Categorizing Suppliers in an Indonesian Shipping Company Using Kraljic's Portfolio Model

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Abstract

The goal of the study is to categorize the goods and services requested from a ship in an Indonesian shipping company into four quadrants using Kraljic Portfolio Model. Currently, the company groups the goods and services (commodities) based on its critical nature and functionality. However, current grouping does not signify the purchasing strategy when the company wants to acquire each commodity. In this study, the commodity scores for their supply risk and potential profit impact are determined using Fuzzy multi-attributes. Three procurement experts in the company are involved in scoring the supply risk and profit impact attributes and a total of seven respondents score a list of group commodities, and the results are used to find out the performance scores with respect to supply risk and profit impact dimensions. The group commodities are then placed in the Kraljic's Portfolio Model with multidimensional scaling. The results reveal that crane parts, generator parts and rigging, mooring, and lifting equipment are strategic items, item bunker fuel oil and lube oil is leverage items, valves, pump parts, etc. are bottleneck items, and non-critical items are stationary, and food provision. The categorizing will help the company to make a proper type of relationship with the supplier so the procurement process can be more reliable.

Keywords
Procurement, Purchasing Strategy, Kraljic Portfolio Model

1. Introduction

An Indonesian Shipping Company procures a huge number and assorted variety of products and services for their ships to meet their operational obligations. Procurement activities pose risks for the company as they involve company resources (time and money). Therefore, purchasing strategies have a big influence on the organization's overall performance.

Kraljic in 1983 introduced a portfolio to help firms in deciding their supply strategy which depends on profit impact and supply risk (Kraljic 1983). The portfolio proposes four categories of items: strategic, leverage, bottleneck, and non-critical items. Each of the categories needs a different approach to the suppliers.

Kraljic recognizes purchasing as an essential issue in management and it clearly differentiates among various purchasing situations and gives sensible suggestions as to how to act (Dubois and Pedersen 2002). Kraljic's portfolio model (KPM) becomes the dominant approach (Croom 1998). Many organizations from different sectors use Kraljic's matrix as their foundation for the purchasing strategy (Lamming and Harrison 2001).

The goal of this study is to determine supplier segmentation for the company using the KPM by employing a fuzzy multi-attribute decision-making approach. The supply risk and profit impact dimensions, and the classification in the KPM are determined using a multidimensional continuous scale (MDS) of -1 to +1. The segmentation will make the procurement process become more reliable. This study is expected to provide recommendations on the most suitable supply strategy for each item, and hence help the company to improve its overall performance.

The remainder of the paper is structured as follows. Section 2 explains the relevant literature review, while Section 3 discusses the methodology, Section 4 presents findings and discussions, and Section 5 explains the conclusions of the research.

2. Literature Review

2.1. Supplier Categorization / Segmentation

Segmentation can be based on four-different supplier segmentation systems depending on the time frame (i.e., short-term versus long-term) and the content (i.e., logistic versus strategic) of the co-operative customer/supplier relationships (Masella and Rangone 2000). Also, supplier categorization can be conducted based on the three principal components: category of disturbance, type of logistics flow, and a source of disturbance (Svensson 2000). Specifically, the type of logistics flow considers the complexity, inventory buffers, materials, and components, and may be used in supplier segmentation. It identifies three levels of logistics flows, namely an A-flow, a B-flow, and a C-flow. Strategic supplier typology, on the other hand, explains the differences in the composition and performance of various types of suppliers (Kaufman et al. 2000). Two dimensions are used, namely technology and collaboration. By dividing these two dimensions into high and low categories, four supplier categories are identified: (1) commodity supplier; (2) collaboration specialists; (3) technology specialists; (4) problem-solving supplier. Lastly, the classification dimension can also use the power dependence between buyer and supplier to differentiate between different types of relationships (or exchanges) (Bensaou 1999).

2.2. Kralljic Portfolio Model

Kraljic portfolio is deemed as a breakthrough in the development of purchasing and supply management (Gelderman and Weele 2003). Markowitz in 1952 was the first person who initially developed the concept of the portfolio model as an instrument for managing equity investments (see Figure 1) (Kraljic 1983).

