Implementation of ANP Method in Determining Supplier to Improve Service towards Supermarket Consumers

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Abstract. Performance assessment on the supplier by the supermarket manager is relatively difficult to conduct and implies subjectivity, because there is no measureable and objective performance indicator. This study aims to assist in the decision making process and to look for alternative solutions in assessing the performance of each supplier, so that the service towards the customers will improve as well. ANP method is used to find the weight of each sub-criteria that will be used to measure the supplier performance. The weight result of each sub-criteria derived from the ANP method is used again in measuring the performance and to rank the performance of each supplier by using TOPSIS method. Performance measuring by using the ANP and TOPSIS that generates the highest value of the supplier is 0.71666 while the lowest value is 0.24825. The result of this study shows that the ANP and TOPSIS methods can be used to measure the supplier performance therefore it can assist the selection of supplier which can increase service towards the mart's consumers.

1. Introduction

Logistics function has already developed into broader strategic approach in terms of distribution management which also known as supply chain management [1]. The concept of *supply chain* (SC) is widely adopted by various companies to support logistics operations conducted by suppliers [2] as well as to assist in the selection of the best suppliers [3]. This concept also explains that a supply chain includes all groups involved to meet customer needs. In fact, the suppliers are directly involved in leading the company towards its success or failure. A good service and performance are some of the main factors that is very important in the business process [4]. Likewise, the service and performance of suppliers is also as important in the supply chain business processes. Assessing the performance of suppliers is considered difficult and subjective because of the absence of measurable performance indicators and objective. Therefore it needs to be supported by the proper identification of Key Performance Indicator (KPI) that serves to measure progress in accordance with the organization objectives in order to determine the performance assessor [4] [5]. Analytic Network Process (ANP) is used for multi criteria decision making. ANP constitute general framework that is used to handle decision problems without making assumptions about group or elements independency [6]. TOPSIS method is used to choose an alternative which simultaneously has the shortest distance from ideal positive solution and the farthest distance from ideal negative solution [7]

[8]. The utilization of ANP and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) holds a contribution on the practical implementation for strategy optimization and objective evaluation [9][10]. The merger of ANP technique is to determine relative weights of several criteria in evaluation, and TOPSIS approach is used for determining the rank that competes in overall performance [11]. Therefore it is necessary to conduct KPI measuring on the performance of the supplier as an important part in the logistics process at the supermarket. An ANP-TOPSIS based methodology is used to measure the performance of the supplier where the KPI identification from the analysed data collected in the form of factors that can affect the performance. Performance evaluation - based ANP method is used to measure the weight of the criteria. Next, the data obtained from weighting using ANP processed by using TOPSIS method for assessment based on potential alternatives.

2. Method

2.1. Analytic Network Process (ANP)

ANP is a development of Analytic Hierarchy Process (AHP), which dependency among the hierarchy elements is taking into account. There are many decision problems that can't be structured hierarchically because it has the tendency to involve interaction and interdependence with the higher level elements towards the lower level elements within the hierarchy. Therefore, the ANP method that is based by network instead of hierarchy, can be used to resolve the issue. ANP is a logical way to handle dependency issue [6]. The model of ANP method is in the form of a network hence we can see the interconnections between each element on the same criteria, or the elements of different criteria.

- Calculating the weight element
  In decision making, it is important to know how well the consistency that exists because we do not want decisions based on consideration with a low consistency.
- Calculate Consistency Index (CI):

$$CI : (\lambda \text{ max-n}) / (n-1) \qquad (1)$$

- Calculate the consistency ratio / Consistency Ratio (CR), using a random index as shown in Table 2.

$$CR : CI/IR \qquad (2)$$

Table 1. Random Index

Matrix Size (N)	IR Value
1	0,00
2	0,00
3	0,58
4	0,90
5	1,12
6	1,24
7	1,32
8	1,41
9	1,45
10	1,49

- Forming the Supermatrix
  Supermatrix is the result of priority vector from the paired comparisons between clusters, criteria and alternatives. Supermatrix consists of three phases, The Unweighted Supermatrix phase, the Weighted Supermatrix phase and the Limiting Supermatrix phase.

2.2. Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS)

The results of the analysis are then completed by using TOPSIS method shows that quality evaluation indicators affecting the results of the evaluation, hence the selection of precise indicator is very important [12]. In general, the procedure of TOPSIS method consists of the steps as follows [7] [8].

