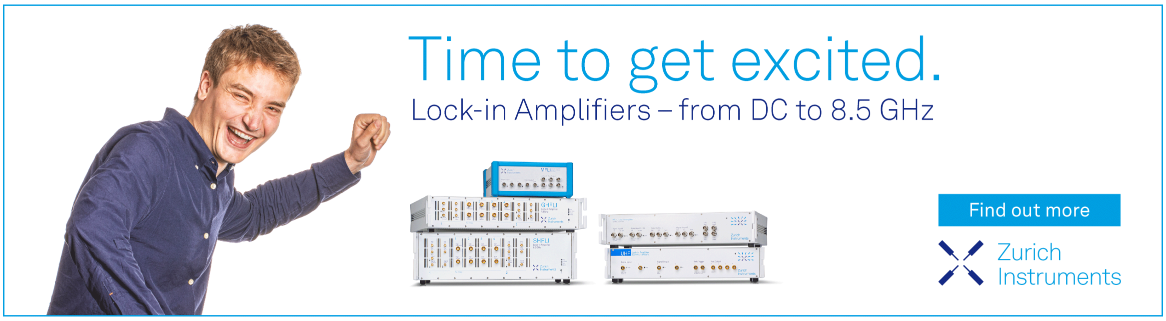
RESEARCH ARTICLE | MAY 12 2023

Formulating strategic purchasing strategy: A case study

Hery Suliantoro; Drajat A. Dilaga; M. Mujiya Ulkhaq

AIP Conference Proceedings 2674, 030025 (2023)
https://doi.org/10.1063/5.0114089



Formulating Strategic Purchasing Strategy: A Case Study

Hery Suliantoro[1,a)], Drajat A. Dilaga[1,b)], and M. Mujiya Ulkhaq[1,c)]

[1]Department of Industrial Engineering, Diponegoro University, Semarang, Indonesia

[a)]suliantoro_hery@yahoo.com
[b)]drajat.dilaga@gmail.com
[c)]Corresponding author: ulkhaq@live.undip.ac.id

Abstract. This research aims to formulate a strategic purchasing strategy in a manufacturing company. A case study was conducted in PT DIM, which is located in Indonesia. The company's core production is in the manufacturing of components for turbine engine, such as guide vanes, canesters, turbine water filters and also make portable turbine maintenance machine. Due to pandemic situation happened in 2020, the company experienced a significant decrease in net income by 63%! The company decided to cut the budget for purchasing activity by 80% and obviously, this policy affected the company's image in the eye of the suppliers. Therefore, a strategic purchasing strategy is needed for the sake of the company. To formulate the strategy, several steps proposed in this study. The first is identifying valid indicators for supply risk dimension, profit impact dimension, and supplier selection using content validity index. The analytic hierarchy process then was used to calculate the weights for each valid indicator. The selected items were then plotted on the Kraljic matrix. Before doing so, the technique for order performance similarity to ideal solution (TOPSIS) was used to identify the coordinate points for each item. Strategies according to each quadrant in the Kraljic matrix were derived; then, the decision-making tree laboratory (DEMATEL) was used to prioritize valid supplier selection criteria. The result of the criteria of supplier selection for strategic items are reputation, quality, and current customer feedback; and for bottleneck items are cooperation, flexibility, and delivery performance.

INTRODUCTION

Net income growth of the manufacturing industry in the world increased from 2015 (amounting to 12,183 trillion USD) to 13,772 trillion US Dollars in 2019 [1]. In 2020, due to pandemic, the global economic situation was very bad in various countries; in the second quarter of 2020, the production of the manufacturing industry fell significantly by 11.1%, while in the third quarter, the production was decreased by 5.9% [2]. This situation also happened in the Southeast Asia as this region experienced a decrease in the manufacturing industry in 2020 [3]. In addition, according to the purchasing manager's index (PMI), in 2020 many countries in the Southeast Asia experienced the smallest PMI in a year, reached 27% compared to the previous 48-53% [4]. Among eleven Southeast Asian countries, six countries are very competitive and competent in the scope of manufacturing, namely Indonesia, Malaysia, the Philippines, Singapore, and Thailand; and among those 6 countries, Indonesia experienced decrease in PMI from February to May 2020. However, in June 2020, the PMI increased by 39.1% [4].

The Minister of Industry of the Republic of Indonesia stated that the country's industrial performance growth fell drastically by 2.01% compared to the previous year of 4.8% [5]. Indonesia also experienced a decrease in gross domestic product (GDP) for the manufacturing industry from the first quarter of 2020 of 580 billion IDR to 558 billion IDR in the fourth quarter [6]. As a consequence, Indonesian companies have to *squeeze* their organizations, resulting in very large layoffs and the decreased of purchasing activities. Supply chain flows were under pressure along with long lead times for items delivery. Moreover, due to pandemic, items price increased significantly [4]. Therefore, in order to be competitive, good supply chain management is needed, especially in the purchasing department with good strategic purchasing.

This study aims to formulate a strategic purchasing strategy in a manufacturing company so that it can help the company to deal with this pandemic situation. A case study was conducted in PT DIM, which is located in

Proceedings of 7th International Conference on Industrial, Mechanical, Electrical and Chemical Engineering 2021 (ICIMECE 2021)
AIP Conf. Proc. 2674, 030025-1–030025-12; https://doi.org/10.1063/5.0114089
Published by AIP Publishing. 978-0-7354-4419-5/$30.00

Indonesia. The company's core production is in the manufacturing of components for turbine engine, such as guide vanes, canesters, turbine water filters and also make portable turbine maintenance machine. According to the interview with the purchasing department, the company does not have a specific contract management mechanism for each item purchased from the suppliers. Consequently, when the company purchased items from the suppliers, sometimes the company had to wait for a long time. For a make-to-order typed of company, this long delivery time is considered as a serious problem. In addition, due to pandemic situation, in 2020, the company experienced a significant decrease in net income by 63%. One of the unpopular policies is that to cut the budget for purchasing activity by 80%! By this policy, the company then can pay the purchasing cost to the suppliers up to three months late; obviously, it can affect the company's image in the eye of the suppliers.

