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Impact of Different Factors Affecting a Facility Location Decision in Ship Supply Services Industry

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1. Introduction

It is well-known that the maintenance of an efficient supply chain of vessel spare-parts is vital to the operational activities carried out by a shipping company [1]. The demand for ship spares can arise at any time and can typically be erratic in nature[2].

Since the accuracy of demand forecasts for vessel spares is questionable, inventories must exist to mitigate the irregularities which occur in the supply chain due to differences between capacity and demand, quality issues, and lead time constraints. This is the major contributing factor to a Facility Location Decision (FLD) in Ship Maintenance Supply Chain (SMSC); mainly to proceed in a systematic manner.

Inability to provide a required spare part at the right time increases the idle time of the ship resulting in a considerable loss of revenue [3]. Thus, the importance of locating a Distribution Centre (DC) in a suitable locality for the smooth provision of supplies, enabling suppliers to minimise the logistics cost incurred in the outbound supply chain, draws the immense attention of the stakeholders involved in the process. This concept was applied to the local shipping industry during the study, which was carried out in the perspective of the shipping agents concerning the 'in-transit' operation of vessel spare parts delivery in Sri Lanka.

Even though the concept of facility location applicable to many industries and has been widely studied by researchers for many years, the shipping industry remains unfocused. Hence this study aims to develop a model considering the factors specifically related to the Ship Maintenance Supply Chain enabling its direct usage for industrial practices.

2. Methodology

The gap identified within the available literature was the basis of the research problem identified. The objectives of the research can be stated as follows.

- Objective 1: To determine major factors affecting a FLD related with Ship Maintenance Supply Chain (SMSC).
- Objective 2: To analyse various factors, evaluating location site alternatives to find the most suitable DC location in Sri Lanka.
- Objective 3: To develop a DC Location decision model for SMSC in Sri Lankan context.

Achieving objective 01: The literature survey was the basis for the accomplishment of objective 01 where common factors affecting a facility location decision in any industry were identified. The next phase was the identification of factors affecting a FLD in SMSC through semi-structured interviews.

Objective 02 and 03: To reduce the complexity of the process, the next two objectives were combined. The output gained from objective 01 was the main input for this phase.

3. Results

AHP was mainly used to prioritise the factors identified during the interviews carried out with industry professionals. This method allows to derive ratio scales from paired comparisons.

Equation 1: Consistency Index

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Equation 2: Consistency Ratio

$$CR = \frac{CI}{RI}$$

CI = Consistency Index: Measures the deviation of inconsistency

λ_max = ∑ [Total of the Factor Column *Weighted Score (normalized value)]

n = Number of identified factors

RI = Random Consistency Index: a constant value for the number of factors

CR = Consistency Ratio

Prior to the factor rating technique, indices were developed for each factor with respect to the proposed locations site alternatives. Factor rating was used to evaluate the two alternatives. To find the impact of changes in each variable on the outcome a Sensitivity Analysis was carried out.

The five main factors which were used in the process;

- Demand for spares: F1
- Time constraints - Lead Time: F2
- Close proximity to international trade routes: F3
- Port clearance charges - cost components: F4
- Available facilities in each port for spare handling/storage: F5

Data gathered through the survey questionnaire were converted to an AHP applicable scale. Then a reciprocal matrix was designed to retrieve the normalized value.

$\boldsymbol{\lambda\_max}$ was calculated using the sum of each column and the normalised priority vectors.

$$\lambda\_max = 5.349$$

$$CI = (5.3498 - 5)/(5 - 1)$$

$$CI = 0.0875$$

$$CR = 0.0875/1.12 = 0.0781$$

As the CR value, is less than 0.1 it can be concluded that the subjective evaluation about preference is consistent.

3.1. Index Development

The derived two location site alternatives from the first phase was denoted as follows;

- **Port of Colombo = CMB**
- **Port of Galle = GLL**

Indexes for each alternative were developed using the secondary data gathered at the beginning of the study. CMBi and GLLj denote indexes for each site.

3.2. Factor Rating

This technique was used to find the best location to place the vessel spare parts distribution centre in Sri Lanka. CMBvi and GLLvj represent the multiplication of index values and AHP weightages.

If 1.323533 = C and 0.934217 = G, according to the final values;

$$\mathbf{C > G}$$

Closer proximity of the Port of Colombo is the best location to place the proposed DC.