2.2.1. Determining TOPSIS needs performance ranking in every Ai alternative over every normalized Cj criteria. This can be seen from the formula below:

$$\mathbf{r}ij = \frac{Xij}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}} \tag{3}$$

with i=1,2,....m; dan j=1,2, n;
Ai is the alternative of an activity
Cj is the kind of criteria

2.2.2. Calculate the normalized weighted decision matrix

$$Y_{ij} = W_i r_{ij} \tag{4}$$

with i=1,2,...,m and j=1,2,...,n

2.2.3. Calculating positive ideal solution A^+ matrix and negative ideal solution A^- matrix.

$$A^+ = (y_1^+, y_2^+,...., y_n^+); \tag{5}$$
$$A^- = (y_1^-, y_2^-,...., y_n^-);$$

Where:
y_j^+ is Max y_{ij} if j is an advantage attribute (benefit)
Max y_{ij} if j is a cost attribute (Cost)
y_j^- Is Min y_{ij} if j is an advantage attribute (benefit)
Min y_{ij} if j is a cost attribute (Cost).

2.2.4. Determining the gap between the values of each alternatives with positive ideal solution matrix and negative ideal solution matrix.
Alternatives to positive ideal solution.

$$D_i^+ = \sqrt{\sum_{j=1}^m (y_i^+ - y_{ij})^2} \quad ; i=1, 2, ..., m \tag{6}$$

Alternatives to negative ideal solution.

$$D_i^- = \sqrt{\sum_{j=1}^m (y_{ij} - y_i^-)^2} \quad ; i= 1, 2, ..., m$$

Where D_i^+ is the distance to the positive ideal solution for I alternative and D_i^- is the distance to the negative ideal solution.

2.2.5. Calculating the preference value for every alternative (V_i).

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \qquad i = 1, 2, ..., m \qquad (7)$$

Preference value is a final value that becomes the benchmark in determining the ratings on all of the alternatives.

3. Result and Discussion

3.1. The Result

Based on the data obtained in the previous stages, criteria and sub-criteria will first be determined in order to determine which eligible supplier chosen by the company. Determination of criteria and sub-criteria is conducted in the computer laboratory of Informatics Engineering, State University of Gorontalo. This stage produces criteria and sub-criteria to determine the supplier chosen by the company. The criteria and sub-criteria consists of five dimensions of evaluation, namely: Reliability, Responsive, Flexibility, Cost, and Asset. Each dimension consists of 3-4 indicators, as shown in table 2.
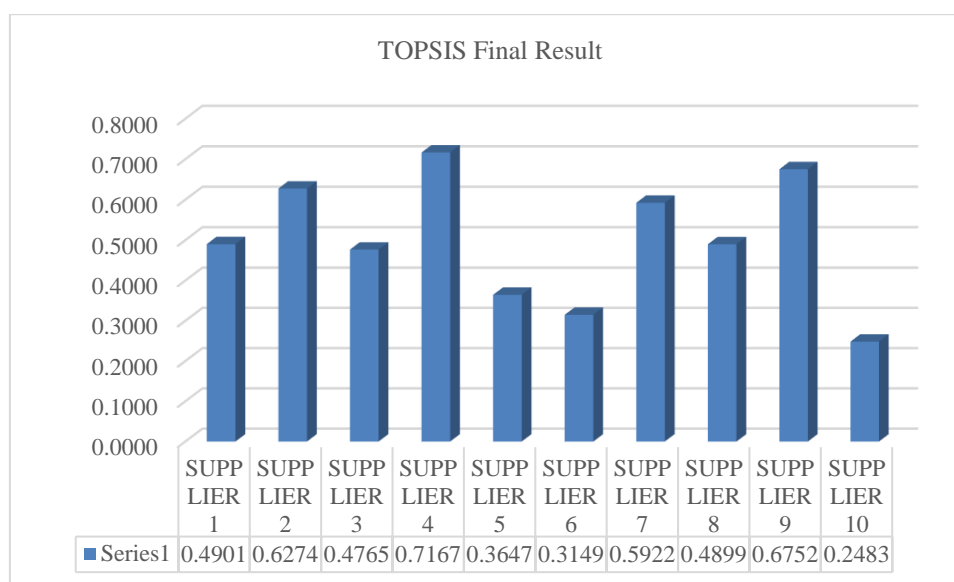
Table 2. Dimensions and Supplier Assessment Indicators

No.	Dimension	Indicator
1.	Reliability	Punctuality in product delivery
		The amount of products as listed on the order
		Delivered products match the order
		Smooth and swift delivery
2.	Responsive	Quick respond to the requests
		Easy of respond to the requests
		Replacement of damaged products
3.	Flexibility	Can anticipate sudden demand
		Short delivery time
4.	Cost	Price suitability
		Providing discount
		Easy of payment
5.	Asset	Sufficient inventories
		Good quality products
		Well-preserved products

Comparisons paired up from the level of importance used by the indicators, producing matrix which then will be used to form a supermatrix by combining the entire matrix that have been formed earlier. The analysis result of ANP delivers normal weight which later will be used for TOPSIS calculation that served in the form of table 3 below.