Another problem in the procurement activity is about the supplier selection. The company only looked at the aspect of price flexibility offered by the suppliers and the quality of the items. The problem raised when the company only considered price flexibility aspect, the company got items that did not meet the standard (or had bad quality). In other hand, when the company only looked at the quality of the items, the suppliers did not offer price flexibility (in other words, the purchasing cost is more expensive). This condition implicitly indicated that supplier selection which only pays attention to price flexibility and item's quality is not enough to manage a good supply chain management.

In implementing strategic purchasing strategy, we should pay attention to supplier selection to ensure purchasing activity can run well. The supplier selection could help companies to assess suppliers' performance [7]. The criteria for supplier selection must be stated clearly so that the company can select appropriate suppliers to strengthen the strategic capabilities of the company's organization [8]. Furthermore, the criteria for supplier selection could form a standard for the company's purchasing (or procurement) department to align external resources with the internal goals of the company's organization [9].

METHODS

The process flow of this research including the methods used is shown in Fig. 1. The first activity is to identify criteria or indicators of supply risk dimension, profit impact dimension, and supplier selection. Literature review was used to identify the indicators. The indicators for supply risk and profit impact dimensions were derived from [10]-[13] (there are eleven and eight indicators for supply risk and profit impact dimensions, respectively), while the indicators for supplier selection were derived from [14]-[17] (there are fourteen indicators); see Table 1. To validate the indicators, we used content validity index (CVI) since this method does not contain repeated iterations. Some experts were interviewed using a four-point Likert scale questionnaire (1: not relevant, 2: quite relevant, 3: relevant, 4: very relevant) to determine whether the criteria are relevant to the object of the research [18]. Polit et al. [19] provide widely cited guidelines on what an acceptable CVI value is and how many experts to be involved are.

After all criteria were validated, we used the analytic hierarchy process (AHP) [20] to prioritize each validated criterion of supply risk and profit impact dimensions. This method is usually used in explaining complex decision-making problem by modeling it into a hierarchical system. It is considered as one of the most popular multi-criteria decision-making tool that has been used for years (see [21]–[24] for examples the application). Seven steps of implementation procedure of the AHP are presented as follows.

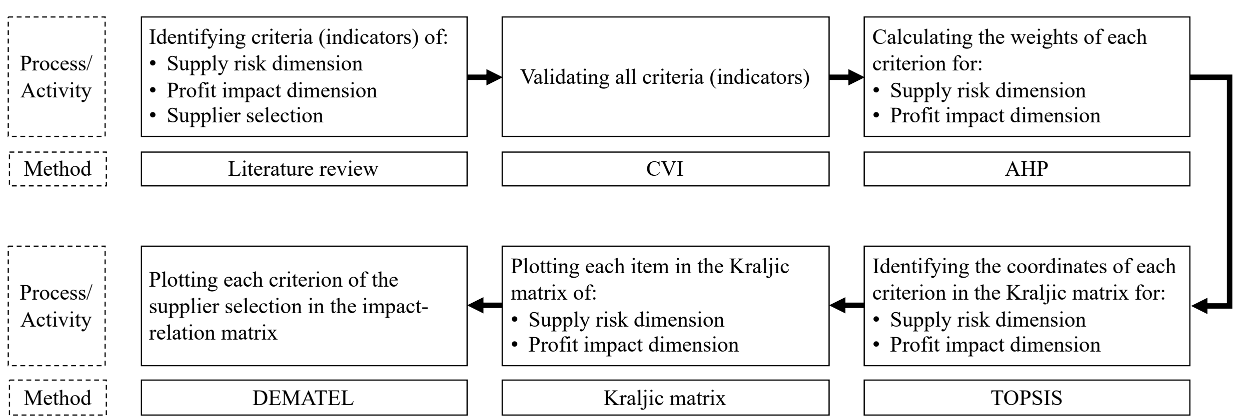


FIGURE 1. The process flow of the research including the methods used

TABLE 1. Indicators of supply risk dimension, profit impact dimension, and supplier selection

Indicator	Definition	Reference
Supply risk dimension:		
Price volatility (PV)	Price changes that occur due to unexpected reasons	[10]
Natural scarcity (NS)	The condition of scarce items that creates a supply-demand gap	[10]
Contract fulfillment risk (CR)	Reputation and acceptance of supplier performance in other supply chains	[13]
Performance Risk (PR)	The state of quality and performance of the suppliers in providing the items	[12]
Availability of the product (AP)	The state of availability of the items in the supply market	[11]
Number of available supplier (NS)	The state of the number of suppliers in the supply market	[11]
Possibilities to switch between make or buy (MB)	The possibility of the items to change between buying or making	[11]
Logistic complexity (LC)	The complexity of logistics activities that makes procurement activities difficult	[10], [11]
Location of suppliers (LS)	The distance between company and supplier that can affect acquisition cost and supply complexity	[10]
Market risk (MR)	Supply market risks, such as type of market monopoly and market access restrictions	[12], [13]
Supply complexity risk (SR)	The state of the products in the market: is it standardized or is it possible to be substituted?	[11], [12], [13]
Profit impact dimension:		
Essentiality of raw material (RM)	Items will be purchased at any price because they are essential for production	[10]
Alternate substitute (AS)	When the price of substitution is expensive, it will affect the price of production.	[10]
Consumption value (CV)	When the level of consumption of high raw materials has an impact on profit	[10], [11]
Purchasing cost (PS)	All costs related to purchasing	[10], [12], [13]
Importance of purchase (PC)	The importance of every items purchased from a product	[12], [13]
Impact of product quality (PQ)	The impact of each items that purchased for product quality	[11]
Impact of profitability (PF)	The effect of raw material's procurement on the company's profit level	[11], [12]
Percentage of total purchase value (TP)	Percentage of procurement that is of value to the company	[11]
Supplier selection:		
Quality (QU)	The ability of suppliers to provide items or commodities of the quality	[14], [16], [17]
Lead time (LT)	The supplier's ability to meet supply demand in terms of duration	[16]
Delivery performance (DP)	The ability of suppliers to provide services in the delivery of commodities ordered	[14], [15], [16], [17]
Purchasing cost (PU)	The price of supply given by the supplier to customers	[14], [15], [16], [17]
Cooperation (CO)	The ability of suppliers to communicate and collaborate with customers	[14]
Flexibility (FX)	The ability of suppliers to adeptly change and need desired by customers	[14], [15]
Reputation (RE)	The reputation of the supplier	14], [15], [16], [17]
Innovation (IV)	The ability of suppliers to innovate in all aspects, both in terms of services and commodities that offered	[17]
Response to customers (RC)	The ability of suppliers to respond orders from customers	[15], [17]

