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# Evaluation of Delay Factors on Dry Bulk Cargo Operation in Malaysia: A Case Study of Kemaman Port

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ABSTRACT

There are various types of delay factors that could affect the efficiency and effectiveness of the dry bulk cargo operation, especially in port. Hence, it raises the concerns of the stakeholders, as some of them can significantly affect their actual transport plans and cost them extra money to handle the cargo. Due to uncertainty of the most significant delay factor in some Malaysia's dry bulk ports, therefore, this study aims to evaluate the most significant delay factors that causing delays in dry bulk cargo operation by using the analytical hierarchy process (AHP) method. This study found that the factor of 'Miscellaneous' is the most significant factor that contributed to the most of delay creations in dry bulk cargo operation in Kemaman port. Meanwhile, sub-criterion of 'Foul weather and tide prediction' is selected as the most significant sub-cause of delay creation in similar port. This study contributes the practical technique and valuable findings to the port and its stakeholders, where it may alert the them to measure the factors that affect their operational performance and business. Also, it introduces the usage of practical and systematical analysis technique for assisting the seaport operator or interested parties in analyzing the potential contributors of a condition in the port settings.



## 1. Introduction

Maritime transport is the backbone of the world economy as more than 90% of world trade was carried by sea (Grote et al., 2016; United Nations Business Action Hub, 2019). In 2013, approximately 9.5 billion tonnes of goods was loaded for seaborne transport in ports worldwide (UNCTAD,

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2014), and it continued to increase in 2015 where approximately 9.8 billion tonnes of goods were transported via seaborne trade annually. Based on the total volume of overall cargoes transported, the dry bulk cargo represented for more than 50% of all loaded goods as compared to the containers (i.e. 16%) and liquid bulk cargo (i.e. 30%) (UNCTAD, 2014; Grote et al., 2016, Port Technology, 2017).

According to the data from United Nation Conference on Trade and Development (UNCTAD), dry bulk cargoes represent the largest cargo group that contributed to the world economic growth (UNCTAD, 2014). In 2013, about 4.3 billion tonnes of dry bulk cargoes (i.e. commodity cargo that is transported unpackaged in large quantities in granular, particulate form) were shipped. The five major bulk commodities (iron ore, coal, grain, bauxite/alumina and phosphate rock) account for about 57% of total volume of all transported dry bulk commodities (UNCTAD, 2014). However, a large range of other dry bulk commodities was also been shipped worldwide. They are handled, stowed and preserved in specialized areas of marine bulk terminals before being transported to their respective destinations.

Regardless the means of the cargo been transported, an economical operation depends on a variety of factors including the availability of good handling operation (Victor et al., 2016). It is a necessity for a port and the transport components to be productive and efficient in the operational settings because it allows the them to highlight their potentials in serving the markets (Ndikom, 2008; Ndikom, 2011; Saeidi et al., 2013).

However, one of the main concerns that can deny the potentials of a port and affect its operational efficiency is the delay factors. Delays factors frequently disrupt the cargo handling operation and affect the effectiveness of the cargo transfers. In general, the delay factors can be the situations or occurrences that hinder the successful completion or execution of an operation within the allocated time frame (Ndikom, 2013). They present themselves in a cargo transportation system and may threaten when a proper attention or action is not given to address or solve the vital issues that are the key roles of a smooth port operation (Ndikom, 2013). These delay factors could exist in any forms which can hamper the productivity of any ports and cargo handling operations worldwide (Ndikom, 2013; Sayareh and Ahouei, 2013; Victor et al., 2016). Nevertheless, less attention has been paid to assess the delay factors of dry bulk cargo operation in Malaysia and it led the threats remain unhighlighted as for the case of Malaysia's dry bulk cargo port. Therefore, this paper is aimed to evaluate the delay factors of dry bulk cargo operation in Malaysia, by taking Kemaman port as the scope for a case study.

## 2. Literature Review

In maritime industry, dry bulk cargoes refer to the dry cargoes that are transported in the ship- or hold-size parcels. They are loaded by either using the gravitational concept or pumps, discharged by either grabs, suction or pumps, and can be stowed in its natural form (Stopford, 1997; Naude, 2016). The examples of dry bulk cargoes include iron ore, coal, grains, wood products, minerals and fertilizers to name but a few (Clarkson, 2014). All of these cargoes are basically handled at the ports or terminals that are equipped with specialized facilities and equipment for handling the dry bulk cargoes.

Despite of various kinds of dry bulk cargoes, for instances from grains to coal and from sugar to cocoa, dry bulk cargoes generally cover a range of produce and raw materials that have two features in common, in which they are unpacked and are homogeneous. These two properties make it easier for dry bulk cargoes to be dropped or poured into the hold of a bulk carrier, which is the specialized cargo ships for transporting the dry bulk cargoes by the seas (Maritime Industry Foundation, 2012).

The influence of dry bulk cargoes to the world economy and needs is undeniable. It is because without the approximated 285 metric dwt of dry bulk shipping transported by sea annually, the lifestyle in most countries may be changed dramatically (Maritime Industry Foundation, 2012). However, one of the biggest challenges that the stakeholders of dry bulk cargo industry might be facing today is decreasing the vessel turnaround time in port (Pjevčević et al., 2013). It is because the dry bulk cargo operation is quite time consuming (HandyBulk LLC, 2019) as compared to containerized and liquid bulk cargoes. Such statement was also supported by the data from the UNCTAD (UNCTAD, 2018), where it indicated that the average time of bulk cargo ships stayed in worldwide ports for 2016 and 2017 was about 2.72 and 2.68 days, respectively. Although it recorded a promising improvement in the average time of ship stays at the ports, the period of time for the bulk cargo ships were actually the longest if compared to the other types of ships (UNCTAD, 2018). Taking into consideration the importance of time and cost in the current competitive world, the companies who can deliver their products to customers in time and at a lower cost are the ones that are successful in their job. Hence, the owners of goods really wish to improve the movement of their goods from ports and to decrease the relevant tariffs and transportation costs (Jafari, 2013a;b).

The lengthy period of ship stays in a port can be due to either strict handling procedures and requirements of the cargo and its carrier, especially when loading and unloading operation of cargo both from and into the ships (Grote et al., 2016), or unpredictable disruptions in cargo operation, which causing delays (Jafari, 2013a;b; Saeidi et al., 2013). Based on Jafari (2013a), who measured the performance of dry bulk cargo loading and unloading operation in Latakia port, he found that there were various factors that can contribute to the delays of dry bulk cargo operation in a port. In his study, he pointed out that the delay creation in dry bulk cargo operation were caused by some crucial elements of the cargo operation such as document incompleteness, shortage of truck, deficiency of horizontal L/U equipment, unpreparedness of owners of goods and administrative and financial issues (Jafari, 2013a).

