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DETERMINATION OF SUPPLIER AND ORDER QUANTITY OF RAW MATERIAL USING AHP METHOD AND LINEAR PROGRAMMING

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ABSTRACT

Companies must choose suppliers properly, because the selection of the right supplier can reduce raw material costs and increase the competitiveness of the company, while improper supplier selection can cause financial and operating problems. The purpose of this study is to determine the optimal supplier and order quantity of raw materials. As for the object of the research is a multipurpose technology machinery company. Data collection methods used in this study were observation, interviews, and questionnaires. Supplier data is processed using the AHP method to determine the right supplier, while the linear programming method is used to determine the order quantity of the raw material. Based on the calculation, the DS supplier gets a weight of 0.65 and the LG supplier gets a weight of 0.35. The optimal order quantity from each supplier is 7.5 tons for DS and 7.5 tons suppliers for LG suppliers. From the results of the optimization, the cost reduction figure is Rp. 3,750,000 or 3% of the total cost of purchase.

INTRODUCTION

Companies must choose the most appropriate supplier, because the selection of sup-pliers significantly reduces raw material costs and increases company competitive-ness, but inaccurate supplier selection can cause financial and operating problems. On the other hand, supplier selection can make the company more efficient and can produce higher quality products [1]. For this reason, the company tries to determine the supplier of the company where there are 4 criteria considered by the company. The following supplier data on table 1 as follows:

Table 1. Supplier Information

Supplier	Cost (Million/ton)	Quality	Delivery	Fulfilment Order
Supplier A	10	0.75	0.75	0.75
Supplier B	9,5	0.25	0.25	0.25

From the data above, it can be known that there are 4 criteria for company suppliers, namely price, quality, delivery and fulfilment of orders. From these 2 suppliers, the company needs to select the right supplier to supply the company's raw materials. Supplier evaluation and selection problems have been solved by several methods in the literature such as linear weighting methods, total cost approaches, mathematical programming methods, statistical methods and Artificial Intelligent methods [2]. AHP method is used because the criteria of all the object were not correlated to other criteria. The literature survey shows that among the many and various types of methodologies and techniques for dealing with the Supplier Selection Process, models based on the Analytic Hierarchy Process and their combinations are the most extensive methods in the literature. Moreover, the survey also highlights that AHP-based models can be used in combination with many other approaches [3].

Because of that, the research that will be carried out is selecting the sup-plier using a method that is different from the others, namely the AHP method for decision making at suppliers. Then the optimal order allocation is done using Linear Programming.

METHODOLOGY

This section discusses research data, data collection methods, and research flow

Research Data

The data collected in this study are data on supplier raw material prices, raw material purchase data, supplier capacity data, and supplier weighting data.

Data Collection Methods

The method of collecting data through 3 methods, namely observation, observation stage is the stage that is carried out by researchers in collecting data on the procure-ment of raw materials. then interview, conduct direct interviews with competent par-ties and are directly related to data collection in accordance with the needs of the research and to determine the criteria, sub-criteria, and alternative raw material sup-pliers and find out the production capacity of each supplier. the last is literature study, literature study in this case is done to study the research theme with literature and related information. The data obtained either from questionnaires, interviews or from the results of observations using the AHP method where AHP is used to do weighting of each criterion and sub-criteria, so that found suppliers that are in ac-cordance with the company. Then the Linear Program is used to determine the opti-mal raw material order from each supplier that has been sorted. After analyzing the results and understanding the available data. Then the results are obtained as a solu-tion which will later become a recommendation for the company regarding the selec-tion of suppliers and the optimal order quantity for each supplier.

RESULT AND DISCUSSION

On this section, will describes about the calculation's methods of AHP and linear programming and the discussion analysis from the methods. The first time AHP and LP approaches to propose a supplier selection model was made by Ghodsypour and O'Brien (1998).

AHP

Criteria	Cost	Quality	Delivery	fullfill orders	Cost	Quality	Delivery	fullfill orders	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
									Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
Cost	1.00	0.20	0.33	0.33	0.08	0.04	0.17	0.05	0.34	0.08	0.35	4.12				
Quality	5.00	1.00	0.33	3.00	0.42	0.22	0.17	0.41	1.21	0.30	1.74	5.74				
Delivery	3.00	0.33	1.00	3.00	0.25	0.07	0.50	0.41	1.23	0.31	1.58	5.11	4.03	0.01	0.90	0.01
fullfill orders	3.00	3.00	0.33	1.00	0.25	0.66	0.17	0.14	1.21	0.30	0.35	1.15				
Total	12.00	4.53	2.00	7.33	1.00	1.00	1.00	1.00	4.00	1.00	4.02	16.12				

Fig. 1. Criteria weighted and consistency test

Sub Criteria	Frequency of rejection of raw materials	Compliance with company standards	Frequency of rejection of raw materials	Compliance with company standards	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
Frequency of rejection of raw materials	1.00	3.00	0.75	0.75	1.50	0.75	1.50	2.00	4.00	2.00	0.00	0.00
Compliance with company standards	0.33	1.00	0.25	0.25	0.50	0.25	1.50	6.00				
Total	1.33	4.00	1.00	1.00	2.00	1.00	3.00	8.00				

Cont.