Indicator	Definition	Reference
Current customer feedback (CF)	The supplier's ability to open a discussion regarding feedback from customers	[15]
Conformity with requirement (CM)	The ability of suppliers to discuss with customers in terms of commodity specifications requested by customers	[15]
Quality system certification (QS)	Supplier has quality system certification	[14]
Usage of next generation (US)	Supplier has up-to-dated technology	[15]
Location (LC)	The location of the supplier	[17]

- Describe the problem and determine the criteria to be used.
- Arrange the problem into the hierarchy by considering the objective.
- Collect the data from the decision makers (DMs). They were asked to compare the criteria on a pairwise basis in order to estimate their relative importance. A nine-point scale questionnaire [25] was used to show the experts' judgment among options as equally, moderately, up to extremely important (or unimportant).
- Develop a paired comparison matrix for the criteria. A total number of $n(n-1)/2$ pairwise comparisons are evaluated, where n is the number of criteria. Let A represent an n×n pairwise comparison matrix as follows:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}. \quad (1)$$

The diagonal elements in the matrix **A** are self-compared of the criteria, and thus $a_{ij} = 1$, where $i = j$, $i, j = 1, 2, \ldots, n$. The values on the left and right sides of the matrix diagonal represent the strength of the relative importance degree of the ith element compared to the jth element. Let $a_{ij} = 1/a_{ji}$, where $a_{ij} > 0$, $i \neq j$.

- Calculate the importance degrees for each criterion. The normalization of the geometric mean (NGM) method was used to determine the importance degrees for each criterion. Let w_i denotes the importance degree for the ith criterion, then

$$w_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}, i,j = 1, 2, \ldots, n. \quad (2)$$

- Test the consistency. To ensure that the evaluation of the pairwise comparison matrix is reasonable and acceptable, a consistency check is performed. Let C denote an n-dimensional column vector describing the sum of the weighted values for the importance degrees of the criteria, then

$$C = [c_i]_{n\times 1} = A \cdot W^T, i,j = 1, 2, \ldots, n, \quad (3)$$

where

$$A \cdot W^T = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{bmatrix}. \quad (4)$$

The consistency values for can be represented by the vector $CV = [cv_i]_{1\times n}$, with a typical element cv_i equals to $cv_i = c_i/w_i$, $i = 1, 2, \ldots, n$. However, to avoid the inconsistency occur when using different measurement scales in the evaluation process, Saaty [20] suggested use the maximal eigenvalue $\lambda_{\max}$ to evaluate the effectiveness of measurements, which can be determined by

$$\lambda_{\max} = \frac{\sum_{i=1}^{n} cv_i}{n},\ , i,j = 1, 2, \ldots, n, \tag{5}$$

A consistency index (CI) is then can be determined by

$$CI = \frac{\lambda_{\max} - n}{n-1}. \tag{6}$$

If $CI = 0$, the evaluation for the pairwise comparison matrix is implied to be completely consistent. Notably, the closer of $\lambda_{\max}$ is to n, the more consistent the evaluation is. Generally, a consistency ratio (CR) [20] can be used as a guidance to check for consistency, where $CR = CI/RI$. RI denotes the average random index with the value obtained by different orders of the pairwise comparison matrices. If the value of CR is below than the threshold of 0.1, then the evaluation of the importance degrees of each criterion are reasonable.

- Determine the relative overall importance degrees.

After the degrees of importance for each criterion have been identified, the technique for order performance similarity to ideal solution (TOPSIS) [26] was used to identify the coordinates of each criterion in the Kraljic matrix (see [27]-[29] for the application plotting items in Kraljic matrix). TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS). The combination of AHP-TOPSIS has been used in abundant literature, see for example [30]-[34]. The steps of TOPSIS are presented as follows.

- Establish a normalized decision matrix. Let Z denote a normalized decision matrix representing the relative performance, with typical element Z_{ij} which can be calculated as

$$Z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{j=1}^{K} y_{ij}^2}}, \tag{7}$$

where y_{ij} is the performance score of alternative j against criterion i ($i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, K$ (number of alternatives)).

- Calculate the weighted decision matrix. Let X_{ij} be the weighted normalized decision matrix. It can be determined by $X_{ij} = w_i \,.\, Z_{ij}$, where w_i is the weight of each criterion (have been identified by AHP).
- Calculate PIS dan NIS, which are defined as

$$\text{PIS} = A_i^{+} = \left\{\left(\min_j X_{ij} \middle| i \in I\right), \left(\max_j X_{ij} \middle| i \in I'\right)\right\}, \tag{8}$$

$$\text{NIS} = A_i^{-} = \left\{\left(\max_j X_{ij} \middle| i \in I\right), \left(\min_j X_{ij} \middle| i \in I'\right)\right\}, \tag{9}$$

where $I = \{i = 1, 2, \ldots, n$ and i is associated with the beneficial criterion of $X_{ij}\}$, and $I' = \{i = 1, 2, \ldots, n$ and i is associated with the cost-effective criterion of $X_{ij}\}$.