Nevertheless, this study believes that the factors to the delay creation in dry bulk cargo operation of a port not only limited to the aforementioned factors. It is because the delay creations in a port are subjective as each port operational system is heterogeneous. Therefore, the factors that affecting Latakia port, for example, may not be similar to the factors that creating delays in other ports. In addition, based on a few studies, varying factors were claimed to have significant influences on the delay situations in different port terminals, respectively. The differences of the outcomes and methodological approaches applied to evaluate the delay factors in the existing studies were summarized as in Table 1 (see Appendix section).

In cases of improving the efficiency and avoidance of delay creation in a port operation, the respective port/terminal, ships, and cargo owners are basically shared a mutual responsibility. Without a party gives a serious attention to the standard process and requirements of handling the dry bulk cargoes, it may affect the smoothness of the whole cargo operation. A proper evaluation on the factors of delays in dry bulk cargo operation of a port should be conducted to ensure proper planning of cargo operation at the respective port can be effectively executed and thus, reduce the extra costs that caused by the delay factors.

### 2.1. *Overview of delay factors in dry bulk cargo operation*

#### *2.1.1 Port*

Seaport is one of the important actors in the maritime transport system. It has been recognized as an entry point where seaborne goods coming into a country from other countries and vice-versa (Victor et al., 2016). According to Clark et al., (2001), a port acts as an enterprise which required to provide quality services to its customers in order to survive economically. This is because the port customers (i.e. shippers, ship owners, etc.) continues to demand an efficient service from port operators for continued patronage. Clark et al., (2001) also noted, the ability of a ship to serve and operate economically largely dependent on the availability of a good functional port, among other factors. In the same manner, Ugboma et al., (2004) stated that a service facility like port need to be properly equipped from the organizational aspect until to the infrastructure and equipment installations in order to serve the customers if its usefulness and performance level is desired to be recognized.

However, a port can be a significant influencing factor to the competitive supply chain system. This because delay in port operation can create a remarkable effect on the period of ship stays in port, period of sedimentation of goods and freight payable to shipping companies (Jafari, 2013a). In addition, it will not only affect the port efficiency alone, but it may also affect the efficiency and effectiveness of the port customers' operational activity.

From the port operation perspective, there are several circumstances that often impede the cargo handling operation. The circumstances that had been noted include deficiency of loading and unloading (L/U) equipment (Bugaric and Petrovic, 2007; Sayareh and Ahouei, 2013; Jafari, 2013a; Saeidi et al., 2013; Yousefi et al., 2018), problems with customs and formalities (Jafari, 2013a; Saeidi et al., 2013; Yousefi et al., 2018), improper storage or yard spaces for cargo allocation (Jafari, 2013a; Saeidi et al., 2013) and labour issue (Jafari, 2013a; Saeidi et al., 2013; Sayareh and Ahouei, 2013; Wong, 2017). These circumstances can create a huge impact on port operation through the delay creation as they are apart of the main components in cargo handling operation at a port. For example, if there is deficiency of (L/U) equipment at the port, then the transferring process of cargo would be slow down because the equipment involved may unable to be running at the normal rate as it should be. Hence, it adds more time to a particular cargo handling operation and indirectly, cause delays to the subsequent cargo handling operations.

### *2.1.2 Ships*

Apart from port, the element of ships that carrying the dry bulk cargoes may also play a huge influence in creating delay of dry bulk cargo operation. This because the loading and unloading process of dry bulk cargo ships are quite complicated. Dry bulk cargo ship is a specialized vessel that designed to carry a specific type of cargo, a number of considerations and crucial measures should be performed in order to ensure the condition of the ship is suitable and safe, as well as keep the condition of cargo stay as it should be. Otherwise, either the ship condition will be affected, or the cargo will be contaminated or likely damaged. If such conditions happened, it will make things worse. As the name itself, the dry bulk cargoes need to be in proper state, which is dry in the entire operation. Any moisture that finds its way into the cargo could ruin the entire load, at considerable cost to the ship owner. It may also be surprising to learn that many dry bulk cargoes are classified as 'Dangerous Goods' requiring special attention during loading, transportation and discharge, as they could shift during shipment, causing ship instability (Maritime Industry Foundation, 2012).

Bulk carrier cargo operations can be time consuming as the captain and terminal operators need to have mutual agreement on a detailed planning of loading and unloading process as per international regulations and design of the ship. It is crucial that the ship's characteristics are written precisely to the charter party so that any misunderstanding between the two parties can be avoided. Any deviation on the agreed-upon ship characteristics (i.e. deficiency or inefficiency of ship's equipment) may result in the cancellation of the charter party or delay of cargo handling operation. As for example, after each unloading process done, the holds of the ship must be well-cleaned before the loading process of next cargo is performed. If the ship is having temporary deficiency with her equipment (e.g. ballasting or hydraulic machinery problem), then it might slow down, or even stop, the loading and unloading operation immediately. This situation will create delay in cargo handling operation as the operation cannot be performed as according to the plan and schedule until the respective fault of ship's equipment is backed up or operate like normal. If not, it will affect the seaworthiness of ship and risks the cargo worthiness. As mentioned by Handybulk LLC, a chartering company which based in New York, seaworthiness of a ship is a very important to the charterers and cargo owners especially, because it can have a huge impact on cargo worthiness. The obligation of the shipowner to provide a seaworthy and cargo worthy ship for the duration of the charter party fixture is absolute (Handybulk LLC, 2019). The deficiency of ship's equipment is one of the common situations that often causing the delays in cargo operation, from the perspective of ship's side. This is supported by several literature which also highlighted the influence of situation in causing delay in cargo operation such as Jafari (2013a; 2013b), Saeidi et al. (2013), and Yousefi et al., (2018), to name a few.

Other than that, a late ship arrival at a port is another situation that sometime cannot be avoided. However, such situation does affect the commencement of the cargo operation in which has been planned and scheduled. The original plan of cargo operation may need to be cancelled and rearranged for another transfer window in order to give a way for other ship that also waiting for their turns. Otherwise, if the operation still be commenced, then the delays of other subsequent cargo operations might be absolute. The influence of this situation in causing delays of cargo operation has also been acknowledged by several literatures such as Mohd Salleh et al., (2017) and Hasheminia and Jiang (2017).