Four stages of item classification in Kraljic Portfolio (Caniëls and Gelderman 2005). Stage one, classifying purchased product for its profit impact and supply risk. After that, weighting of its suppliers against its own power in terms of bargaining power. Then, positioning the products that are identified in stage one as strategic (high-profit impact and high supply risk) in a portfolio matrix. The last stage, developing purchasing strategies and action plans for the strategic products, considering its own strength and the strength of the supply market. Purchasing strategies that are recommended in Kraljic are exploit (in case of buyer dominance), balance (in case of balanced relationship), and diversify (in case of supplier dominance) (Caniëls and Gelderman 2005).

Importance of purchasing	**Low**	**Complexity of supply market**	**High**
High	Leverage items: Materials management		Strategic items: Supply management
Low	Non-critical items: Purchasing management		Bottleneck items: Sourcing management

Figure 1. The kraljic purchasing portfolio (Dubois and Pedersen 2002).

3. Methodology

In order to assess each commodity group in KPM, experts are needed to fill up two questionnaires. The attributes are rated by the experts for its contribution to a particular dimension. Since the imprecise nature of attributes makes inadequate measure to precisely determine their importance, hence the triangular fuzzy number (TFN) is used (Padhi et al. 2011). Multiple experts were asked for opinions to eliminate subjectivity, creating dimension and attributes which has objective evaluation. A two by two matrix is the result of the usage of only ‘low’ and ‘high’ levels for commodities arrangement in the KPM which resulting the loses of finer distinction among the group commodities in each cluster. The continuous scale of -1 to +1 in MDS provides a mapping of group commodities which leads to a user-driven number of quadrants (Padhi et al. 2011). The fuzzy multi-criteria decision-making was used to measure the priority weights of the dimensions and attributes of the commodities. Several studies [15–19] are using the same approach to define the priority weights.

Top 20 of group commodities which are mostly requested by vessel in the shipping company are selected for this research, ranging from machinery parts, food provision, toiletries etc. Two questionnaires are required to obtain the data for supply risk and profit impact attributes. The first questionnaire is used to determine the importance level of each supply risk and profit impact attribute, while the second questionnaire addresses the identification of a list of group material and was used for finding out the performance scores with respect to supply risk and profit impact dimensions.

4. Findings and Discussions

4.1. Positioning Group Commodities Along the Two Dimensions of the KPM

The group commodities are placed along the two dimensions of the KPM by consolidating the fuzzy multi-attribute utility scoring and MDS techniques. Below are the steps (Padhi et al. 2011):

First step: Compose a linguistic scale. Table 1 provides the 10-point linguistic scale.
Second step: Collect scores of domain-experts on the attributes using the first questionnaire and convert them into fuzzy numbers from Table 1.

The first questionnaire addresses questions about how vital supply risk and profit impact attributes while buying works or services for the company. Three experts scored the first questionnaire ranging from '1: None' to '10: Extremely high

Table 1. Linguistic scale point and their triangular fuzzy numbers.

Linguistic scale Point	Triangular fuzzy Number
None	(1,1,2)
Extremely low	(1,2,3)
Very low	(2,3,4)
Low	(3,4,5)
Medium low	(4,5,6)
Medium	(5,6,7)
Medium high	(6,7,8)
High	(7,8,9)
Very high	(8,9,10)
Extremely high	(9,10,10)

Third step: Find out the average of importance score (see Table 2).

$$\overline{\theta_m} = \frac{\sum_{e=1}^{E} \widetilde{\theta_{em}}}{E}, \forall m = 1,2,\dots,M \quad (1)$$

where e = 1, 2, … , E (index for the expert, here E = 3) and m is the, m = 1, 2, 3, …, M (index for the purchasing portfolio attribute, here M = 3 for supply risk and profit impact attributes). AG_{SR}, and AG_{PI} shown average preference score vector for supply risk and profit impact attributes respectively:

$$AG_{SR} = [(4.3, 5.3, 6.3)\ (6.7, 7.7, 8.7)\ (5.7, 6.7, 7.7)\ ] \text{ and } AG_{P} = [(5.7, 6.7, 7.7)\ (7.7, 8.7, 9.7)\ (4.3, 5.4, 6.3)\ ]$$

Table 2. Importance rating of attributes for supply risk and profit impact.