- Compute the distance of each alternative from PIS and NIS. Let the S_j^{+} denotes the distance of each alternative from PIS and S_j^{-} denotes the distance of each alternative from NIS, then

$$S_j^{+} = \left[\sum_{i=1}^{n} \left(X_{ij} - A_i^{+}\right)^2\right]^{1/2}, \tag{10}$$

$$S_j^- = \left[\sum_{i=1}^{n} \left(X_{ij} - A_i^- \right)^2 \right]^{1/2} . \tag{11}$$

- Compute the closeness coefficient (CC_i) of each alternative as

$$CC_i = \frac{S_j^-}{S_j^+ + S_j^-} . \tag{12}$$

After all coordinates have been identified, the items then were plotted into the Kraljic matrix [35]. It is a two-dimensional state space where the vertical axis describes the profit impact while the horizontal axis describes the supply risk. There are four quadrants in the Kraljic matrix, i.e., leverage, strategic, non-critical, and bottleneck. The lines which divide the matrix into four quadrants are calculated from the average CC_i value of the supply risk and profit impact (see Equation (12)). The first quadrant, i.e., leverage, is located in the north-west corner. Items belong to this quadrant are considered have good profit but have low supply risk value. They are most profitable for company because the items do not hard to be supplied. The second quadrant, i.e., strategic, indicates that both supply risk and profit impact of the items are high. Items belong to the third quadrant (non-critical) have low supply risk and profit impact. The last quadrant, i.e., bottleneck, is located in the south-east of the diagram. They are hard to be supplied but have low profit impact.

To prioritize supplier, the supplier selection criteria was used. We used decision making tree laboratory (DEMATEL) questionnaire [36]. It is a comprehensive method for building and analyzing structured problems involving cause and effect relationships between complex factor [37]. The validated supplier selection criteria using CVI became inputs for DEMATEL. The results are values of prominence and relation for each criterion. The values were used to establish impact-relation matrix [38]. It is again two-dimensional state space where the vertical axis describes the relation while the horizontal axis describes the prominence. There are four quadrants in the impact-relation matrix, i.e., core factors, driving factors, independent factors, and impact factors. The lines which divide the matrix into four quadrants are calculated from the average value of the prominence and relation. The first quadrant, i.e., core factors, is located in the north-east corner. Criteria belong to this quadrant have high prominence and relation; thus, become the first priority. The second quadrant, i.e., driving factors, indicates criteria having low prominence and high relation; thus, become the second priority. The third quadrant, i.e., independent factors, is located in the south-west of the diagram. It indicates that prominence and relation values are low, thus there are not recommended. The criterion belongs to the last quadrant, i.e., impact factors, cannot be directly improved.

RESULT AND DISCUSSION

A case study has been conducted in PT DIM, where we formulated the strategic purchasing strategy for this company. After criteria of supply risk dimension, profit impact dimension, and supplier selection were identified from the literature review, we then validated those criteria using CVI. Three decision makers (DMs) from the company were selected. They are head of logistic department, head of administration and finance department, and head of production department. The respondents were chosen because they had authority for decision for the items purchasing process. The head of logistic has the highest authority in process of purchasing items, also direct contact with suppliers. The head of administration and finance has the highest authority for make legal of purchasing items and payment purchasing costs to suppliers. The head of production has authority for decision specification items that want to purchase by the company. All of them have at least ten-year experience in the manufacturing field. To conduct CVI, Polit et al. [19] suggested to assign five DMs or less. We used 1 (one) as an acceptable value of CVI. It means that all DMs agree that the criteria are valid content. The result is shown in Table 2 for supply risk and profit impact dimensions, and Table 3 for supplier selection. Notice that not all criteria were valid. In supply risk dimension, only seven criteria were valid, making other fours (LC, LS, MR, and SR) discarded for further analysis. In profit impact dimension, PF and TP were eliminated due to having CVI values less than one. In supplier selection, QU, LT, DP, PU, CO, FX, RE, IV, RC, CF, and CM would go for the next step.

After valid criteria of supply risk and profit impact dimensions were identified, the next step is calculating the weights for each criterion using AHP. Again, three DMs were asked to fill the pairwise comparison to express their preferences between the criteria in a nine-point scale questionnaire. Portable turbine maintenance machine product was selected to be analyzed since this product has a huge impact for the company's profit. This product has seventeen items. These items were compared by DMs using seven criteria (for supply risk dimension) and six criteria for profit impact dimension. The AHP result is given in Table 4 and Table 5 for supply risk dimension and profit impact dimension, respectively. Notice that the consistency ratio is below the threshold 0.1; thus, the result can be used for further analysis.

The supply risk dimension shows that there are six criteria that have the highest weight in several items of the product, namely, performance risk, natural scarcity, availability of product, contract fulfillment, number of suppliers, and price volatility. The highest weight of such criterion indicates that in implementing strategic purchasing strategy, the criterion is a priority to be considered. The profit impact dimension shows that there are four criteria that have the highest weight in several items, i.e., impact on product quality, importance of purchase, essentiality of raw material, and purchasing cost. The four criteria indicate that in implementing strategic purchasing strategy, these criteria are priority to considered.

The seventeen items were then plotted on the Kraljic matrix according to the supply risk dimension (for *x*-axis) and profit impact dimension (*y*-axis). Before doing so, TOPSIS was used to identify the coordinate points for each item. Also, TOPSIS can be used to calculate the crosshair of the matrix. This crosshair divides the Kraljic matrix into four quadrants as has been previously discussed. The result of TOPSIS is given in Table 6. The crosshair for *x*-axis is 0.9498, while for *y*-axis is 0.9493. The Kraljic matrix is shown in Fig. 2.

