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Supplier Selection Analysis Using Minmax Multi Choice Goal Programming Model

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ABSTRACT

Production control, inventory and distribution is an important factor in trading activities. These three factors are discussed in a system called Supply Chain Management (SCM). Procurement of goods from a company or trading business related to suppliers. In some cases, there are several suppliers that can be assessed by considering certain factors. In certain cases, the data from several factors that are considered are uncertainty, so the fuzzy approach can be used. The MINMAX Multi Choice Goal Programming model can be used to solve fuzzy supplier selection problems with linear membership function. It can be applied to selecting supplier of Brastagi Oranges. There are four suppliers, namely Jaya, Mako, Baros. Gina. There are three factor to consider, cost, quality and delivery. The decision maker selects the best supplier for ordering 17000 kg Brastagi oranges. The results, the best supplier is Gina with an order quantity of 10000 kg and Mako with a total order of 7000 kg.

Keywords: fuzzy; MINMAX multi choice goal programming; supply chain management; supplier selection

INTRODUCTION

Supply chain management has three main components, namely the process of obtaining suppliers of raw materials, the process of changing raw materials into finished products and the product distribution process. The first stage in the supply chain is supplier selection. Selection of suppliers aims to get products with good quality and competitive prices. Supplier selection is related to the process of procuring goods to meet customer demands. price and quality, time of delivery is a consideration in supplier's selection, especially for perishable products. Fruit is a type of product that does not last long if not stored in the refrigerator.

Research related to supply chains with application in various fields and solutions have been carried out with several approaches. The application of fuzzy TOPSIS in supplier selection was introduced by [1]. The fuzzy approach is also used by [2] in the selection of suppliers in manufacturing companies. The application of the supply chain concept to inventory control and supplier selection for planning new product production in several planning horizons was carried out by [3]. Discussion of supply chain problems

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by considering price, supply and demand factors is carried out by [4] and an efficient Lagrangian relaxation algorithm is proposed to solve the model. A discussion of bioethanol supply chain network problems with a robust approach was introduced [5]. A deterministic approach to solving the supply chain problem of food product distribution is discussed by [6]. The application of the mix integer programming model to the distribution and supply chain problems of liquid helium is given by [7]. The research of the [8] is combines the concepts of siting, inventory and routing in the supply chain.

There are two main studies related to the supplier selection model to be used, namely the concept of fuzzy and fuzzy goal programming. The Goal Programming (GP) model is used in problems with several objectives to be achieved simultaneously. The GP model with fuzzy numbers is called the Fuzzy Goal Programming (FGP) model. The concept of FGP with random variables was introduced by [9]. Fuzzy and probabilistic approaches to the FGP model are discussed by [10]. Completion of the FGP model with a genetic algorithm is discussed by [11]. Research [12] uses a multi-choice goal programming model to determine energy renewal facilities. [13] used the FGP model in production planning. The choice of waste transportation mode using the FGP model was introduced by [14]. The application of the Weighted Goal Programming model in the urban planning process is given by [15]. The application of the GP model in capital management is given by [16]. The use of the FGP model in transportation problems with several modes of transportation is given by [17].

The research that has been mentioned is the implementation of the supply chain concept to supplier, inventory and distribution components. This research will discuss the problem of selecting suppliers of Brastagi oranges using MINMAX Multi Choice Goal Programming models (Minmax MCGP). The research focus is on component suppliers. This research is a basic research by developing the MINMAX Multi Choice Goal Programming introduced by [2]. In [2], the fuzzy number used is the trapezoid fuzzy number by considering the factors of price, quality and technology offered. In this study, price, quality and time of delivery are considering. Linear membership function is used to define these tree factor.

METHODS

The steps for completing the supplier selection using the MINMAX MCGP method are:

1. Data Collection and Description
   The data used in this study is primary, consist of data on the purchase with the parameters of cost, quality and delivery. The data collection period is from 18 February to 18 March 2020.
2. Determine the fuzzy triangular membership value for the goal of price, quality and delivery. Following are given fuzzy membership functions for the respective three goals, in order of price, quality and timeliness of delivery which are formulated based on the data in step 1. The restriction value of variable c, k, d is determined based on the data in step 1.