### *2.1.3 Cargo owners*

Cargo owners are one of the important actors that should plays effective role in ensuring the delays of cargo operation can be avoided from their sides. Although there is no control of cargo owner to prevent the delays, they however should avoid from creating it. To avoid creating delays on the cargo owners' side, the cargo owner must be fit in any condition either to receive or deliver cargoes from or to vessels throughout the port, after completing all the port and custom formalities. However, unpreparedness of cargo owners to receive or deliver cargoes from or to vessels throughout the port is one of often situations that keep pausing the effective completion of cargo handling operation (Jafari, 2013a; Jafari et al, 2013; Sayareh and Ahouei, 2013). This situation basically happened when the relevant documents that should be prepared by the cargo owners for the purpose of delivering or receiving the cargoes are either incomplete or unacceptable by the local authority or port operator. Sayareh and Ahouei (2013) in their study on dry bulk terminals also shared similar opinions as they found that unfitness of cargo owner had created more than 69% of total pauses in cargo handling operation and it was considered a significant contribution.

Not just that, according to Sayareh and Ahouei (2013), the cargo owners did have a large influence on the cargo operation as they are the ones who in charge on the preparation of the cargoes before the loading and unloading operation at the port take places. Another common situation that often contribute to the delay creation in cargo operation that contributed by cargo owners' side is the administrative and financial issue (Jafari, 2013a; Jafari et al, 2013; Sayareh and Ahouei, 2013). This is because the cargo owners sometime can oversee this situation as improper handling of the cargo and its documentations can cause extra costs to be charged and problem to get the clearances for the cargo and ship.

Apart from that, the number of trucks supplied by the cargo owners to handle the cargoes also has effect on the overall cargo operation as shortage of trucks can slow down the movement of cargo to and from the loading and unloading sites. Unplanned slowdown will cause delays in overall handling operations. The influence of this situation in causing delays in cargo operation has also been cited in several literature such as

Jafari (2013a;b), Jafari et al, (2013); Sayareh and Ahouei (2013) and Saeidi et al. (2013), to name a few.

*2.1.4 Miscellaneous*

Despite of the situations that raise from the aspects of port, ships and cargo owners, there are a number of other situations that also can have a huge impact on delay creation in the dry bulk cargo handling operation, has been separately grouped. This because the situations that been grouped under 'Miscellaneous' are likely the situations that port, ships and cargo owners have no direct control of them and sometimes, they can be unpredictably threatened the dry bulk operation although the crucial measures have been performed. Generally, they are contributed by outside elements or forces, other than port, ships and cargo owners. Jafari (2013a) highlighted the situations were included foul weather and tide prediction, incompetence of transporting equipment and problem with safety issue. Similar opinions have been shared in several other literatures which also pointed out similar situations and their influences in delay creation of dry bulk cargo operation. The literatures include Jafari (2013b), Jafari et al, (2013), Sayareh and Ahouei (2013) and Saeidi et al. (2013).

Taking the potential impact of weather and tide condition as the example, one of the hazards that can be induced is the structural damage on the ship's body (IACS, 2018). Due to such potential impact it can cause, International Association of Classification Societies (IACS) emphasized that the commence of water ballast exchange at sea should always be carried out in calm weather conditions in order to minimalize the risk of structural damage (IACS, 2018). All available weather forecasting should be utilized to determine that the weather condition is appropriate within the 'weather window' of the ballast water exchange operation. This because 'weather window' should be determined accordingly to the ballast water exchange sequence and the achievable ballasting/de-ballasting rates. A sufficient time margin should always be considered in case of any interruption of unexpected circumstances such as the breakdown of ballast pumps. If there is foul in weather and tide prediction, then it will affect the commencement of operation as according to the original plan and schedule. In order to engage with the effective and safe execution of ballast water exchange operation as well as reduce the risk of ship's structural damage, then the particular operation might be delayed until the appropriate 'weather window' is determined. Therefore, the weather and tide condition can be one of the important elements in delay creation because it would affect the original plan of dry bulk cargo operation (i.e. L/U operation, ballast operation, etc.) if unfavourable condition takes place.

2.2. *Overview of Dry Bulk Cargo Port, Kemaman, Malaysia*

The Port of Kemaman is one of the Malaysian ports that was classed as a medium-sized port (Othman et al., 2019). Located in Terengganu, which is a state in the east coast of Peninsular Malaysia, Kemaman port is one of the deepest seaports in Malaysia and an emerging port that acting as the new gateway to the Asia-Pacific region. It is also a regional centre for transhipment activities as well as cargo consolidation and distribution activities. Kemaman port operates all year round in all weathers and has the capability of handling vessels of up to 150,000 DWT. With a number of terminals that equipped the port operation, it handles various types of cargo ranging from general cargo, dry bulk to liquid bulk cargoes (Eastern Pacific Industrial Corporation Berhad, 2019). However, since the study focus on the dry bulk cargo operation, then only the operation of the dry bulk cargo terminal has been taken into this case study. The dry bulk cargoes are handled on the East Wharf, where the terminal is operated by Lembaga Pelabuhan Kemaman. The East Wharf terminal was equipped with 3 berths with the main function of handling dry bulk and general cargoes. In this terminal, the trucks, grab and unloader are used for the loading and unloading operation, with a loading rate of 500 metric tonnes per hour per gang. Several cranes which ranging of 25 tons to 90 metric tons, grab bucket shore/ship and electromagnet plate are available to be used in the cargo handling operation at the terminal. In addition, the terminal is also equipped with several other cargo handling equipment such as trailers, prime movers, low loader, a conveyor belt system, grab and hopper and forklifts. Not just that, the terminal also provides an open storage area with capacity of 5 hectares within port boundary and covered storage area with capacity of 5,000 square meters, that acting as the transit warehouse (Konsortium Pelabuhan Kemaman, 2019).