TABLE 2. Result of CVI for supply risk dimension and profit impact dimension

DM	**Supply risk dimension**											**Profit impact dimension**							
	PV	NS	CR	PR	AP	NS	MB	LC	LS	MR	SR	RM	AS	CV	PS	PC	PQ	PF	TP
DM1	4	3	4	3	4	4	4	3	4	3	3	4	4	4	3	4	4	3	3
DM2	3	4	3	4	3	3	4	1	1	1	1	4	3	4	3	4	3	4	1
DM3	4	3	3	4	3	4	3	1	2	3	4	4	4	3	3	3	4	2	4
CVI	1	1	1	1	1	1	1	0.33	0.33	0.67	0.67	1	1	1	1	1	1	0.33	0.67

TABLE 3. Result of CVI for supplier selection

DM	**QU**	**LT**	**DP**	**PU**	**CO**	**FX**	**RE**	**IV**	**RC**	**CF**	**CM**	**QS**	**US**	**LC**
DM1	3	3	4	4	3	3	4	3	3	4	3	3	3	4
DM2	4	3	4	4	3	3	4	4	4	3	4	1	1	1
DM3	4	3	3	4	3	4	4	3	4	3	4	2	1	3
CVI	1	1	1	1	1	1	1	1	1	1	1	0.67	0.33	0.67

TABLE 4. Result of the AHP for supply risk dimension

Items	**PV**	**NS**	**CR**	**PR**	**AP**	**NS**	**MB**
Aluminum	0.027	0.412	0.072	0.059	0.256	0.151	0.024
Fastener	0.028	0.028	0.308	0.349	0.153	0.066	0.068
Belt	0.149	0.032	0.241	0.429	0.053	0.073	0.024
Mild steel thickness above 30 mm	0.028	0.414	0.073	0.060	0.252	0.148	0.026
Mild steel thickness below 30 mm	0.032	0.053	0.143	0.072	0.427	0.248	0.025
Vise lathe	0.064	0.028	0.260	0.402	0.066	0.155	0.026
Controller	0.026	0.414	0.070	0.058	0.145	0.264	0.023
Cooler oil	0.405	0.065	0.028	0.257	0.145	0.076	0.024
Drive shaft	0.027	0.248	0.061	0.145	0.426	0.070	0.024
H beam	0.140	0.026	0.058	0.443	0.226	0.073	0.034
Hydraulic power pack	0.032	0.256	0.051	0.135	0.069	0.434	0.024
Inverter	0.032	0.417	0.070	0.054	0.257	0.146	0.025
Lathe table	0.068	0.029	0.399	0.250	0.160	0.025	0.071
Motor gearbox	0.034	0.414	0.077	0.242	0.147	0.060	0.026
Steel plate	0.165	0.035	0.236	0.357	0.095	0.075	0.037
Oil hose	0.027	0.071	0.257	0.405	0.061	0.153	0.025
Steel rail	0.068	0.024	0.413	0.052	0.033	0.152	0.258

TABLE 5. Result of the AHP for profit impact dimension

Items	RM	AS	CV	PS	PC	PQ
Aluminum	0.027	0.412	0.072	0.059	0.256	0.151
Fastener	0.028	0.261	0.078	0.114	0.470	0.031
Belt	0.149	0.092	0.037	0.034	0.459	0.259
Mild steel thickness above 30 mm	0.028	0.221	0.033	0.099	0.146	0.462
Mild steel thickness below 30 mm	0.032	0.261	0.030	0.093	0.118	0.464
Vise lathe	0.064	0.108	0.033	0.097	0.253	0.472
Controller	0.026	0.115	0.077	0.300	0.473	0.043
Cooler oil	0.405	0.119	0.096	0.031	0.263	0.036
Drive shaft	0.027	0.261	0.076	0.044	0.471	0.031
H beam	0.140	0.034	0.074	0.456	0.126	0.267
Hydraulic power pack	0.032	0.108	0.030	0.091	0.480	0.035
Inverter	0.032	0.115	0.031	0.086	0.273	0.036
Lathe table	0.068	0.033	0.040	0.115	0.455	0.264
Motor gearbox	0.034	0.114	0.033	0.044	0.476	0.257
Steel plate	0.165	0.074	0.044	0.246	0.484	0.096
Oil hose	0.027	0.109	0.094	0.252	0.480	0.036
Steel rail	0.068	0.034	0.094	0.115	0.466	0.254

TABLE 6. Result of TOPSIS for each item

Items	Supply risk dimension	Profit impact dimension
Aluminum	0.9581	0.9517
Fastener	0.8994	0.8847
Belt	0.9071	0.8606
Mild steel thickness above 30 mm	0.9580	0.9475
Mild steel thickness below 30 mm	0.9569	0.8505
Vise lathe	0.9071	0.9466
Controller	0.9606	0.9573
Cooler oil	0.8942	0.9585
Drive shaft	0.9248	0.8112
H beam	0.8952	0.9508
Hydraulic power pack	0.9583	0.8487
Inverter	0.9498	0.9493
Lathe table	0.8963	0.9477
Motor gearbox	0.9581	0.9604
Steel plate	0.8781	0.9309
Oil hose	0.9019	0.8870
Steel rail	0.9002	0.9469

The leverage quadrant contains items: H beam, steel plate, vise lathe, lathe table, steel rail, and cooler oil. These items are standardized but the prices for these items are expensive; so, the company's main focus for items in this quadrant is price reduction. The relationship with the supplier is arm-length. The type of contract is a spot purchase order with a short-term relationship for H beam and steel plate items, and call of contract with a mid-term relationship for vise lathe, lathe table, cooler oil, and steel rail items. The method of procurement is limited auction. The operational strategy is making a supplier assessment framework, payment terms in installments and employees who are able to negotiate.

The non-critical quadrant contains items: oil hose, fastener and belt, these items are standardized and easy to find in the supply market; so, the company's main focus for items in this quadrant is reducing administrative costs to the suppliers. The relationship with the supplier is arm-length. The type of contract is a spot-purchase order with a short-term relationship. The procurement method is direct procurement. The operational strategy is making category management, purchases through e-commerce, reduces inspection activities and employees have knowledge of the right time and quantity of items.