$$\mu(c) = \begin{cases} 1, & c \leq 7800 \\ 1 - \left[\frac{(C - SL_1(c))}{SL_2(c) - SL_1(c)}\right], & 7800 \leq c \leq 10000 \\ 0, & c \geq 10000 \end{cases} \quad (1)$$

$$\mu(k) = \begin{cases} 1, & k \geq 100. \\ \frac{k}{SL_2(k)}, & 0 < k \leq 100. \\ 0, & k \leq 0. \end{cases} \quad (2)$$

$$\mu(d) = \begin{cases} 1, & d \geq 100. \\ \frac{d}{SL_2(d)}, & 0 < d \leq 100. \\ 0, & d \leq 0. \end{cases} \quad (3)$$

Where

$\mu(c)$ is the membership function for the cost.
$\mu(k)$ is the membership function for the quality.
$\mu(d)$ is membership function for delivery
k is the percentage of average supplier quality.
$SL_1(c)$ is Satisfaction Level lower bound for the unit cost.
$SL_2(c)$ is Satisfaction Level upper bound for the unit cost.
$SL_2(k)$ is Satisfaction Level upper bound for the unit quality.
$SL_2(d)$is Satisfaction Level upper bound for the unit delivery.

3. The MINMAX MCGP model formulation based on the membership function values defined in Step 2. The following is the MINMAX MCGP model introduced by [2].

Min D

Subject to

$$\begin{aligned} & D \geq \alpha_i d_i^+ + \beta_i d_i^-, i = 1,2, \dots m, \\ & D \geq \delta_i (e_i^+ + e_i^-), i = 1,2, \dots m, \\ & \mu(x_i) - d_i^+ + d_i^- = y_i, \quad i = 1,2, \dots m, \\ & y_i - e_i^+ + e_i^- = g_{i,max}, \ i = 1,2, \dots, m, \\ & g_{i,min} \leq y_i \leq g_{i,max}, \ i = 1,2, \dots, m, \\ & d_i^+, d_i^-, e_i^+, e_i^- \geq 0, \ i = 1,2, \dots, m, \end{aligned} \quad (4)$$

where

D : the deviation variable of the objective function
α_i and β_i : weight of the positive deviation penalty in the objective function
d_i^+ and d_i^- : positive and negative deviation of the objective function
δ_i : the sum of the deviation in the objective function
e_i^+ and e_i^- : positive and negative deviation on $|y_i - g_{i,max}|$.
y_i : continuous variable with a range of interval value
$g_{i,min}$ and $g_{i,max}$: minimum and maximum y_i value
$\mu(x_i)$: membership function for the supplier to *i*

4. Completion of the model obtained in step (4) uses Lingo 13.0 software
5. Analyses and conclusion

RESULTS AND DISCUSSION

This research discusses supplier selection problem of citrus fruits for the type of Brastagi oranges. The data used are primary data with a data collection period of 30 ordering periods. The research was conducted at a fruit shop in Palembang . The following is given the research data.

Table 1. Ordering the Data for Each Supplier

No	Supplier Name	Ordering		delivery		On time delivery		Price offered		Precentage of quality (%)
		Date	*Month*	*Date*	*Month*			Cost (@kg)	Total	
1	Jaya	21	Feb	21	Feb	√	-	8500	45900000	80
2	Mako	21	Feb	21	Feb	√	-	8000	43200000	85
3	Baros	22	Feb	24	Feb	-	√	8500	45900000	80
4	Gina	22	Feb	22	Feb	√	-	9000	48600000	95
5	Jaya	23	Feb	23	Feb	√	-	8500	45900000	85
6	Mako	24	Feb	24	Feb	√	-	8500	45900000	90
7	Baros	25	Feb	25	Feb	√	-	8000	43200000	80
8	Mako	25	Feb	25	Feb	√	-	9000	48600000	90
9	Gina	26	Feb	26	Feb	√	-	9000	48600000	90
10	Mako	27	Feb	28	Feb	-	√	8000	43200000	85
11	Jaya	27	Feb	27	Feb	√	-	8500	45900000	85
12	Baros	28	Feb	28	Feb	√	-	8000	43200000	85
13	Mako	29	Feb	1	Maret	-	√	9000	48600000	85
14	Gina	29	Feb	29	Feb	√	-	9500	51300000	90
15	Jaya	1	Maret	2	Maret	-	√	8500	45900000	85
16	Mako	1	Maret	1	Maret	√	-	9000	48600000	95
17	Baros	2	Maret	2	Maret	√	-	9000	48600000	80
18	Mako	3	Maret	3	Maret	√	-	9000	48600000	85
19	Gina	4	Maret	4	Maret	√	-	9500	51300000	85
20	Jaya	5	Maret	6	Maret	-	√	9000	48600000	85
21	Baros	5	Maret	5	Maret	√	-	9000	48600000	80
22	Mako	6	Maret	6	Maret	√	-	9000	48600000	90
23	Gina	7	Maret	7	Maret	√	-	9500	51300000	95
24	Jaya	8	Maret	10	Maret	-	√	9000	48600000	80
25	Baros	8	Maret	8	Maret	√	-	9000	48600000	85
26	Gina	9	Maret	9	Maret	√	-	9500	51300000	95
27	Mako	9	Maret	9	Maret	√	-	9000	48600000	90
28	Jaya	10	Maret	12	Maret	-	√	8500	45900000	85
29	Baros	10	Maret	10	Maret	√	-	9000	48600000	80
30	Gina	11	Maret	11	Maret	√	-	9500	51300000	85
31	Jaya	12	Maret	13	Maret	-	√	9000	48600000	80
32	Mako	13	Maret	13	Maret	√	-	9000	48600000	85
33	Jaya	13	Maret	14	Maret	-	√	9000	48600000	90