Similar to some other states of the country, the weather condition in Terengganu in general is fairly hot and humid all year round. However, Terengganu can be received heavy rainfalls and strong winds when the north-east monsoon blows the region in which usually between November and January/February (Othman et al., 2018; Konsortium Pelabuhan Kemaman, 2019). Due to such conditions, some areas in Terengganu including Kemaman may suffer severe wet conditions (i.e. flooding) on annual basis, and the sea at the region can be very rough (Yaakob and Chau, 2005). In a study by Othman et al., (2018) regarding the analysis of the 2014 Flood of Kemaman, Terengganu, Malaysia, they found that the flood that occurred at the Kemaman area of Terengganu was due to a combination of physical factors, including high tides and elevation, apart from heavy rainfalls. Nevertheless, in some clear sunny days during the monsoon season, surprisingly east coast is always presented with clear blue sky and cooling wind. Therefore, since Kemaman Port is located in one of the states on the east coast of Peninsular Malaysia, the port somehow cannot avoid being exposed to unfavourable weather conditions in that particular part of the region. It may pose a hard time to the port operation especially when the dry bulk cargo operation takes place.

## 3. Methodology

This study utilizes the qualitative research method, which combined the primary data and the secondary data sources in order to produce a solid outcome. The primary data source is the primary information that collected directly from the qualified experts. In this study, the information obtained was primarily through structured questionnaires that were distributed during the discussion with the experts. Meanwhile, for the secondary data source, it is basically the information that extracted from the published documents or databases such as from books, journals, reports, official websites etc. This study also incorporates with an Analytical Hierarchy Process (AHP) method for the analysis of the data collected. This method is used to rank factors in the order of preference order from the most significant to the less significant factors.

AHP method is one of the multi-criteria decision-making approaches which use a hierarchizing process system to carry out a wide-ranging evaluation and final decision on one of the causes of a particular problem. It is a method that can be used to analyze qualitative data (Saaty, 1980; Saaty, 2008). This approach basically points out a set of elements which are mutually related in the problem investigated. The elements will form a particular hierarchy, which is crucial for considering the possible contributors to the system, both natural and human-made. The system analyzed will form a multi-layer arrangement where the layers are differentiated by internal structure and functions (Saaty, 2008). The functions of elements on a lower level are subordinated to the functions of elements on a higher level. The functioning of the higher-level elements is dependent on the functioning of the lower level elements (Saaty, 1980; Saaty, 2001). This structural hierarchy method helps to indicate the relationships between the component parts of complex systems, where the relationships are an arrangement of structural properties used to organise and analyse complex decisions using the mathematical structure of consistent matrices for determining the weightage values (Merkin, 1979;

Saaty, 1980; Abdul Rahman, 2012).

For data collection process, AHP method is incorporated with the pairwise comparison method to produce a rating scale format with the aim of getting qualified judgments on the particular elements evaluated. The qualified judgments are analysed using matrix mathematical structure where the judgments on pairs of attribute $Ai$ and $Aj$ are represented by a $n$ $x$ $n$ matrix $A$ as shown in Equation 1 (Abdul Rahman, 2012).

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

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. Such a weight value can be calculated using the following Equation 2 (Abdul Rahman, 2012).

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

where $a_{ij}$ stands for the entry of row $i$ and column $j$ in a comparison matrix of order $n$. Then, the consistency ratio ($CR$) can be calculated using Equation 3 for determining the consistency of the pair-wise comparison matrix. While, $RI$ is the random index for the matrix size, A., and the $RI$ value has shown in Table 2 by referring to the number of items being compared (Saaty, 2008).

$$CR = \frac{CI}{RI} \quad (3)$$

**Table 2**

Random index ($RI$) table

| ***n*** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| ***RI*** | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

*Source: Saaty, 2008*

Next, the Consistency Index (CI) will be computed using Equation 4 as follows (Saaty, 2008):

$$CI = \frac{\lambda_{max} - n}{n-1} \quad \text{(n = 1, 2, 3…k, matrix size)} \quad (4)$$

Then, the $\lambda max$ is a maximum eigenvalue of $n$ $x$ $n$ comparison matrix A that is calculated as follows (Asuquo et al., 2014):

$$\lambda_{max} = \frac{\sum_{j=1}^{n}\left[\frac{\sum_{k=1}^{n} w_k a_{jk}}{w_j}\right]}{n} \quad (5)$$

where, $w_k$ = the weight value of specific criterion, $a_{jk}$= the pair-wise criterion base on specific row and column, $w_j$ = the weight value of criterion. Then, the consistency of the pair-wise comparison needs to be evaluated. A consistency process can be performed by using a consistency ratio ($CR$). $CR$ is designed in a way that a value greater than 0.10 will indicates an inconsistency in pair-wise comparison. However, if $CR$ is determined 0.10 or less, the consistency of the pair-wise comparisons is considered reasonable (Drake, 1998; Abdul Rahman, 2012). Meanwhile, if the consistency check fails to reach the required level, then the judgements to the comparison matrix need to be re-examined (Dey, 2003; Aminbakhsh et al., 2013; Raka and Liangrokapart, 2017). Further detail of the calculation process can be referred to Drake (1998) and Anderson et al., (2003).

Basically, the preferences ranking order are the results from the AHP method which is ranked based on the weightage values calculated from the pairwise comparison scale in respect to the consistent judgements. Any inconsistent judgements can be detected using the AHP by calculating the consistency ratio of the pairwise comparison before the weightage is determined in order to ensure that the preference is consistent and valid. It is the reason why this method enables comparison of criteria with respect to a criterion in the nature of the pair-wise comparison mode (Abdul Rahman, 2012). The application of AHP method can be found in various areas, such as strategic decision making (Bhushan and Rai, 2004; Abdul Rahman and Ahmad Najib, 2017), engineering education (Drake, 1998; Abdel-Malak et al., 2017) and risk analysis (Dey, 2003; Aminbakhsh et al., 2013; Raka and Liangrokapart, 2017).

The reason of using AHP method in this study is that it is a clear, straightforward and well-documented method. Although it involves complex calculations, but it can be very much understandable. Besides, AHP helps to capture both subjective and objective evaluation measures. AHP help to reduce bias in decision making by providing a useful mechanism for checking the consistency of the evaluation measures and alternatives. In addition, it supports group decision-making through consensus by calculating the geometric mean of the individual pairwise comparisons, which is the approach of this study. Although some of studies highlighted several weaknesses of this method such as 1) it did not consider the vagueness in the personal judgements (Ayhan, 2013), 2) the judgements used in it can be affected by human emotions (Ayhan, 2013; Karthikeyan et al., 2016), 3) it cannot unravel non-straight models (Karthikeyan et al., 2016), and 4) a distortion may occur if some of the attributes used in the evaluation failed to differentiate among the alternatives which will affect the score or result of the alternative's selection (Raz, 1997; Palcic and Lalic, 2009), as to name a few, this study however had took a protective action which thought relevant and sufficient to ensure the output quality of the analysis. Apart from the consistency analysis that incorporated in AHP technique, this study has conducted the face-to-face qualitative approaches with the qualified experts of the port industry, specifically the individuals that actively engaged with the dry bulk cargo operation themselves. With the insights from the field experts themselves, a study can be considered has a strong information that can reduce the level of uncertainty or errors in the analysis process. Despite of that, the study only incorporated a simple hierarchical model in which not contribute to any significant inconsistency of the evaluations. The reliability of the action that had been taken in this study can be supported by Karthikeyan et al., (2016), who noted that this method did useful to settle just simple and direct models that are specifically corresponding to its information.