The strategic quadrant contains items: motor gearbox, inverter, controller, mild steel with thickness above 30 millimeters and aluminum. These items are of special specifications; thus, it is difficult in the supply market and the company buys these items outside Indonesia. The main focus is to reduce the company's dependence on the suppliers. The relationship with the supplier is partnership. Contract type is a unit price contract with a long-term relationship for motor gearbox, inverter, and controller, items with a mid-term relationship for mild steel with thickness above 30 millimeters and aluminum items. The procurement method is supplier selection. The operational strategy is making framework for priority supplier selection criteria, maintain strategic partnership, quality assessment, and employees who have good communication skills.

The bottleneck quadrant contains items: hydraulic power pack, drive shaft and mild steel with thickness below 30 millimeters. These items are special specifications, meaning that the number of suppliers in the supply market is small. The company still buys these items domestically. The company's main focus is to reduce dependence on the suppliers. The relationship with supplier is partnership. Unit price contract with a long-term relationship for hydraulic power pack and drive shaft items; while a mid-term relationship for mild steel with thickness items below 30 millimeters. The procurement method is supplier selection. The operational strategy is making safety stock policy, a non-recurring purchase strategy, a framework for priority supplier selection criteria and employees who have good communication skills.

This study only considers bottleneck and strategic quadrants. Items in the strategic quadrant have high supply risk because these items have special specifications and these items greatly affect the quality to the product. The procurement method for items in these quadrants is supplier selection; thus, it is necessary to propose the priority for supplier selection criteria to be a reference for the company to choose the right suppliers. The company can apply partnership with long-term and mid-term relationships. To do prioritization, the DEMATEL was used to prioritize valid supplier selection criteria (see Table 3). Respondents were given a questionnaire to provide an assessment of supplier criteria in accordance with the procurement strategy for strategic items and bottleneck items, in the form of prominence and relation values. These values are then plotted into the four quadrants of the prominent-relation matrix. The result of DEMATEL is shown in Table 7. The numbers in Table 7 were used as coordinate in the prominent-relation matrix, as shown in Fig. 3.

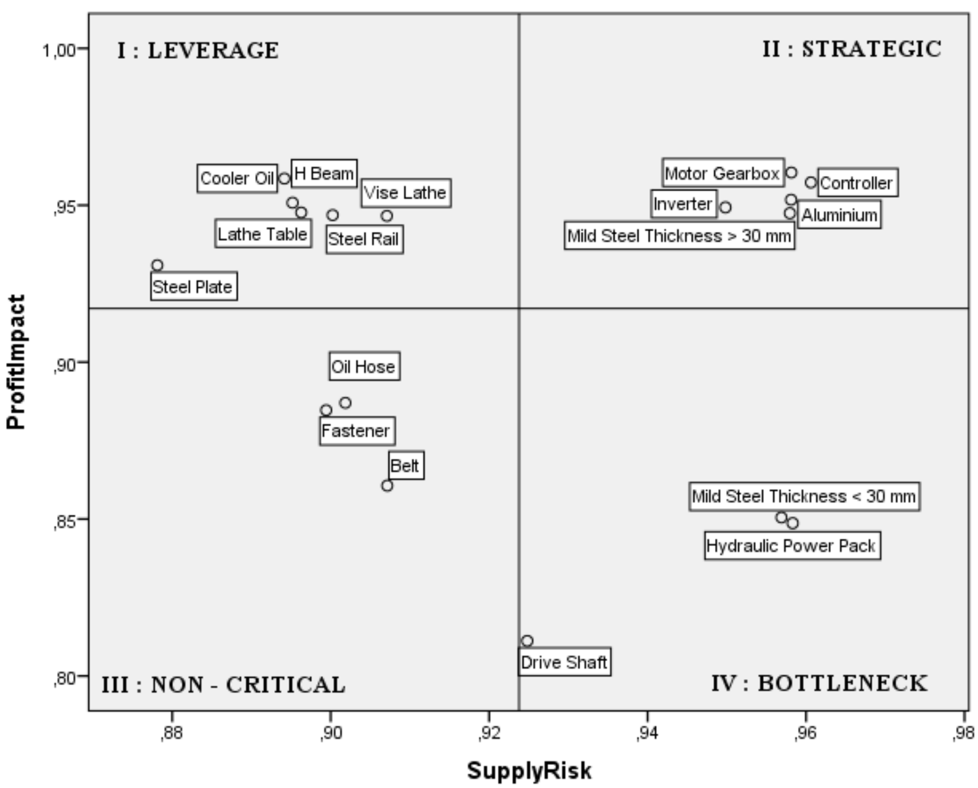
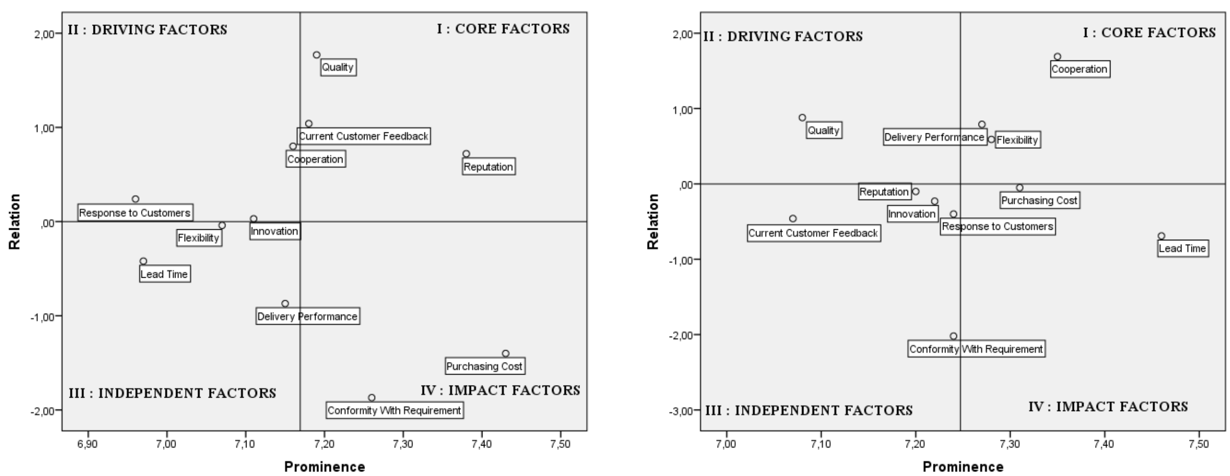