Sub Criteria	Timeliness of Delivery	Suitability of the quantity of goods sent with the quantity of goods ordered	Timeliness of Delivery	Suitability of the quantity of goods sent with the quantity of goods	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
Timeliness of Delivery	1.00	0.33	0.25	0.25	0.50	0.25	0.50	2.00	3.17	1.17	0.00	0.00
Suitability of the quantity of goods sent with the quantity of goods ordered	3.00	1.00	0.75	0.75	1.50	0.75	3.25	4.33				
Total	4.00	1.33	1.00	1.00	2.00	1.00	3.75	6.33				

Fig. 2. Sub Criteria weighted and consistency test

Cost	DS	LG	DS	LG	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
DS	1.00	3.00	0.75	0.75	1.50	0.75	1.50	2.00	3.17	1.17	0.00	0.00
LG	0.33	1.00	0.25	0.25	0.50	0.25	1.08	4.33				
Total	1.33	4.00	1.00	1.00	2.00	1.00	2.58	6.33				

Cont.

Quality	DS	LG	DS	LG	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
DS	1.00	3.00	0.75	0.75	1.50	0.75	1.50	2.00	3.17	1.17	0.00	0.00
LG	0.33	1.00	0.25	0.25	0.50	0.25	1.08	4.33				
Total	1.33	4.00	1.00	1.00	2.00	1.00	2.58	6.33				

Cont.

Delivery	DS	LG	DS	LG	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
DS	1.00	3.00	0.75	0.75	1.50	0.75	1.50	2.00	3.17	1.17	0.00	0.00
LG	0.33	1.00	0.25	0.25	0.50	0.25	1.08	4.33				
Total	1.33	4.00	1.00	1.00	2.00	1.00	2.58	6.33				

Cont.

fullfill orders	DS	LG	DS	LG	1	2	3	4 = 3/2	5 = Sum 4/Sum 1	6 = (5 - Sum 1)/(Sum 1- 1)	7	8 = 6/7
					Total Weight Matrix	eugen vector	Matrix Multiple	Eugen Value	λ maks	CI	IR	CR
DS	1.00	3.00	0.75	0.75	1.50	0.75	1.50	2.00	3.17	1.17	0.00	0.00
LG	0.33	1.00	0.25	0.25	0.50	0.25	1.08	4.33				
Total	1.33	4.00	1.00	1.00	2.00	1.00	2.58	6.33				

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Fig. 3. Criteria Alternative weighted and consistency test

Timeliness of Delivery	DS	LG	DS	LG	1 Total Weight Matrix	2 eugen vector	3 Matrix Multiple	4 = 3/2 Eugen Value	5 = Sum 4/Sum 1 λ maks	6 = (5 - Sum 1)/(Sum 1- 1) CI	7 IR	8 = 6/7 CR
DS	1.00	3.00	0.50	0.75	1.25	0.63	1.75	2.80	3.23	1.23	0.00	0.00
LG	1.00	1.00	0.50	0.25	0.75	0.38	1.38	3.67				
Total	2.00	4.00	1.00	1.00	2.00	1.00	3.13	6.47				

Cont.

Frequency of rejection of raw materials	DS	LG	DS	LG	1 Total Weight Matrix	2 eugen vector	3 Matrix Multiple	4 = 3/2 Eugen Value	5 = Sum 4/Sum 1 λ maks	6 = (5 - Sum 1)/(Sum 1- 1) CI	7 IR	8 = 6/7 CR
DS	1.00	1.00	0.50	0.50	1.00	0.50	1.00	2.00	2.50	0.50	0.00	0.00
LG	1.00	1.00	0.50	0.50	1.00	0.50	1.50	3.00				
Total	2.00	2.00	1.00	1.00	2.00	1.00	2.50	5.00				

Cont.

Compliance with company standards	DS	LG	DS	LG	1 Total Weight Matrix	2 eugen vector	3 Matrix Multiple	4 = 3/2 Eugen Value	5 = Sum 4/Sum 1 λ maks	6 = (5 - Sum 1)/(Sum 1- 1) CI	7 IR	8 = 6/7 CR
DS	1.00	3.00	0.50	0.75	1.25	0.63	1.75	2.80	3.23	1.23	0.00	0.00
LG	1.00	1.00	0.50	0.25	0.75	0.38	1.38	3.67				
Total	2.00	4.00	1.00	1.00	2.00	1.00	3.13	6.47				

Cont.