### *3.1 Empirical Analysis on Delay Factors of Dry Bulk Cargo Operation using AHP method*

#### *3.1.1 Step 1: Develop a hierarchy model of the study*

A test case was conducted to evaluate the delay factors of dry bulk cargo operation in Malaysia. Firstly, the factors of this study were structured by forming a hierarchical model for the analysis process. The model was basically consisting of three levels, named as goal (first level), the main factors (secondary level) and sub-factors (tertiary level). Based on the hierarchical structured model, each main factor was grouped with a number of sub-factors as the underlying elements that can influence the contribution of the main factor. The hierarchical model of this study is shown in Figure 1.

Figure 1 generally indicates the links between the elements of upper level and those in lower levels. The links of the elements highlighted was basically identified by using the literature surveys. Meanwhile, the elements used in this study was basically selected by the experts based on the common situations the happened at the port respectively. Nevertheless, the contribution of the delay factors highlighted in Figure 1 yet have not been discovered on dry bulk cargo operation in Malaysia, particularly in Kemaman port. Therefore, this study intends to evaluate the most contributing delay factors that affect the dry bulk cargo operation in Kemaman port, Malaysia.

*3.1.2 Step 2: Data collection using pairwise comparisons*

The data was collected from the industry experts using the pairwise comparison technique which used close-ended questionnaires that developed corresponding to the model in Figure 1. Basically, the technique basically required the experts to evaluate the criteria involved based on the rating scales shown in Table 3 (Saaty, 2001; Saaty, 2008; Abdul Rahman and Ahmad Najib, 2017).

**Table 3**

Rating scale for pairwise comparison

| Scale | Numeric value(s) |
|---|---|
| Equally important | 1 |
| Fairly important | 3 |
| Moderately important | 5 |
| Strongly important | 7 |
| Extremely important | 9 |
| Intermediate values to reflect fuzzy inputs | 2,4,6,8 |
| Reflecting dominance of second alternative compared to the first | Reciprocals |

The qualified experts were consulted throughout the study to get the precision of the information and data collected. The experts consisted of individuals that engaged with the current dry bulk operation in Malaysia which included the stevedores, shipping executive, manager, cargo owner and the ship officers with a number of seven experts in total. These experts are chosen based on their broad experiences in dry bulk cargo operation at Malaysian port with each of them having more than 5 years of experiences, in general. Those criteria made them as qualified experts for this study. The backgrounds of the industry experts involved are shown in Table 4.

**Table 4**

The backgrounds of industry experts

| No. | Designation | Working background | Years of experiences |
|---|---|---|---|
| Expert 1 | Stevedores | Engaged with cargo handling operation at the port | More than 5 years |
| Expert 2 | Shipping Executive | Handled the cargo documentation and clearance process at the port | More than 5 years |
| Expert 3 | Manager | In-charged on the plan and execution of the port operation | More than 10 years |
| Expert 4 | Cargo Owner | In-charged on the movement of the cargo | More than 10 years |
| Expert 5 | Ship Officer | In-charged on the ship operation | More than 5 years |
| Expert 6 | Ship Officer | In-charged on the ship operation | More than 5 years |
| Expert 7 | Marine Pilot | Assisted the ship movements, entering and moving out of the port | More than 10 years |

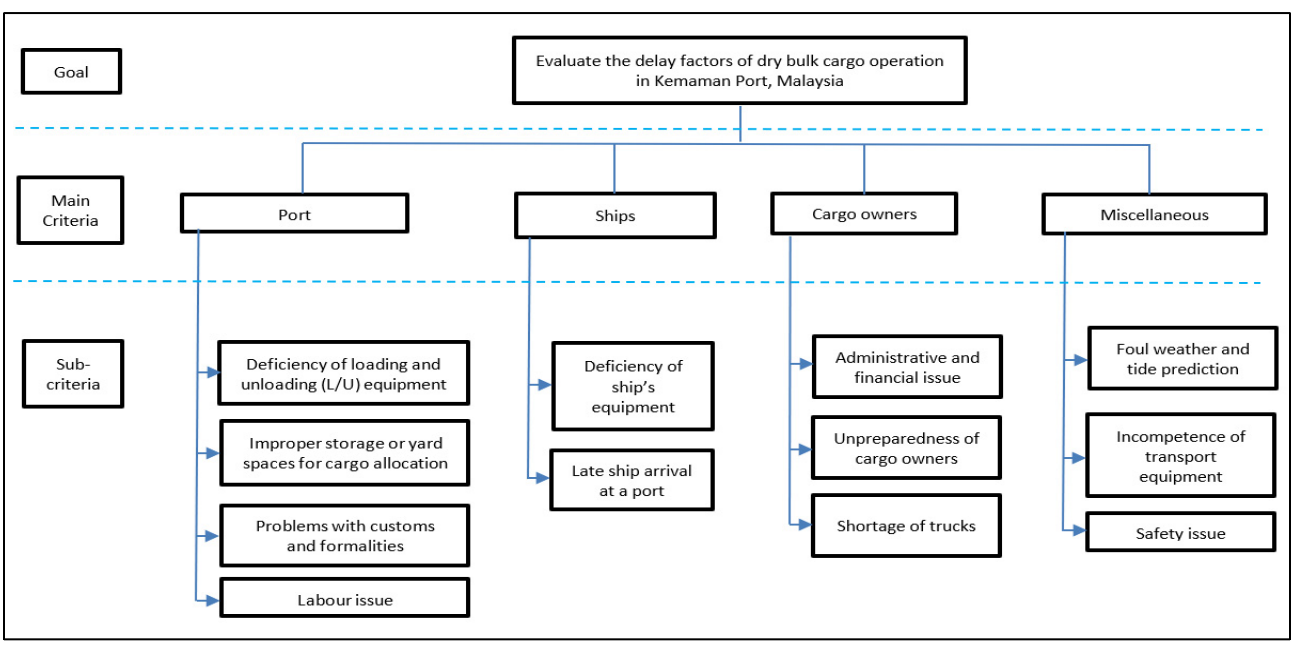


**Fig. 1.** Model development on studying delay factors of dry bulk cargo operations

*3.1.3 Step 3: Tabulate the pairwise comparison values of criteria into the pairwise comparison matrix*

