and rising production cost (HCPC)	8.15	4
Lack of incentives for SBSR industry players (INC)	4.52	7
Modernizing / automate / adopt new technologies (MOD)	4.03	10
High cost of imported raw materials and services (RAW)	3.68	11
Equipment that are locally manufactured and produced are less sophisticated ones (EQU)	0.01	15
Overdependence on local contracts (OVD)	11.51	3
Too many yards offering same products/services (OFFER)	8.07	5
Inefficient supply chains (INEFC)	3.04	13

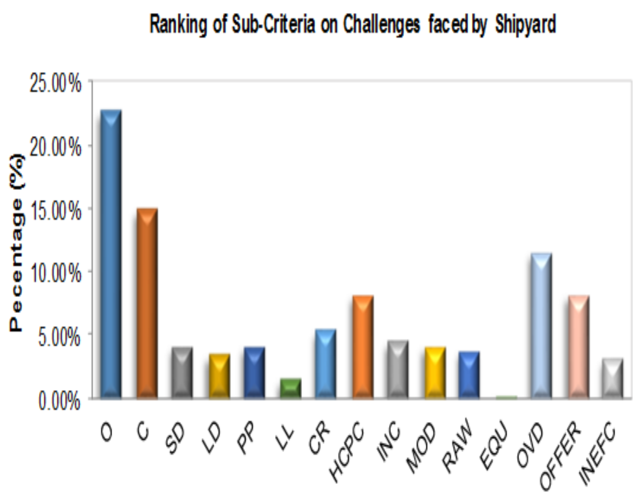

Figure 9: Prioritization of sub-criteria

Based on Table 6 and Figure 9, the sub-criteria of 'Overcapacity in shipping and offshore structure market' had the highest rank with a weighted percentage of 22.68%. This element was derived from the 'Market' criterion. This was then followed by the sub-criteria of 'Competition from more cost effective foreign yards (C)' with 14.92%, 'Overdependence on local contracts (OVD)' with 11.51%, 'Huge capital cost and rising production cost (HCPC)' with 8.15%, and 'Too many yards offering same products/services (OFFER)' with 8.07%. These sub-criteria were ranked as the top five contributing elements that had influenced the challenging factors, whether directly or indirectly.

This prioritisation methodology helps to emphasize the crucial factors and elements that the shipyard industry should give attention to, particularly those located in Malaysia. The decision makers should consider these factors and elements in their strategic management and operation planning, otherwise, the shipyard's businesses could be affected.

As a recommendation, the local shipyards may build more medium and small sized vessels that require low capital and to avoid the overproduction of vessels. On the other hand, the management of a shipyard organization should be assessed by using a bottom-top approach. This should start with the careful planning of a new shipbuilding project that meets customers' requirements. It is also crucial for shipyards to maintain the quality and safety of their new vessels.

The shipyard industry has now become one of the manufacturing sectors proposed by the Ministry of International Trade and Industry (MITI) in the 11th Malaysia Plan since the government has recognised the Shipbuilding/ Ship Repair (SBSR) industry as a strategic industry that could help transform Malaysia into a fully developed economy by the year 2020. This industry was worth about RM1.1 billion in 2013, which indicates that there had been a higher level of confidence placed in the Malaysian-made vessels market. Due to the value of this industry, MITI had pledged its commitment in facilitating appropriate incentives to the industry as a means of supporting the SBSR Industry Strategic Plan 2020 targets (MIGHT, 2015). Therefore, the shipyard industry in Malaysia should take advantage of this opportunity in the continued sustenance and expansion of their businesses.

5. Conclusion

As a conclusion, the purpose of this study to identify and to rank the factors affecting the Malaysian shipyard industry has been achieved. The results from this study showed that the shipyards in Malaysia had faced a significant challenge from the 'Market' factor, since it had the highest rank from all the factors investigated.

This was then followed by the 'Management', 'Money', 'Manpower', and 'Material' aspects. This study had also highlighted the top sub-factors of the main factors that had influenced the shipyard industry in Malaysia. The most important sub-factor had been 'Overcapacity in shipping/ offshore structure market (O)', which were followed by 'Competition from more cost effective foreign yards (C)', 'Overdependence on local contracts (OVD)', 'Huge capital cost and rising production cost (HCPC)', and 'Too many yards offering same products/services (OFFER)'.

This study had provided an expansion in the assessment of factors faced by the Malaysian shipyard industry by using the multi-criteria decision-making approach, which had helped in understanding the complex structure of a problem. The outcomes from this study may vary in other researches that conduct a similar area of study since it depends on the criteria as well as the methodological approach that is being used to analyse the data.

This study can also assist decision-makers or policy-makers in recognising the potential factors that may impose challenges on Malaysian industries, such as the shipyard industry. The methodology proposed in this study can be used to analyse a problem that is associated with a variety of factors and assist in decision making process that will benefit both decision- and policy-makers.

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Appendices

A. Table 3: Pair-wise comparison matrix

	Market	Manpower	Money	Material	Management
Market	1	5.4	3.8	4.5	1.34
Manpower	0.1852	1	0.4267	2.05	0.2719
Money	0.2632	2.3436	1	3.35	0.7962
Material	0.2222	0.4878	0.2985	1	0.7386
Management	0.7463	3.6778	1.2560	1.359	1
Total	**2.4169**	**12.9092**	**6.7812**	**12.2539**	**4.1467**

B. Table 4: Weight values of main criteria

						Weight value	Rank
Market	1 ÷ 2.4169 =0.41375	5.4 ÷ 12.91 =0.41831	3.8÷6.781 =0.56040	4.5÷12.254 =0.36720	1.34÷4.1467 =0.32310	=0.41660	1
Manpower	0.07663	0.07746	0.06292	0.16730	0.06557	=0.08998	4
Money	0.10890	0.18150	0.14750	0.27340	0.19200	=0.18070	3
Material	0.09194	0.03779	0.04402	0.08161	0.17810	=0.08669	5
Management	0.30880	0.28490	0.18520	0.11050	0.24120	=0.22612	2
Total	1	1	1	1	1		