Attribute	Expert 1	Expert 2	Expert 3	Average score ($\overline{\theta_m}$)
Supply risk				
Market risk	(4,5,6)	(5,6,7)	(4,5,6)	(4.3, 5.3, 6.3)
Performance risk	(7,8,9)	(7,8,9)	(6,7,8)	(6.7, 7.7, 8.7)
Complexity risk	(6,7,8)	(6,7,8)	(5,6,7)	(5.7, 6.7, 7.7)
Profit impact				
Impact on profitability	(6,7,8)	(5,6,7)	(6,7,8)	(5.7, 6.7, 7.7)
Criticality of purchase	(7,8,9)	(8,9,10)	(8,9,10)	(7.7, 8.7, 9.7)
Value/cost of purchase	(5,6,6)	(5,6,7)	(4,5,6)	(4.3, 5.4, 6.3)

Based on the discussion with the procurement experts, they (subjectively) prioritize the profit impact attribute more than supply risk, weighing at least 0.6 for profit impact and 0.4 for supply risk. Global average is calculated using this weighting.

Fourth step: Importance scores for the attributes of supply risk and profit impact are normalized, and can be obtained with following Steps:
Step 4a: Fuzzy judgment matrix *AG'* to be constructed in order to get average importance scores (pair-wise comparison):

$$AG' = \left[(1,1,1)\ \tilde{\lambda}_{12}\ \tilde{\lambda}_{1M}\ \tilde{\lambda}_{21}\ (1,1,1)\ \tilde{\lambda}_{2M}\ \tilde{\lambda}_{M1}\ \tilde{\lambda}_{M2}\ (1,1,1)\right]$$

The formula for fuzzy weight vectors:

$$\tilde{\lambda}_{11} = \frac{\tilde{\theta}_1}{\tilde{\theta}_1},\ \tilde{\lambda}_{12} = \frac{\tilde{\theta}_1}{\tilde{\theta}_2},\ \ldots,\ \tilde{\lambda}_{(M-1)M} = \frac{\tilde{\theta}_{M-1}}{\tilde{\theta}_M},\ \tilde{\lambda}_{MM} = \frac{\tilde{\theta}_M}{\tilde{\theta}_M} \quad (2)$$

Step 4a: Calculate the fuzzy attribute weights ($\tilde{\beta}_m$) from the elements of *AG'* (Deng, 1999).

$$\tilde{\beta}_m = \frac{\sum_u^M \ =1 \lambda_{mu}}{\sum_u^M \ =1 \sum_u^M \ =1 \lambda_{mu}} \quad (3)$$

Step 4c: Fuzzy attribute weights are then defuzzified using the simple and popular centroid method (Chou and Chand, 2008) in Equation (4) for all $m = 1, 2, \ldots, M$. Then, determine and calculate NW_m, the normalized weight of the m^{th} attribute, by dividing the priority weight of the m^{th} attribute by the sum of the priority weights (Equation 5).

$$df_{\tilde{M}} = \frac{a+b+c}{3} \quad (4)$$

$$NW_m = \frac{\beta_m}{\sum_{e=1}^E \ \beta_m} \quad (5)$$

As per steps 4a, 4b, and 4c; supply risk and profit impact importance scores of the attributes that already normalized can be shown in Table 3.

Fifth step: Scores for the supply risk and profit impact attributes for 20 group commodities are obtained by asking 7 experts in the company to complete the second questionnaire. The experts individually rate each group of commodities. Work or service performance can be viewed as its utility score and is obtained by multiplying the normalized weight (NW_m) for every attribute with the average achievement score of all experts, and summing it up over all the attributes for each group of commodities as in Equation (6).

Table 3. Normalized priority weights of supply risk and profit impact attributes.