34	Gina	14	Maret	14	Maret	√	-	9500	51300000	90
35	Baros	15	Maret	16	Maret	-	√	8500	45900000	85
36	Mako	15	Maret	15	Maret	√	-	9000	48600000	90
37	Gina	16	Maret	16	Maret	√	-	9500	51300000	90
38	Jaya	16	Maret	18	Maret	-	√	8500	45900000	85
39	Mako	17	Maret	17	Maret	√	-	9000	48600000	90
40	Gina	19	Maret	18	Maret	-	√	9000	48600000	95
41	Baros	19	Maret	19	Maret	√	-	8500	45900000	90
42	Jaya	19	Maret	20	Maret	-	√	8500	45900000	80
43	Mako	19	Maret	21	Maret	-	√	8500	45900000	80
44	Gina	20	Maret	20	Maret	√	-	9000	48600000	90
45	Jaya	20	Maret	22	Maret	-	√	8000	43200000	80
46	Baros	21	Maret	21	Maret	√	-	8500	45900000	90
47	Mako	21	Maret	22	Maret	-	√	8500	45900000	85

(Source : PD Wibowo, 21 februari until Maret 2020)

Table 1 can determine the percentage of on-time delivery, the variable price offered, and the varying percentage of quality citrus in good condition with the total of all oranges sent by the supplier. The price value of each supplier is obtained by adding up each price in purchases divided by the number of investments, determined the average value for each data cost, quality, and timeliness. The calculation results are given in Table 2 below.

Table 2. Value Percentage Criteria from Four Suppliers

Supplier	x_i	**Cost (Rp)**	**Quality (%)**	**Delivery (%)**	**Total Order (kg)**
Jaya	$\boldsymbol{x_1}$	8625	83,33	25,00	64800
Mako	$\boldsymbol{x_2}$	8750	87,50	71,43	75600
Baros	$\boldsymbol{x_3}$	8600	83,50	80,00	54000
Gina	$\boldsymbol{x_4}$	9318	90,91	90,91	59400

Determined the degree of membership for the level of satisfaction of the Decision Maker (DM) of each goal using (1), (2), (3). The calculation results are given in Table 3 below:

Table 3. Degree of Membership for DM Satisfaction Level of Each Goal

Decision	**Lowest**				**Highest**
$\boldsymbol{c}$: Cost	> 10000	8465.4	8243.6	8021.8	7800
SL(c), Satisfaction Level c	0	0,7	0,8	0,9	1
$\boldsymbol{k}$: Kualitas	0	40	60	80	100
SL(k), Satisfaction Level k	0	0,4	0,6	0,8	1
$\boldsymbol{d}$: Ketepatan Waktu	0	40	60	80	100
SL(d), Satisfaction Level d	0	0,4	0,6	0,8	1

The value of the level of satisfaction is in the interval [0,1]. Based on Table 3, it is known that for the lowest decision value, DM gives a satisfaction level value of 0. For the highest decision value, DM gives a satisfaction level value 1. The level of satisfaction for each goal of cost, quality, and time delivery is determined based on equations (1), (2), and (3). The results are given in Table 4 below.