The pairwise comparison values of criteria evaluated in Step 2 were then determined. In this step, the judgements provided by the experts were averaged and tabulated into the pairwise comparison matrix as according to Equation 1. Taking the main criterion 'Miscellaneous' as the example, the sample calculation of pairwise comparison value is shown as follows:

Main criterion of 'Miscellaneous'

$$= \frac{(0.167+0.167+0.167+0.167+0.143+0.143+0.143)}{7} = \mathbf{0.157}$$

The calculated pairwise comparison values for all criteria are summarized in Table 5.

**Table 5**

Pairwise comparison values of main criteria

| | Port | Ship | Cargo Owner | Miscellaneous |
|---|---|---|---|---|
| Port | 1.000 | 1.711 | 1.748 | **0.157** |
| Ships | 0.584 | 1.000 | 1.314 | 0.158 |
| Cargo Owners | 0.572 | 0.761 | 1.000 | 0.138 |
| Miscellaneous | 6.369 | 6.329 | 7.246 | 1.000 |
| Total | 8.525 | 9.801 | 11.308 | 1.453 |

Meanwhile, in case of sub-criteria, the similar calculation was also applied to calculate their pairwise comparison values.

*3.1.4 Step 4: Calculate the relative weights of the criteria and sub-criteria*

In this step, the relative weight (eigenvalue) of each criterion and sub-criterion was calculated from the pairwise comparison matrix values (in Step 3) using Equation 2. The sample calculation of the relative weights of the criteria and sub-criteria is shown as follows, by taking main criterion 'Miscellaneous' as the example.

Main criterion of 'Miscellaneous' = 0.157 ÷ 1.453 = **0.108**

The relative weight values calculated for all criteria are summarized in Table 6.

**Table 6**

Relative weights of main criteria

| | Port | Ships | Cargo Owners | Miscellaneous |
|---|---|---|---|---|
| Port | 0.117 | 0.175 | 0.155 | **0.108** |
| Ships | 0.069 | 0.102 | 0.116 | 0.109 |
| Cargo Owners | 0.067 | 0.078 | 0.088 | 0.095 |
| Miscellaneous | 0.747 | 0.646 | 0.641 | 0.688 |

In accordance to the calculation applied for the main criteria, similar calculation was also applied to calculate the relative weights of the sub-criteria involved.

*3.1.5 Step 5: Determine the normalized weights of the criteria and sub-criteria*

The normalized weight (eigenvector) of the criteria and sub-criteria basically indicates the relative importance of the criterion being evaluated. In that case, to determine the importance level of the criterion or sub-criterion involved, the normalized weights of each criterion or sub-criterion can be obtained by using Equation 2. Taking the main criterion 'Port' as the example, the normalized weight of criteria can be determined as follows:

Main criterion of 'Port'
= (0.117+0.175+0.155+0.108) / 4 = 0.139

Similar calculation was applied to determine the normalized weights of all criteria and sub-criteria that involved in this study. The normalized weight values of all the criteria and sub-criteria calculated in this step are summarized in Table 7.

**Table 7**

Normalized weights of criteria and sub-criteria

| Main criteria | Normalized weight | Sub-criteria | Normalized weight |
|---|---|---|---|
| Port | **0.139** | Deficiency of loading and unloading (L/U) equipment | 0.255 |
| | | Problems with customs and formalities | 0.293 |
| | | Improper storage or yard spaces for cargo allocation | 0.177 |
| | | Labour issue | 0.275 |
| Ships | 0.099 | Deficiency of ship's equipment | 0.500 |
| | | Late ship arrival at a port | 0.500 |
| Cargo owners | 0.082 | Administrative and financial issue | 0.408 |
| | | Unpreparedness of cargo owners | 0.317 |
| | | Shortage of trucks | 0.350 |
| Miscellaneous | 0.680 | Foul weather and tide prediction | 0.385 |
| | | Incompetence of transport equipment | 0.267 |
| | | Safety issue | 0.348 |

*3.1.6 Step 6: Check the consistency of comparison matrix*

In this step, the consistency of the comparison matrix is checked to measure the level of reliability of the results. This is because comparisons made using AHP method are subjective and the acceptability of judgements is basically determined by checking the consistency value of the judgements received. The checking of the consistency value is referred to the consistency ratio (*CR*) value. According to Saaty (2001; 2008), the *CR* value is recommended to be below 0.1 in order to be acceptable as it is nearly consistent. If it is more than 0.1, then the inconsistency of the judgements is too large, and it could lead to error of the results.

Before the *CR* value can be determined using Equation 3, the value of consistency index, *CI*, should be known in the first place. However, to get the *CI* value, the $\lambda max$ also need to be determined. Using Equation 5, the $\lambda max$ of comparison matrix of the main criteria and sub-criteria calculated are shown in Table 8.

**Table 8**

The λmax of comparison matrix of the main criteria and sub-criteria

| Comparison matrix | $\lambda max$ value |
|---|---|
| Main criteria | 4.035 |
| Sub-criteria for criterion 'Port' | 4.074 |
| Sub-criteria for criterion 'Ships' | 1.500 |
| Sub-criteria for criterion 'Cargo Owners' | 3.010 |
| Sub-criteria for criterion 'Miscellaneous' | 3.061 |

After obtaining the $\lambda max$ value, then the *CI* value can be computed using Equation 4 as follows, by taking the λmax value of main criteria as the example.

Consistency Index ($CI$) of main criteria
$= (4.035 - 4) \div (4 - 1) = 0.012$

Since the $CI$ value has been known, then the $CR$ value can be calculated using Equation 3, to check the level of consistency of the comparison matrix. The value of RI can be referred to Table 2.

Consistency ratio ($CR$) of main criteria $= 0.012 \div 0.9 =$ **0.013**

The consistency ratio ($CR$) of main criteria calculated was 0.013, which is less than 0.1. Based on such value, the judgements provided by the experts was considered as reasonably consistent and acceptable. The CR values of all the sub-criteria were also recorded to have an acceptable consistency level, which is less than 0.1. The values of $CR$ for all the sub-criteria are summarised in Table 9.