Supply risk		Profit impact

Attribute	Normalized priority weights		Attribute	Normalized priority weights
Market risk	0.271		Impact on profitability	0.323
Performance risk	0.390		Criticality of purchase	0.419
Complexity risk	0.339		Cost/value of purchase	0.258

$$\tilde{s}_j = \sum_{m=1}^{M} \left[NW_m \frac{1}{E} \sum_{e=1}^{E} \tilde{x}_{jme} \right] \forall j = 1,2, \ldots . \text{J} \quad (6)$$

where $\tilde{s}_j$ is the fuzzy utility score of the linguistic attribute of the j^{th} group commodities, j = 1, 2, ..., J, $\tilde{x}_{jme}$ is the fuzzy achievement score given by the e^{th} expert for the j^{th} group commodities in the m^{th} attribute, $\tilde{s}_j$ is the utility score of the j^{th} group commodities, j = 1, 2, ..., J, calculated by fuzzifying the $\tilde{s}_j$ using Equation (6). Table 4 summarizes the average performance scores of the 20 group commodities for each supply risk and profit impact attribute, as well as the weighted and global average for each dimension.

Sixth step: The group commodities is then positioned using multidimensional scaling. Trough the MDS, the pattern of point and dimensionality are known with the axes are for supply risk and profit impact. The formula to get euclidean distance function for *n*-dimensions as follows:

$$d_{jk} = \sqrt{\sum_{i=1}^{n} (s_{ij} - s_{ik}{}^2} \quad (7)$$

Table 4. Respondents' performance scores for two the KPM dimensions.

Group commodities		Supply Risk						Profit Impact				
		Market risk	Performance risk	Complexity risk	Weighted Average	Global Average		Impact on Profitability	Criticality of Purchase	Value / Cost of Purchase	Weighted Average	Global Average
S1	Crane Parts	8.619	9.238	9.143	9.038	3.615		9.095	9.238	8.667	9.045	5.427
S2	Generator Parts	8.762	9.238	9.286	9.125	3.650		8.810	9.190	8.429	8.871	5.323
S3	Rigging, Mooring & Lifting Equipment	7.000	8.619	6.286	7.389	2.956		8.286	8.714	8.524	8.527	5.116
S4	Bunker Fuel Oil	8.000	8.714	8.000	8.278	3.311		4.190	5.048	2.714	4.169	2.501
S5	Lube oil & grease	7.857	8.286	8.000	8.073	3.229		3.571	4.571	2.429	3.696	2.218
S6	Valve	4.857	5.190	3.571	4.551	1.821		6.571	7.714	7.286	7.235	4.341
S7	Pump Parts	3.857	3.714	3.571	3.705	1.482		7.143	8.143	6.857	7.488	4.493
S8	LSA & FFA	4.571	4.857	5.429	4.973	1.989		6.429	7.571	7.143	7.092	4.255
S9	Safety PPE	4.571	5.000	3.143	4.254	1.702		6.571	7.571	7.286	7.175	4.305
S10	Piping	3.571	4.000	4.143	3.932	1.573		6.429	7.857	6.857	7.138	4.283
S11	Bunker FW	4.429	5.143	3.429	4.368	1.747		6.714	7.714	7.286	7.281	4.369
S12	Food Provision	4.286	4.857	3.429	4.218	1.687		6.714	7.571	7.571	7.295	4.377
S13	Welding Tools	3.714	4.714	5.000	4.540	1.816		6.571	6.857	7.286	6.876	4.125
S14	Electrical Store	4.143	4.857	3.429	4.179	1.672		6.714	7.429	7.429	7.198	4.319
S15	Paint	3.714	4.000	3.714	3.826	1.530		7.143	8.143	6.857	7.488	4.493
S16	Galley Equipment	4.286	3.571	3.857	3.862	1.545		8.000	6.714	8.000	7.461	4.476
S17	Hand Tools	3.714	3.714	3.857	3.763	1.505		6.857	6.714	7.429	6.945	4.167
S18	Carpenter Store	3.857	3.857	3.429	3.712	1.485		7.143	8.143	6.857	7.488	4.493
S19	Household & Toiletries Item	3.286	4.286	3.429	3.724	1.490		3.286	3.571	3.857	3.553	2.132
S20	Office Stationery	3.143	4.571	3.000	3.651	1.461		3.143	2.714	3.429	3.037	1.822

where sij and sik express the utility score of group commodities j and k, respectively, in it's dimension, for all i = 1, 2, … , n. in this case n = 2 (supply risk and profit impact). Input data from Table 5 to MDS (using software SPSS 22). Figure 2 shows the positioning of the group commodities in the two-dimensional coordinate and for the coordinate values shown in Table 6. These depict a -1 to +1 scale on the two dimensions of the KPM framework.