FIGURE 2. The Kraljic matrix

TABLE 7. Result of DEMATEL

Criteria	Strategic Quadrant		Bottleneck Quadrant	
	Prominence	Relation	Prominence	Relation
QU	7.19	1.77	7.08	0.88
LT	6.97	-0.42	7.46	-0.69
DP	7.15	-0.87	7.27	0.79
PU	7.43	-1.40	7.31	-0.05
CO	7.16	0.80	7.35	1.69
FX	7.07	-0.04	7.28	0.59
RE	7.38	0.72	7.20	-0.10
IV	7.11	0.03	7.22	-0.23
RC	6.96	0.24	7.24	-0.40
CF	7.18	1.04	7.07	-0.46
CM	7.26	-1.87	7.24	-2.02



(a) Strategic quadrant (b) Bottleneck quadrant

FIGURE 3. Prominent-relation matrix

Based on prominent-relation matrix, the supplier selection criteria included in the first quadrant are referred to as core factors or main criteria because they have high level of prominence and high level of relations in accordance with the procurement strategy. The criteria included in this quadrant are criteria that should be prioritized for their implementation [38]. In this research, the criteria included in this quadrant for items in the strategic quadrant are reputation, quality, and current customer feedback (see Fig. 3 (a)); and for the bottleneck quadrant are cooperation, flexibility and delivery performance (see Fig. 3 (b)). These criteria became the first priority because the partnership relationship requires trust and commitment between the company and the suppliers. The company considers track record of potential suppliers. In addition, the company also needs to provide feedback in terms of services and commodities provided by suppliers in order to minimize risks that may occur.

The criteria included in the second quadrant refer to driving factors because they have low level of prominence and high level of relation. The criteria included in this quadrant are the second priority criteria to be implemented [38]. In this research, the criteria included in this quadrant for items in the strategic quadrant are cooperation, innovation, and response to customer; and for item in the bottleneck quadrant is only quality.

The criteria included in the third quadrant refer to independent factors because they have low level of prominence and low level of relations. The criteria included in this quadrant are criteria that are not recommended to be implemented [38]. In this research the criteria included in this quadrant for items in the strategic quadrant are lead time, delivery performance, and flexibility; and for the bottleneck quadrant are current customer feedback, reputation, conformity with requirement, innovation, and response to customer. The criteria included in the fourth quadrant refer to impact factors because they have high level of prominence and low level of relation. The criteria included in this quadrant are criteria whose level of influence on other criteria is low when compared to the criteria in the first quadrant and in the second quadrant. These criteria cannot be implemented directly, or in other words, they should be influenced by other criteria [38]. In this research, the criteria included in this quadrant for items in the strategic quadrant are conformity with requirements and purchasing cost; and for items in the bottleneck quadrant are purchasing cost and lead time.

CONCLUSION

This study aims to formulate strategic purchasing strategy that can be implemented in a company. To do so, there are several steps conducted in this research. The first is identifying indicators for supply risk dimension, profit impact dimension, and supplier selection. The result as can be seen in Table 1 is eleven indicators for supply risk dimension, eight indicators for profit impact dimensions, and fourteen indicators for supplier selection. Three DMs considered as expert in the field of manufacturing were asked to validate the indicators using CVI. The results of CVI are depicted in Table 2 and Table 3. There are seven valid indicators for supply risk dimension, six valid indicators for profit impact dimensions, and eleven valid indicators for supplier selection. The AHP then was used to calculate the weights for each valid indicator. Portable turbine maintenance machine product was selected to be analyzed. Seventeen items of portable turbine maintenance machine product were compared according to seven and six valid criteria of supply risk and profit impact dimensions. The AHP result is given in Table 4 and Table 5 for supply risk dimension and profit impact dimension, respectively. TOPSIS was used to identify each coordinate of the items before plotting them into Kraljic matrix. The result of the matrix is given in Fig. 2. Strategies according to each quadrant in the Kraljic matrix have been provided in the previous section.

DEMATEL is then used to prioritize valid supplier selection criteria based on prominence and relation to the implementation of procurement strategies for strategic and bottlenecks items. This study only considers bottleneck and strategic quadrants of the Kraljic matrix because items located in those quadrants have special specifications and greatly affect the quality to the product. The first priorities for supplier selection criteria for strategic items are reputation, quality, and current customer feedback; and for the second are cooperation, innovation, and response to customer. The first priorities for supplier selection criteria for bottleneck items are and cooperation, flexibility and delivery performance, while the second is quality.

This research still has limitations in determining alternative strategies for strategic items and bottlenecks. Further research needs to use quantitative analysis tools, such as quality function deployment to determine the priority of the procurement strategy according to the characteristics of the items.

ACKNOWLEDGMENTS

We thank to PT DIM for providing useful information and support for this research.