Table 3. Supermatrix Limits

LS		KPI1				KPI2			KPI3			KPI4			KPI5		
		A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1	D2	D3	D1	D2	D3
KPI1	A1	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024
	A2	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059	0,059
	A3	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020	0,020
	A4	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005	0,005
KPI2	B1	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064	0,064
	B2	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039	0,039
	B3	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054	0,054
KPI3	C1	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107	0,107
	C2	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080	0,080
	C3	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057	0,057
KPI4	D1	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050	0,050
	D2	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027	0,027
	D3	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024	0,024
KPI5	E1	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113	0,113
	E2	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126	0,126
	E3	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150	0,150
Jumlah		**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**

Table 3 shows the value of global significance of each KPI that resulted from super matrix calculation, each column has the same value.

Figure 1. Result of the ranking

In Figure 1 we obtain the final result of the ranking by using the TOPSIS method, therefore we obtain the information that each supplier has their own final value based on the respondent's assessment. In addition, the end result of this evaluation is the level of performance of each supplier who has been

ranked. The result of TOPSIS analysis shows the value of preference of each supplier as a whole which are presented in tabular form as shown in figure 1 and sorted from highest to lowest.

4. Discussion

There are 10 supermarkets that have become the respondents and filled out a questionnaire based on their assessment of the supplier. The derived result from data processing using Analytic Network Process (ANP) analysis and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) to measure the supplier performance shows that both of these methods can be used to conduct performance measurement with reference to the previous criteria that has been arranged. Some of the sub-criteria that interlinked to one another has to be identified first hand by examining the linkages between one sub-criteria to the other sub-criteria, in order to obtain a network structure from the comparison between the sub-criteria.

The next stage is to determine the pairwise comparison matrix. At this stage the relationship between the criteria formulated. In table 4 we can see an example of pairwise comparison matrix to determine the punctuality of product delivery (A1) as a control factor that is used to see the effect on factors / other

Table 4 shows that A2 criteria is the most influential criteria towards A1, with priority value of 0.5889 followed by A3 and A4, with priority value of 0.2519 and 0.1593

Table 4. Matrix of pairwise comparisons to determine Punctual Delivery Product (A1) as a control factor in Procurement Section

A1	A2	A3	A4	vector Priority
A2	1	3	3	0,5889
A3	1/3	1	2	0,2519
A4	0,3333	½	1	0,1593
Amount	**1,6667**	**4,5000**	**6,0000**	**1,0000**

Once the priority vector or Eigen vector obtained from pairwise comparisons among all sub-criteria, the next step is to create super matrix. The first step is to create non-weighted supermatrix that taken from priority vector of each pairwise comparison matrix. After the non-weighted supermatrix obtained we will then determine the weigthed supermatrix. At the stage of weighted supermatrix, the supermatrix is produced by normalizing the unweighted supermatrix with weighted criteria that obtained from comparison matrix between the matching criteria. Then, the limiting supermatrix obtained by quadrating the weighted supermatrix so that the column would have the same value.

From the limit supermatrix calculation we obtain the normal weight of each criteria that add up to one. These normal weights will later be used in TOPSIS phase to determine the rank. The normal weights which obtained from each limiting supermatrix from those three parts will later on be used to rank the supplier. So that each section has a weight measurement that is different from each other. The value of the weight of each criterion is 0,0244993, 0,0594580, 0,0203804, 0,0052750, 0,0635921, 0,0635921, 0,0537633, 0,1067309, 0,0798543, 0,0573107, 0,0501060, 0,0270064, 0,0240805, 0,1125856, 0,1259782 and 0,1501141.

After the weighting using ANP process is completed, the next stage is ranking by using TOPSIS method. Data processing using TOPSIS begins by inputting the decisions table from each sub-criteria in every alternatives that obtained from the questionnaire result. The process in TOPSIS method continued by weighting on the normalized matrix. The elements from normalized decision matrix multiplied by the weights of the criteria (that has been calculated in the ANP process) so that we acquired the normalized weighted decision matrix. Below is the weights criteria table which obtained from the ANP calculation.