Table 5. The euclidean distance matrix of the 20 group commodities.

	Group Commodities	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20

S1	Crane Parts	0.00	0.11	0.73	2.94	3.23	2.10	2.33	2.00	2.22	2.34	2.15	2.20	2.22	2.24	2.28	2.28	2.46	2.33	3.92	4.20
S2	Generator Parts	0.11	0.00	0.72	2.84	3.13	2.08	2.32	1.97	2.20	2.32	2.13	2.18	2.19	2.22	2.28	2.27	2.44	2.32	3.85	4.13
S3	Rigging, Mooring & Lifting Equipment	0.73	0.72	0.00	2.64	2.91	1.37	1.60	1.29	1.49	1.61	1.42	1.47	1.51	1.51	1.56	1.55	1.73	1.60	3.32	3.62
S4	Bunker Fuel Oil	2.94	2.84	2.64	0.00	0.30	2.37	2.70	2.20	2.42	2.49	2.44	2.48	2.21	2.45	2.67	2.65	2.46	2.70	1.86	1.97
S5	Lube Oil & Grease	3.23	3.13	2.91	0.30	0.00	2.55	2.87	2.39	2.59	2.65	2.61	2.65	2.37	2.62	2.84	2.82	2.60	2.87	1.74	1.81
S6	Valve	2.10	2.08	1.37	2.73	2.55	0.00	0.37	0.19	0.12	0.25	0.08	0.14	0.22	0.15	0.33	0.31	0.36	0.37	2.23	2.54
S7	Pump Parts	2.33	2.32	1.60	2.70	2.87	0.37	0.00	0.56	0.29	0.23	0.29	0.24	0.50	0.26	0.05	0.07	0.33	0.00	2.36	2.67
S8	LSA &FFA	2.00	1.97	1.29	2.20	2.39	0.19	0.56	0.00	0.29	0.42	0.27	0.33	0.22	0.32	0.52	0.50	0.49	0.56	2.10	2.49
S9	Safety PPE	2.22	2.20	1.49	2.42	2.59	0.12	0.29	0.29	0.00	0.13	0.08	0.07	0.21	0.03	0.25	0.23	0.24	0.29	2.18	2.49
S10	Piping	2.34	2.32	1.61	2.49	2.65	0.25	0.23	0.42	0.13	0.00	0.19	0.15	0.29	0.11	0.21	0.20	0.13	0.23	2.15	2.46
S11	Bunker FW	2.15	2.13	1.42	2.44	2.61	0.08	0.29	0.27	0.08	0.19	0.00	0.06	0.25	0.09	0.25	0.23	0.32	0.29	2.25	2.56
S12	Food Provision	2.20	2.18	1.47	2.48	2.65	0.14	0.24	0.33	0.07	0.15	0.06	0.00	0.28	0.06	0.20	0.17	0.28	0.23	2.25	2.56
S13	Welding Tools	2.22	2.19	1.51	2.21	2.37	0.22	0.50	0.22	0.21	0.29	0.25	0.28	0.00	0.24	0.47	0.44	0.31	0.49	2.02	2.33
S14	Electrical Store	2.24	2.22	1.51	2.45	2.62	0.15	0.26	0.32	0.03	0.11	0.09	0.06	0.24	0.00	0.22	0.20	0.23	026	219	2.51
S15	Paint	2.28	2.28	1.56	2.67	2.84	0.33	0.05	0.52	0.25	0.21	0.25	0.20	0.47	0.22	0.00	0.02	0.33	0.05	2.46	2.67
S16	Gallery Equipment	2.28	2.27	1.55	2.65	2.82	0.31	0.07	0.50	0.23	0.20	0.23	0.17	0.44	0.20	0.02	0.00	0.31	0.06	2.35	2.66
S17	Hand Tools	2.46	2.44	1.73	2.46	2.60	0.36	0.33	0.49	0.24	0.13	0.32	0.28	0.31	0.23	0.33	0.31	0.00	0.33	2.04	2.35
S18	Carpenter Store	2.33	2.32	1.60	2.70	2.87	0.37	0.00	0.56	0.29	0.23	0.29	0.23	0.49	0.26	0.05	0.06	0.33	0.00	2.36	2.67
S19	Household & Toiletries Item	3.92	3.85	3.32	1.86	1.74	2.23	2.36	2.18	2.18	2.15	2.25	2.25	2.02	2.19	2.36	2.35	2.04	2.36	0.00	0.31
S20	Office Stationery	4.20	4.13	3.62	1.97	1.81	2.54	2.67	2.49	2.49	2.46	2.56	2.56	2.33	2.51	2.67	2.66	2.35	2.67	0.31	0.00