Table 1: Factor Rating

Factors	AHP Weightages	CMBi	GLLj	CMBvi	GLLvj
F1 Demand for spares	38%	0.94	0.06	0.3572	0.0228
F2 Lead Time	21%	0.77	0.63	0.1617	0.1323
F3 Proximity to trade routes	16%	0.33	0.67	0.05333	0.106667
F4 Port Fees	12%	-0.51	-0.49	-0.0612	-0.0588
F5 Port Facilities	13%	6.25	5.625	0.8125	0.73125
			Final Value	1.323533	0.934217

3.3. Sensitivity Analysis

In the sensitivity analysis each factor was omitted randomly at a given time to assess its impact on the result.

Comparatively the logistics centric nature supports CMB in a higher degree. It is visible that a considerable variation in Demand may impact the final output.

Two competitive advantages of each location alternative can be stated as the higher level of demand for spares (CMB) and the benefits gained due to the strategic location (GLL) respectively.

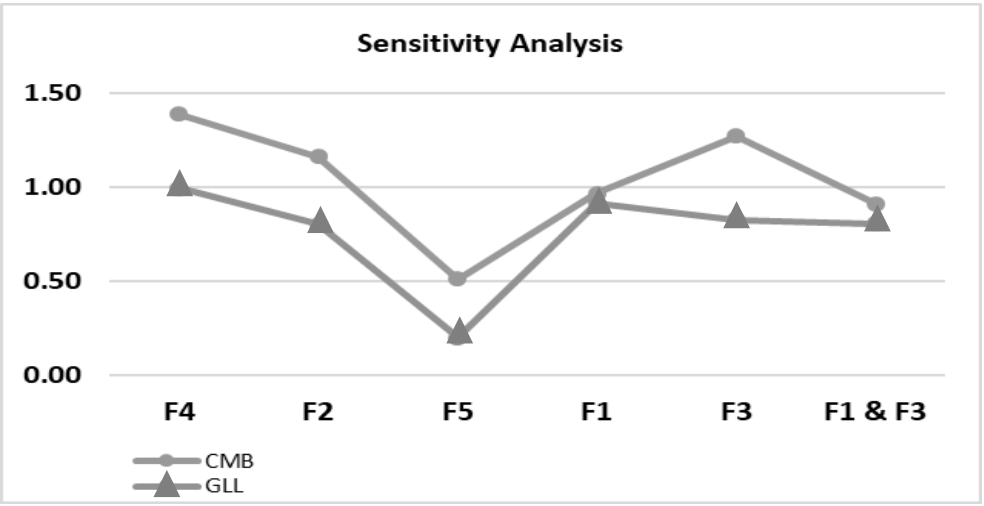

Figure 1: Comparison between competitive advantages

3.4. The Proposed Model for a FLD in SMSC

$$The\ most\ suitable\ location = j * WF1 + k * WF2 + l * WF3 + p * WF4 + q * WF5 + \ldots\ldots + \emptyset * WFn$$

j , k , l , p , q , ……. , ø = The Indices developed for each proposed location alternative

W_F1 , W_F2 , W_F3 , W_F4 , W_F5 ,… , W_Fn = Assigned weightages for each identified factor according to the priority level

4. Conclusion/Recommendation

According to the literature available and the findings of this study it is visible that demand for a product/service plays a key role in the facility location decision making process. It was concluded that in Sri Lankan context a ship spares DC was best located in closer proximity to Port of Colombo. Together with this, the final objective of the research was achieved. The proposed FLD model for SMSC contains different factors affecting such a strategic level decision.

This model can be applied to any geographical context. Factors can be varied according to the perception of professionals and the method used to collect data. Once the location site alternatives were identified and the indexes were developed the best location to place the desired storing facility in the supply chain can be obtained.

The flexibility of the proposed model to dynamic factors in the shipping industry is a major advantage as it can be applied to any geographical locality without an effort to change the core of the equation.

References

[1] W. Wang and A. A. Syntetos, “Spare parts demand: Linking forecasting to equipment maintenance,” Transp. Res. Part E Logist. Transp. Rev., vol. 47, no. 6, pp. 1194-1209, 2011.

[2] C. Jiang and M. Kong, “Research on the 6 torage 6 cheme of Spare Parts for Long Voyage Vessel,” no. 91872, pp. 1173-1178, 2011.

[3] J. Ben Hmida, G. Regan, and J. Lee, “Inventory Management and Maintenance in Offshore Vessel Industry,” vol. 2013, 2013.

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