REFERENCES

1. UNIDO, *United Nations Industrial Development Statistics* (UNIDO, 2020).
2. World Bank, *Manufacturing, Value Added (current US$)* (World Bank, 2020).
3. M. Jamrisko and E. Curran, "Asian factories slammed as China's PMI drops to record low", in *The Jakarta Post* (2 March 2020).
4. E-Bi, "What you need to know about manufacturing status of SE Asia during the pandemic," in *E-Bi* (21 July 2020).
5. BKPM, *The Increase of Investment in Manufacturing Sector in Indonesia During Pandemic* (BKPM, Jakarta, 2021).
6. Trading Economics, "Indonesia GDP from manufacturing," in *Trading Economics* (2021).
7. A. Nair, J. Jayaram and A. Das, *International Journal of Production Research* **53**, 1-16 (2015).
8. B. Hillebrand and W. G. Biemans, *The Journal of Product Innovation Management* **21**, 110-122 (2004).
9. J. Sarkis and S. Talluri, *The Journal of Supply Chain Management* **38**, 18-28 (2002).
10. S. Jaipuria, M. Jenamani and M. Rankumar, *International Journal of Procurement Management* **9**, 524-547 (2016).
11. S. R. Gangurde and A. A. Chavan, *Benchmarking: An International Journal* **23**, 1751-1779 (2016).
12. A. N. Rachman and Nofrisel, *Advances in Economics, Business and Management Research* **72**, 225-230 (2018).

13. L. Sun, Z. Li, X. Zhang, F. Ke, X. Z. and M. Chen, "Positioning of distribution network commodities using the Kraljic portfolio matrix," in *14th IEEE Conference on Industrial Electronics and Applications* (IEEE, 2019).
14. R. Kaya and B. Yet, *Expert Systems with Applications* **134**, 234-248 (2019).
15. A. Kumar, A. Pal, A. Vohra, S. Gupta and S. Manchanda, *Benchmarking: An International Journal* **25**, 1528-1547 (2018).
16. P. M. Ozfirat, *South African Journal of Industrial Engineering* **31**, 35-46 (2020).
17. M. A. Basset, G. Manogaran, A. Gamal and F. Smarandache, *Design Automation for Embedded Systems* **22**, 257-278 (2018).
18. V. Zamanzadeh, A. Ghahramanian, M. Rassaouli, A. Abbaszadeh, H. A. Majd and A. R. Nikanfar, *Journal of Caring Sciences* **4**, 165-178 (2015).
19. D. E. Polit, C. T. Beck and S. V. Owen, *Research in Nursing & Health* **30**, 459-467 (2007).
20. T. L. Saaty, *The Analytic Hierarchy Process: Planning, Priority Setting* (McGraw-Hill, New York, 1980).
21. M. M. Ulkhaq, A. D. Siamiaty, A. Handoko, S. A. Madjid, and D. 'Sa Nu, *IOP Conference Series: Materials Science and Engineering* **219**, 012012 (2019).
22. M. M. Ulkhaq, R. L. Nartadhi and P. Y. Akshinta, *Industrial Engineering & Management Systems* **15**, 77-91 (2016).
23. M. M. Ulkhaq, W. R. Wijayanti, D. A. Dilaga, A. A. Qadarullah and F. Arfi, "Combining the analytic hierarchy process and importance-performance analysis to assess service quality of m-commerce: A case of Indonesian m-commerce," in *2021 IEEE 8th International Conference on Industrial Engineering and Applications* (IEEE, 2021), pp. 6-10.
24. S. N. W. Pramono, M. M. Ulkhaq, R. Trianto, P. R. Setiowati, D. R. Rasyida, N. A. Setyorini and W. A. Jauhari, *AIP Conference Proceedings* **1902**, 020035 (2017).
25. T. L. Saaty and J. M. Alexander, *Thinking with Models: Mathematical Models in the Physical, Biological and Social Sciences* (Pergamon Press. London, 1984).
26. C. Hwang and K. Yoon, *Multiple Attribute Decision Making: Methods and Application* (Springer, New York, 1981).
27. D. Pujotomo, H. Suliantoro and A. F. Huseina, "Procurement strategy in power plant companies (case study in the supply of water generator engine parts)," in *Annual Conference on Industrial and System Engineering* (2019).
28. S. M. Arabzad, J. Razmi and M. Ghorbani, *Research Journal of International Studies* **21**, 1-7 (2011).
29. M. Medeiros and L. Ferreira, *Production Planning & Control*, 1-17 (2018).
30. M. M. Ulkhaq, P. Y. Akshinta, R. L. Nartadhi, and S. N. W. Pramono, *MATEC Web of Conferences* **68**, 09003 (2016).
31. W. R. Wijayanti, W. R., Dewi, F. Ardi, A. Fajri, M. M. Ulkhaq, and P. Y. Akshinta, "Combining the fuzzy AHP and TOPSIS to evaluate service quality of e-commerce website," in *10th International Conference on Education Technology and Computers* (ACM, 2018), pp. 397–402.
32. D. P. Sari, W. R. Wijayanti, A. Prayogo, M. M. Ulkhaq, and D. I. Rinawati, *MATEC Web of Conferences* **204**, 02014 (2018).
33. M. M. Ulkhaq, F. Fidiyanti, M. F. M. Raharjo, A. D. Siamiaty, R. E. Sulistiyani, P. Y. Akshinta, and E. A. Nugroho, "Evaluating hospital service quality: A combination of the AHP and TOPSIS," in *2nd International Conference on Medical and Health Informatics* (ACM, 2018), pp. 117–124.
34. M. M. Ulkhaq, W. R. Wijayanti, M. S. Zain, E. Baskara, and W. Leonita, "Combining the AHP and TOPSIS to evaluate car selection," in *2nd International Conference on High Performance Compilation, Computing and Communications* (ACM, 2018), pp. 112-117.
35. P. Kraljic, *Harvard Business Review* **61**, 109-117 (1983).
36. A. Gabus and E. Fontela, *World Problems, An Invitation to Further Thought within the Framework of DEMATEL* (Battelle Geneva Research Centre, Geneva, 1972).
37. A. S. Jarosz, *Transport Economics and Logistics* **82**, 129-142 (2019).
38. S. L. Si, X. Y. You, H. C. Liu and P. Zhang, *Mathematical Problems in Engineering*, 1-33 (2018).