4.2. Positioning Group Commodities in the KPM and Its Validation

Figure 2 is then converted to Figure 3 for heuristic mapping of the 20 group commodities (Padhi et al. 2011). Figure 3 indicates that group commodities form four clusters in four quadrants of the two-dimensional matrix.

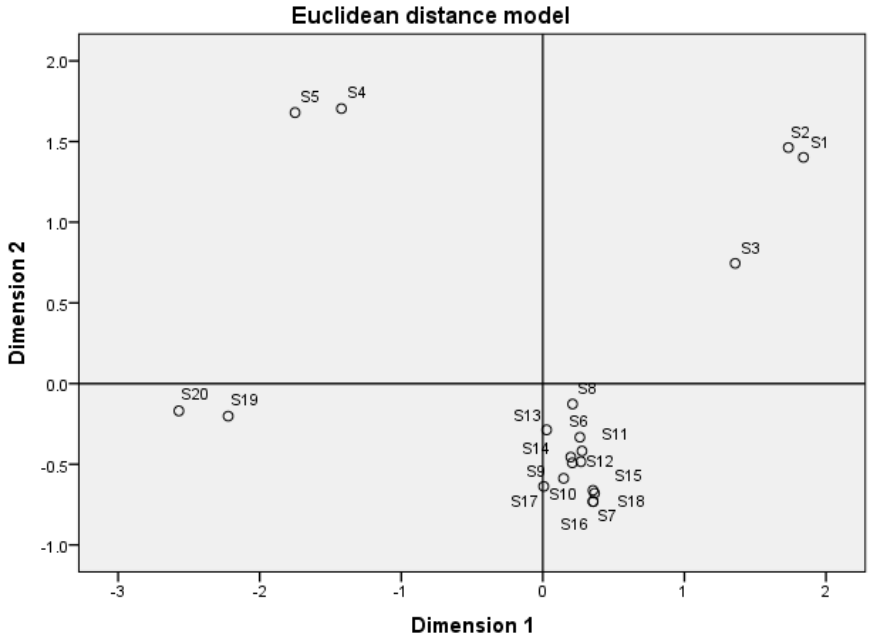

Figure 2. Mapping of the 20 groups commodities along the two dimensions.

Profit impact		
High	**Leverage** ● Bunker Fuel Oil ● Lube oil & grease	**Strategic** ● Crane Parts ● Generator Parts

	● Rigging, Mooring & Lifting Equipment	
Non-critical ● Bunker fresh water ● Household & Toiletries Item ● Office Stationery	**Bottleneck** ● Valves ● Pump Parts ● LSA/FFA ● Safety PPE ● Piping ● Food Provision	● Welding Tools ● Electrical Store ● Paint ● Galley Equipment ● Hand Tools ● Carpenter Store

Low

Low **Supply risk** High

Figure 3. Mapping of the 20 group commodities in the quadrants of the KPM.

Strategic items. This quadrant has the main characteristics of high supply risk and high-profit impact. The group commodities included in this category are crane parts, generator parts, and rigging, mooring & lifting equipment. From the dimension of supply risk, these group commodities are difficult to obtain in the market because of the specific specifications needed. The suppliers are specialized in supplying the product, not general suppliers or retailers, which we can get quickly in the market. The company so far often have complaints, especially on the difficulty of getting the right goods. The impact of profit on company efficiency is reasonably high due to the direct effect on the ship's performance. The reliability of the ship at work is also very dependent on these three groups of goods. Hence, the suitable strategy for commodities in this quadrant (strategic items) is building a strategic partnership.