**Table 9**

The values of *CR* for criteria and sub-criteria

| Comparison matrix | *CR* value |
|---|---|
| Main criteria | **0.013** |
| Sub-criteria for criterion 'Port' | 0.028 |
| Sub-criteria for criterion 'Ships' | 0.000 |
| Sub-criteria for criterion 'Cargo Owners' | 0.009 |
| Sub-criteria for criterion 'Miscellaneous' | 0.052 |

Similar calculation steps applied to the main criteria have also been applied to check the $CR$ values of sub-criteria' comparison matrixes.

*3.1.7 Step 7: Finalise the global normalized weight and rank of the main criteria and sub-criteria*

The global normalized weight values of the main criteria and sub-criteria can be finalised once the CR values of criteria and sub-criteria have been considered consistent and at the acceptable level. In this step, the global normalized weights of the main criteria were similar to the local normalized weights determined in Step 5, as shown in Table 10.

**Table 10**

Global normalized weights of the main criteria

| Main criteria | Global weight | Percentage (%) | Rank |
|---|---|---|---|
| Port | 0.139 | 13.9% | 2nd |
| Ships | 0.099 | 9.9% | 3rd |
| Cargo owners | 0.082 | 8.2% | 4th |
| Miscellaneous | 0.680 | 68.0% | 1st |

Despite of that, the global normalized weight values of the sub-criteria need to be finalised by multiplying the local normalized weights of main criteria and the local normalised weight of sub-criteria of each respective group. The example of the calculation is shown as follows:

Global normalized weight of sub-criteria 'Efficiency of L/U Equipment'
= *local normalised weights of main criterion 'Port'* x *local normalised weight of sub-criterion 'Efficiency of L/U Equipment'*
$= 0.139 \times 0.255$
= **0.035**

Similar calculation was done to all the sub-criteria and the weight values of the sub-criteria are summarized as in Table 11.

**Table 11**

Global normalized weights of the sub-criteria

| Main criteria | Sub-criteria | Global weight | Percentage (%) | Rank |
|---|---|---|---|---|
| Port | Deficiency of loading and unloading (L/U) equipment | 0.035 | 3.5% | 8 |
| | Problems with customs and formalities | 0.041 | 4.1% | 6 |
| | Improper storage or yard spaces for cargo allocation | 0.024 | 2.4% | 12 |
| | Labour issue | 0.038 | 3.8% | 7 |
| Ships | Deficiency of ship's equipment | 0.049 | 4.9% | 4 |
| | Late ship arrival at a port | 0.049 | 4.9% | 4 |
| Cargo owners | Administrative and financial issue | 0.033 | 3.3% | 9 |
| | Unpreparedness of cargo owners | 0.026 | 2.6% | 11 |
| | Shortage of trucks | 0.029 | 2.9% | 10 |
| Miscellaneous | Foul weather and tide prediction | 0.262 | 26.2% | 1 |
| | Incompetence of transport equipment | 0.182 | 18.2% | 3 |
| | Safety issue | 0.237 | 23.7% | 2 |

## 4. Finding and Discussion

The results of the study are summarized as in Tables 10 and 11. Based on the both tables, the weight values were also presented in form of percentage values in order to give a clear indication of the weight differences. Based on the results in Table 10, the main criterion of 'Miscellaneous' was determined to be the most significant factor that contributed to the delays of dry bulk cargo operation in a case study conducted at Kemaman port, Malaysia, with the percentage weight of 68.0%. The dominant influence of the 'Miscellaneous' factor was followed by the factors of 'Port' with 13.9%, 'Ship' with 9.9%, and the 'Cargo Owner' with 8.2%, which took the last place.

The percentage weight values of sub-criteria calculated, on the other hand, were shown as in Table 11. According to the results in Table 11, the sub-criterion of 'Foul weather and tide prediction' was ranked to be the most significant sub-criterion that contributed to the most delay creation in dry bulk cargo operation at the Kemaman port among other sub-criteria involved with the percentage weight of 26.2%. The leading position of the sub-criterion was then followed by the sub-criteria of 'Safety issue (23.7%)', 'Incompetence of transport equipment (18.2%)', 'Deficiency of ship's equipment (4.9%)', 'Late ship arrivals at port (4.9%)', and 'Problems with customs and formalities (4.1%)', 'Labour Issue (3.8%)', 'Deficiency of L/U Equipment (3.5%)', 'Administrative and Financial Issue (3.3%)', 'Shortage of trucks (2.9%)', 'Unpreparedness of cargo owners (2.6%)', and 'Improper storage or yard spaces for cargo allocation (2.4%)', respectively, according to their percentage weights.

The main criterion of 'Miscellaneous' was ranked as the most significant factor that contributed to the delays of dry bulk cargo operation in this study because most of the events that cause the delays in dry bulk cargo operation at the Kemaman port were not significantly contributed by the factors of 'Port', 'Ships' or 'Cargo owners'. According to the experts involved in this study, most of the events that cause the delays were happened unpredictably in which it forces the operation of dry bulk cargo at that port to be delayed accordingly to ensure the protection of safety and cargo value aspects.

On the other hand, the selection of the sub-criterion 'Foul weather and tide prediction' as the most significant sub-criterion that contributed to the delay creations in dry bulk cargo operation at the Kemaman port can be because of the influence of climate conditions at the region which can create severe effect on the overall flow of dry bulk cargo operation. Although standard measures have been taken out by using all available weather forecast information, however, the information that supplied only consist of the forecasted data. As it is a forecasted data, then the information can be true and also, can be untrue in all round. Hence, if the weather and tide prediction is fault, then the planned operation of the dry bulk operation is definitely affected and delayed until an appropriate weather or tide window is re-determined. This is because the nature of dry bulk itself which some of them need to stay dry in the whole transfer operation. If moisture is found in the cargo or the cargo holds, then it may contaminate the cargo or even probably damage it. If this happened, it will cause the owner of the cargo to face a huge loss as the cargo value could drop significantly.