Table 5. Normalization of Decision Matrix

Alternative	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
S1	0,0086	0,0205	0,0068	0,0015	0,0225	0,0141	0,0183	0,0350	0,0271	0,0206	0,0159	0,0081	0,0081	0,0390	0,0391	0,0420
S2	0,0063	0,0165	0,0059	0,0018	0,0177	0,0122	0,0183	0,0350	0,0240	0,0195	0,0177	0,0094	0,0068	0,0347	0,0402	0,0540
S3	0,0066	0,0183	0,0067	0,0016	0,0177	0,0115	0,0164	0,0350	0,0217	0,0162	0,0149	0,0089	0,0063	0,0336	0,0402	0,0480
S4	0,0086	0,0188	0,0054	0,0018	0,0213	0,0133	0,0144	0,0318	0,0309	0,0206	0,0154	0,0097	0,0099	0,0379	0,0379	0,0585
S5	0,0084	0,0188	0,0074	0,0012	0,0250	0,0111	0,0202	0,0286	0,0302	0,0152	0,0177	0,0070	0,0078	0,0336	0,0437	0,0345
S6	0,0081	0,0205	0,0065	0,0017	0,0189	0,0137	0,0159	0,0329	0,0217	0,0195	0,0135	0,0070	0,0073	0,0379	0,0368	0,0390
S7	0,0066	0,0183	0,0068	0,0019	0,0183	0,0111	0,0164	0,0371	0,0240	0,0162	0,0131	0,0097	0,0068	0,0347	0,0368	0,0540
S8	0,0066	0,0188	0,0061	0,0018	0,0177	0,0126	0,0168	0,0350	0,0232	0,0173	0,0177	0,0083	0,0068	0,0336	0,0425	0,0465
S9	0,0086	0,0188	0,0058	0,0020	0,0207	0,0119	0,0154	0,0382	0,0247	0,0173	0,0149	0,0097	0,0081	0,0358	0,0368	0,0570
S10	0,0084	0,0183	0,0068	0,0012	0,0201	0,0122	0,0173	0,0276	0,0232	0,0179	0,0168	0,0070	0,0076	0,0347	0,0437	0,0330

Both of the positive ideal solution and the negative ideal solution are obtained by the normalized weighted matrix. The element from A+ on the positive ideal solution table and the negative ideal solution is the highest value of each column on normalization of weighted decision matrix table, meanwhile the element from A$^-$ on the positive ideal solution and the negative ideal solution table is the lowest from each column on normalization of weighted decision matrix table. The next step is to determine the distance for each alternative towards the positive ideal solution and distance for each alternative towards the negative ideal solution.

The final preference value will become the benchmark in determining the rank of every available alternative. The final preference value on an alternative is a comparison between distance from the negative ideal solution and the amount of distance towards positive ideal solution.

Table 6. Final Ranking Values

NO.		RANK	
1	SUPPLIER 4	V4	0,7167
2	SUPPLIER 9	V9	0,6752
3	SUPPLIER 2	V2	0,6274
4	SUPPLIER 7	V7	0,5922
5	SUPPLIER 1	V1	0,4901
6	SUPPLIER 8	V8	0,4899
7	SUPPLIER 3	V3	0,4765
8	SUPPLIER 5	V5	0,3647
9	SUPPLIER 6	V6	0,3149
10	SUPPLIER 10	V10	0,2483

The assessment on supplier performance shows result of the final score as ranking from each alternative that has been sorted from the alternative with the highest score to the alternative with the lowest score. The score of the supplier 4 is considered to be the highest with value of 0,7167 followed by supplier 9 with value of 0,6752, supplier 2 with value of 0,6274, supplier 7 with value of 0,5922, supplier 1 with value of 0,4901, supplier 8 with value of 0,4899, supplier 3 with value of 0,4765, supplier 5 with value of 0,3647, supplier 6 with value of 0,3149 and supplier 10 with value of 0,2483. This is also demonstrated with a score graph from each supplier. Thus concludes the performance of supplier 4 is acknowledged to be the highest compared to the performance of other suppliers according to the respondents who rate.

The result of the analysis shows that ANP and TOPSIS can be used by the mart's manager in measuring the suppliers' performance hence it can provide ratings on suppliers who have good performance that is derived from the value of each supplier. This is because the use of ANP is a lot more

optimal because the ANP method compares all indicators and eliminates dependencies between elements. Supplier ranking using TOPSIS is used to obtain preference value that generated by considering the gap between the ideal positive solution and ideal negative solutions. Therefore, with the good supplier's performance, the service of mart towards consumers will improve, because there is no delay in the supply of goods by the supplier that caused stock emptiness in the mart's stash.

5. Conclusion

The supplier performance and service are some of the most important factor in business process of a supermarket enterprise. Measuring performance of the suppliers is a difficult thing to do and could imply subjectivity. This is due to the absence of measurable and objective performance indicator. The use of ANP is more optimal because the ANP method compares all indicators and eliminates dependencies between elements. Indicator or criteria and sub-criteria consists of five dimensions of evaluation, which are: Reliability, Responsive, Flexibility, Cost, and Asset. Supplier ranking by using TOPSIS is used to obtain preference value generated by considering the gap between the ideal positive solution and ideal negative solution. The implementation of ANP and TOPSIS methods on supplier performance evaluation can identify suppliers based on the predetermined assessment. The analysis result of the case study shows that the assessment of the supplier on the supermarket has a different value in accordance with the weight obtained from pairwise comparisons between sub-criteria. To get the results of appropriate decision-making, someone with an understanding of the problem is emphasized, especially in determining the input value to be provided in order to obtain a value corresponding to the sub-criteria.

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