Leverage item. This quadrant has the main characteristics of low supply risk and high-profit impact. Group commodities in this quadrant are bunker fuel oil and lube oil & grease. From the dimension of supply risk, these group commodities are readily available on the market. The company so far has no complaints about the timeliness, availability of supplies, or the quality of the goods. There are particular standards or specifications for this group commodities; however, because each supplier can supply as per specification, then it can be said that the complexity is very low. The impact of profit on company efficiency is quite high because of the price and quantity purchased are relatively high. For these leverage items, the proper strategy is to exploit buying power; however, the groups commodities can be moved to strategic items if the company held a strategic partnership with the vendor to get a better price and steadfast commitment.

Bottleneck item. This quadrant has the main characteristics of high supply risk but low-profit impacts. Items included in this category are Valves, Pump Parts, LSA & FFA, PPE Safety, Piping, Food Provision, Welding Tools, Electrical Stores, Paint, Galleys, Equipment, Hand Tools, Carpenter Stores. The complexity of these group commodities is not low because there are particular standards or specifications that must be met. The strategy for commodities in this quadrant is to avoid the shortage of goods/materials. Thus, the ship's crew needs to manage the safety stock or the number of spare parts.

Non-critical item. This quadrant has the main characteristics of low supply risk and low-profit impact. Group commodities in this quadrant are bunker fresh water, household & toiletries items and office stationery. These three items are readily available on the market, with various types of suppliers providing them. In the aspect of supplier performance risk, the company so far has no complaints either regarding the timeliness, availability of supplies, or the quality of the goods. There is no complexity, standardization, or particular specifications regarding these items. The strategy for commodities in this quadrant is optimizing inventory levels.

Once the matrix is completed, in-depth discussions are held to validate the framework (Padhi et al. 2011). After the analysis of MDS (i.e. obtaining Figure 3), three experts filled a short questionnaire for content validity, asking whether the experts are satisfied (or not) with the matrix shown in Figure 3, and whether position change of a commodity to another quadrant is needed. The paper considering consensus-based decisions through strategic discussions with experts which provide in-depth insights (achieved through commodities relocating).

5. Conclusions

The Kraljic's purchasing portfolio has become popular and broadly accepted because it gives reasonable guidelines for handling various purchasing circumstances, and/or supplier. The study aims to categorize items with Kraljic's

Portfolio Model. The outcomes show that the strategic items are crane parts, generator parts, and rigging, mooring, and lifting equipment. Leverage items are bunker fuel oil and lube oil & grease. Bottleneck items are Valves, Pump Parts, LSA & FFA, PPE Safety, Piping, Food Provision, Welding Tools, Electrical Stores, Paint, Galleys, Equipment, Hand Tools, Carpenter Stores. Non-critical items are bunker fresh water, household & toiletries items and office stationery. As most of the group commodities are in bottleneck quadrant. hence managing spare part inventory is critical and management should put their attention on the reporting system regarding spare part inventory to avoid unnecessary downtime which resulted from the breakdown which occurred because there is no spare part on board. This study has limitation. The portfolio may not apprehend all the aspects that are considered vital for buyer–supplier relationships from a network perspective.

Table 6. Twenty group commodities' two-dimensional coordinates.

	Group Commodities	Supply risk (dimension 1)	Profit impact (dimension 2)
S1	Crane Parts	1.8410	1.4021
S2	Generator Parts	1.7344	1.460
S3	Rigging, Mooring & Lifting Equipment	1.3588	0.7454
S4	Bunker Fuel Oil	-1.4266	1.7040
S5	Lube oil & grease	-1.7505	1.6792
S6	Valve	0.2618	-0.3328
S7	Pump Parts	0.3549	-0.7309
S8	LSA & FFA	0.2101	-0.1267
S9	Safety PPE	0.1974	-0.4553
S10	Piping	0.1467	-0.5876
S11	Bunker FW	0.2766	-0.4181
S12	Food Provision	0.2695	-0.4838
S13	Welding Tools	0.0268	-0.2868
S14	Electrical Store	0.2083	-0.4913
S15	Paint	0.3652	-0.6794
S16	Galley Equipment	0.3543	-0.6619
S17	Hand Tools	0.0062	-0.6370
S18	Carpenter Store	0.3550	-0.7312
S19	Household & Toiletries Item	-2.2226	-0.2018
S20	Office Stationery	-2.5712	-0.1691

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