Table 4. Membership Function Value for Each Goal

Supplier	**Amount Of Order**	**Cost**	**Quality**	**Delivery**
Jaya	x_1	0,625	0,83	0,25
Mako	x_2	0,568	0,88	0,71
Baros	x_3	0,636	0,84	0,8
Gina	x_4	0,31	0,91	0,91
Average		0,53	0,865	0,6675
Maximum Value		0,636	0,91	0,91

The lower bound for the price goal is determined based on the average price value multiplied by the minimum order. The upper price is the product of the maximum value of the price times the maximum order. The same calculation is done for quality goals and on time delivery. We obtained a lower bound and an upper bound for the goal value of price, quality and on time delivery respectively 28876,5; 48081,6; 49013,2; 70308; 36045; 68796. The formulation of the MINMAX MCGP model (4) the problem of supplier's selection of Brastagi Oranges with a maximum order quantity for each supplier of 10000 kg, minimum order of 15000 kg and a maximum of 17000 kg is given as follows.

Minimum D
Subject to

$$
\begin{aligned}
& D \geq 3d_1^+ + d_1^- \\
& D \geq e_1^+ + e_1^- \; ; D \geq d_2^+ + 5d_2^- \\
& D \geq e_2^+ + e_2^- ; D \geq d_3^+ + 3d_3^- \; ; D \geq e_3^+ + e_3^- \\
& 0{,}625x_1 + 0{,}568x_2 + 0{,}636x_3 + 0{,}31x_4 - d_1^+ + d_1^- = y_1 \\
& y_1 - e_1^+ + e_1^- = 48081{,}6 \\
& 28876{,}5 \leq y_1 \leq 48081{,}6 \\
& 0{,}83x_1 + 0{,}88x_2 + 0{,}84x_3 + 0{,}91x_4 - d_2^+ + d_2^- = y_2 \\
& y_2 - e_2^+ + e_2^- = 70308 \\
& 49013{,}2 \leq y_2 \leq 70308 \\
& 0{,}25x_1 + 0{,}71x_2 + 0{,}8x_3 + 0{,}91x_4 - d_3^+ + d_3^- = y_3 \\
& y_3 - e_3^+ + e_3^- = 68796 \\
& 36045 \leq y_3 \leq 68796 \\
& x_1 \leq 10000; x_2 \leq 10000 \; ; x_3 \leq 10000 \; ; x_4 \leq 10000 \\
& x_1 + x_2 + x_3 + x_4 \geq 15000 \; ; x_1 + x_2 + x_3 + x_4 \leq 17000 \\
& d_1^+, d_1^-, e_1^+, e_1^-, y_1, y_2, y_3 \geq 0
\end{aligned}
\qquad (5)
$$

Solving the linear model (5) uses LINGO 13 software and the solution is obtained in Table 5 below.

Table 5. MINMAX MCGP Model Solution for Citrus Fruit Supplier Selection

No	Variable	Value
1.	x_1	0
2.	x_2	7000
3.	x_3	0
4.	x_4	10000
5.	y_1	39463.88
6.	y_2	28876.50
7.	y_3	36764.17
8.	D_1^+	0
9.	D_1^-	32387.88
10.	e_1^+	0
11.	e_1^-	8617.725
12.	D_2^+	0
13.	D_2^-	13616.5
14.	e_2^+	0
15.	e_2^-	39919.50
16.	D_3^+	0
17.	D_3^-	22694.17
18.	e_3^+	0
19.	e_3^-	32031.83
20.	D	68082.50

In Table 5, for a maximum total order of 17000 kg, an order is recommended for x_2 (Supplier Mako) and x_4 (Supplier Gina). The values of y_1 (Aspiration Rate G1) = 39463.88, y_2 (Aspiration Rate G2) = 28876.50, y_3 (Aspiration Rate G3) = 36764.17, and other deviations are given in Table 5. The values of x_1, x_2, x_3, and x_4 are 0, 7000, 0, 10000, respectively. It can be concluded that the order for selecting the best supplier is Supplier Gina with an order quantity of 10000 kg, Supplier Mako with an order quantity of 7000 kg.

CONCLUSIONS

the results obtained the best supplier for orders of a maximum of 17000 kg are Gina Supplier with a total order of 1000 kg of Brastagi oranges and Mako supplier with a maximum order of 7000 kg. The best supplier order is obtained by looking at the difference in the value of the deviation from the target for each goal of price, quality and delivery. The difference in goal value results in a different order of supplier selection.

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