Apart from the weather and tide conditions, the 'Safety issue', 'Incompetence of transport equipment', and 'Deficiency of ship's equipment' were also ranked as the top significant sub-criteria in creating delays of dry bulk cargo operation at the Kemaman port. According to the experts, safety issue mostly arises when loading and unloading process of the cargo take place. This because some of the dry bulk cargoes can be hazardous or very sensitive materials. Hence, a strict measure and appraisal to the changes of conditions of the ship and the port environment need to be applied. If there is any unfavourable condition is detected either to the ship, cargo or even the handling equipment, then the operation should be stopped immediately for a thorough safety evaluation. Meanwhile, in case of 'Incompetence of transport equipment', this situation is likely happened when it involved external contractors to deliver or receive the cargoes on behalf the cargo owners. The competency of transport equipment supplied by cargo owner to deliver or receive the cargo basically is out of cargo owner's control. If the cargo is handled by the incompetence of transport equipment, then it may cause some risks to be existed during the transport process which include risks of time unpunctuality and recklessness of cargo handling. Such risks definitely will delay the cargo handling operation at the port especially when the condition of the cargo is affected during the delivery to the port. On the other hand, the deficiency of ship's equipment also can be one of the situations where commonly happen during the loading and unloading operation although its contribution on delay creation is not very significant as compared to the top three contributing sub-criteria. Some of the deficiency of ship's equipment can be included the malfunctions of ballast operation pump, hydraulic hold covers system, and ship's crane system, to name a few. So, these deficiencies somehow may take some of the times before it is recovered or backed up.

Nevertheless, the presence of the delay factors in dry bulk cargo operation at some ports may be varied as it could be influenced by various forms of factors and conditions. Despite of that, the approach and findings of this study did give the port operator a fruitful insight regarding delay factors in their cargo operation activities. Also, this might help the port to prepare an effective alternative or action plan to recover or avoid the delay creation in the dry bulk cargo operation in future which could affect the port productivity. Apart from that, the factors and sub-factors examined in this study may be useful if taken into consideration for conducting any similar or relevant study of other cargo ports, especially the ports that handled dry bulk cargoes. It is due to the similarity of the natures of the business engaged and the cargo type handled.

## 5. Conclusion

In conclusion, this study has been successfully conducted to achieve its objective. The main factors and sub-factors have been analysed and ranked accordingly from the most significant/influential to the least significant/influential. This paper also has highlighted the delays factors that affect the dry bulk cargo operation in one of the Malaysian ports, in which may potentially trigger the port and cargo stakeholders' attentions.

The findings of this study may help to strengthen the shipping and port system through a scientific analysis approach. It contributes an insight to reduce the burden of extra costs of the shippers and shipping companies, as well as maximize the profit of the port in which by taking proper action on the most contributing factors/causes without neglecting the associate factors/causes. This study is relevant to be conducted extendedly to assess the operation of other dry bulk cargo ports in Malaysia to improve their efficiency and productivity. Not only this study may benefit the port stakeholders, it also contributes positive impact to port as port can enhance the economies of scale of its operation. Nevertheless, it should be noted that each port may have different kinds of influential factors that affect their operation although they are in similar business or handle similar type of cargoes. It may be because of the environment of the ports with respect to the geographical port location, types of port equipment, the level of port infrastructure, as for examples, which may not directly link to the delay creation of dry bulk cargo operation. Therefore, this study is relevant to be further conducted in future as it has valuable contribution to the port and shipping industry.

From the theoretical perspective, this study contributes the practical technique and valuable findings to the port and its stakeholders, where it may alert the port and its stakeholders, to measure the factors that affect their operational performance and business. If the main contributors to the problematic conditions are well-recognized through the comprehensive analysis, it will allow the port to have better insight on the situation. Hence, port can prepare the potential solutions to control or eliminate the influence of the contributors.

Meanwhile, from the managerial perspective, this study contributes to introduce the usage of practical and systematical analysis technique for assisting the seaport operator or interested parties in analyzing the potential contributors of a condition in the port operation. In general, the technique can be used to examine any relevant situations, not just the problematic ones, that involving a multiple or variety of criteria. It can be useful for the port to evaluate any relevant conditions in port operations in such way by recognizing the main contributor of the respective condition. This technique is also useful to assist the port decision-makers in their decision-making process. It may ensure the decisions that they made are workable and effective to improve the system or recover the situation.

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## Appendix

**Table 1**

Summary of the outcomes and methodological approaches applied to evaluate the delay factors in the existing studies

| Citations | Objective of study | Area of study | Methods applied | Main outcomes of the study |
|---|---|---|---|---|
| Jafari (2013a) | Detection and prioritization of causes of delay in dry bulk cargo loading/unloading operation at the dry bulk terminal. | Dry bulk terminal of Latakia port, Syria | PROMETHEE method | Document incompleteness was ranked as the most significant factor causing the delays in dry bulk cargo operation. |
| Saeidi et al., (2013) | Identification and prioritization of the inveterate causes of delay creation in general cargo loading/unloading operation. | Port of Amirabad, Northern Iran | FMEA model | Deficiency and malfunction of quay vertical transportation equipment was ranked as the most significant factor causing the delays in general cargo operation. |
| Jafari (2013b) | Identification and prioritization of causes of halt and lag in container handling operation. | Mina Salman container terminal, Bahrain | FMEA model + SIPOC model + Pareto analysis + Cause and effect diagram | Deficiency and malfunction of quay horizontal transportation equipment was ranked as the most significant factor causing the delays in container handling operation at the port terminal. |
| Jafari et al., (2013) | Analysis on the delay in container handling operation and container port competitiveness. | Khorramshahr container terminal, Iran | Hybrid ANP and TOPSIS grey method | Lack of adequate and specialized equipment was ranked as the most significant factor causing the delays in container handling operation at the port terminal. |
| Sayareh and Ahouei (2013) | Improving the efficiency and productivity a marine bulk terminal by reducing the delays of cargo handling operations and smoothing their loading/unloading activities. | Dry bulk terminal of port of Imam Khomeini (BIK), Iran | Failure Mode and Effect Analysis (FMEA) + Cause and Effect Diagram + Pareto Analysis | Unfitness of port was found to be the most significant factor to cause delays of cargo handling operation at the port. Meanwhile, quarantine and formalities were found to be main sub-cause of creating the delays. |
| Yousefi et al., (2018) | Identification and prioritization of the inveterate causes of delay creation in container handling operation. | Beirut container terminal, Lebanese Container Port | FMEA model + SIPOC model + Pareto analysis + Cause and effect diagram | Technical malfunction and deficiency of vertical quay transportation equipment was ranked as the most significant factor causing the delays in container handling operation at the port terminal. |