Suitability of the quantity of goods sent with the quantity of goods ordered	DS	LG	DS	LG	1 Total Weight Matrix	2 eugen vector	3 Matrix Multiple	4 = 3/2 Eugen Value	5 = Sum 4/Sum 1 λ maks	6 = (5 - Sum 1)/(Sum 1- 1) CI	7 IR	8 = 6/7 CR
DS	1.00	3.00	0.50	0.75	1.25	0.63	1.75	2.80	3.23	1.23	0.00	0.00
LG	1.00	1.00	0.50	0.25	0.75	0.38	1.38	3.67				
Total	2.00	4.00	1.00	1.00	2.00	1.00	3.13	6.47				

Fig. 4. Sub Criteria Alternative weighted and consistency test

From Fig. 2 to Fig. 5, it can be seen that, the CR value of the entire image is less than 0.1, therefore the test is consistently successful and it can be concluded that the data has been valid and can proceed to the decision to determine the supplier weights

	Atribute						
	Biaya	Kualitas			Pengiriman	Memenuhi Pesanan	
		0.30			0.31		
Atribute Weight	0.08	Frekuensi penolakan terhadap bahan baku yang dikirim	Kesesuaian dengan standar perusahaan	Ketepatan waktu pengiriman	Kesesuaian kuantitas barang yang dikirim dengan kuantitas barang yang dipesan	0.30	*Alt. Weight Evaluation*
		0.75	0.25	0.25	0.75		
	Alternatif						
DS	0.75	0.50	0.63	0.63	0.63	0.75	0.65
LG	0.25	0.50	0.38	0.38	0.38	0.25	0.35

Fig. 5. Decision Making

Linear Programming

The formulation of linear programming models in this study refers to the re-search of Lin et al. (2011) with the title An ERP model for supplier selection in electronics industry and Ghodsypour & O'Brien (1998) with the title A decision support system for supplier selection using integrated analytical hierarchy process and linear programming. The following is the objective function in the linear programming model

Max Zi = $\sum_{i=1}^{n} S_i \ . X_i$ (1)

then the constraint function in the linear programming model is:

1. Constraint of demand
   $\sum_{i=1}^{n} X_i$ = Q (2)
2. Constraints of cost
   $\sum_{i=1}^{n} X_i \ . B_i \leq$ C (3)
3. Constraint of quality
   $\sum_{i=1}^{n} X_i \ . K_i \leq$ QK (4)
4. Constraint of delivery
   $\sum_{i=1}^{n} X_i \ . P_i \leq$ QP (5)
5. Constraint to fulfilment orders
   $\sum_{i=1}^{n} X_i \ . M_i \leq$ QM (6)

Constant linear programming model:

S_i = rating scale supplier
X_i = quantity order supplier (ton)
B_i = raw material price (Rp/ton)
K_i = supplier quality criteria weights
P_i = weight of supplier delivery criteria
M_i = criteria for fulfilling orders weights
Q = company demand (ton)
C = cost of purchase (Rp/ton)
K = quality weights
P = delivery weights
M = weights fulfiment order

		DS	LG		
	quantity	7.5	7.5		
variables	**Variable**			**used**	**constrains**
	cost	10,000,000	9,500,000	146,250,000.00 ≤	150,000,000
	quality	0.75	0.25	7.50 ≤	7.5
	delivery	0.75	0.25	7.50 ≤	7.75
	fullfillment	0.75	0.25	7.50 ≤	7.5
	DS			7.50 ≤	25
	LG			7.50 ≤	25
	demand			15.00 =	15
objective	**maximize**	**0.65**	**0.35**	7.50	

Fig. 6. Optimization results using excel solver

From the Fig. 6, it can be concluded that the determination of the optimal quantity of ingredients for both suppliers is 7.5 tons for DS suppliers and 7.5 tons for LG suppliers. Then the costs that can be reduced from this optimization, which is equal to Rp 3,750,000 or 3% of the purchase cost, can be reduced from this optimization.

CONCLUSION

From the results of the above research, it can be concluded, the results of determi-nation of supplier weight using the AHP method, namely DS suppliers get a weight of 0.65 and LG suppliers get a weight of 0.35. The optimal order for each supplier is a DS supplier of 7.5 tons and an LG supplier of 7.5 tons and costs re-duced from this optimization result of Rp 3,750,000 or the purchase cost can be reduced by 3%.

REFERENCES

[1] Uhl, C., Nabhani, F., Kauf, F., Shokri, A., Hughes, D.: Purchasing Management: The Optimisation of Product Variance. Procedia Manufacturing. 11, 1366-1374 (2017).
[2] Omurca, S.: An intelligent supplier evaluation, selection and development system. Applied Soft Computing. 13, 690-697 (2013).
[3] Bruno, G., Esposito, E., Genovese, A., Passaro, R.: AHP-based approaches for supplier evaluation: Problems and perspectives. Journal of Purchasing and Supply Management. 18, 159-172 (2012).