Production Planning Optimization Using Goal Programming Method in Habibah Busana

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***Abstract*—Habibah Busana is a company that engaged in field of convection. The main products are moslem fashion and mukena for children. As we know, main challenge in the field of convection business is unpredictable changes in model. To face these challenges, company must be able to calculate amount of production. We propose Goal Programming method to determine combination of number of products by considering multiple objectives, namely maximizing revenue, minimizing production costs and maximizing machine usage. This method has been widely used for solving multi-criteria problems in various fields. The result shows how many products should be produced to achieve the most optimal production results, which appropriate with company objective.**

***Index Terms*—goal programming, multi-criteria, production planning**

I. Introduction

Convection Company is a company that process cloth raw materials into clothing in a home industry business scale. At this time, many convection companies come up in the business world that makes a very tight competitive atmosphere. Convection business has a big challenge. That challenge is modelling changing period that hard to predict. That is why convectional company must have a strategy so that company can survive and become the leader in it's own field. [1].

Habibah Busana is a company that specialized in Moslem clothing and mukena for children convection. In the course of its business, Habibah Busana has several aims. That aims are maximize profit, minimize production cost, and maximize machine usage. To reach those aims, several factors have to be considered, such as customer, product, market, and manufacture.

All this time, Habibah Busana has not yet reach optimal profit. This information can be known from remain of sales. Every sale has an average of 20 % remain from total sales. If Habibah Busana plan its production good enough, it's remaining sales can be minimized so optimal profit can be achieved.

The fast evolving of technology and increasing problem complexity in company make the demand to solve the problem is high. In previous work, there were several approach methods used by scientist to do research about optimization of product planning, one of them is Linear Programming. Linear Programming is a method for searching optimal value from a problem that can be transformed to linear model [2]. The lack of this method is it's capability to compute goal model function. This method only execute linear model with one goal function [3]. That is why production planning problem in Habibah Busana Company can not use this method because there are several goal to be considered [4].

To solve the problem in this research, a method that can take decision based on several criteria is needed. Therefore, Goal Programming methods is implemented. This method has been used as multi criteria problem solving in many fields. In this research, goal programming method will be used to determine the sum of product combination that take account of several company goals [5].

II. Methodology

A. Data Processing

Data acquired from Habibah Busana is still a raw data that need to be processed. Data that need processing are product request, raw material cost, labor cost, rent cost, and overhead cost. Equation (1) to (5) is fomula that are used to calculate overhead cost :

- a and b calculation :

$$b = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \quad (1)$$

$$a = \frac{\sum y}{n} - b(\frac{\sum x}{n}) \quad (2)$$

- BOH total (Y)

$$(Y) = a + bx \quad (3)$$

$$BOH/_{unit/_{period}} = \frac{processtime}{totalproduction} \cdot BOH_{total} \quad (4)$$

$$BOH/_{unit/_{period}} = \frac{\frac{BOH}{unit}/_{period}}{numberofproductionunit} \cdot BOH_{total} \quad (5)$$

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To predict the next product demand data, demand forecasting process is needed. Product demand forecasting use Winter and Double Moving Average method because there are two type of purchasing data. Fig. 1 show an example of data type comparison graph that is forecasted using Winter and Double Moving Average method.

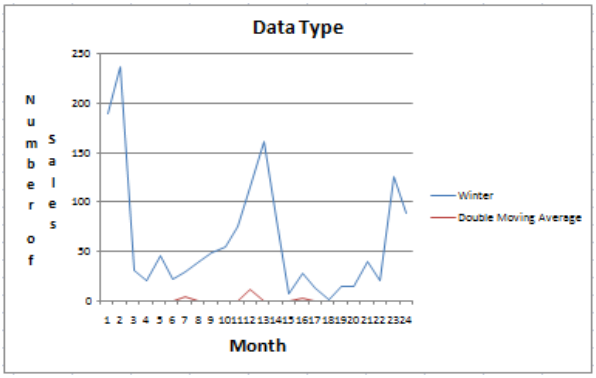

Figure 1. Data type comparison that forecasted using winter and double moving average method

B. Goal Programming Model Development

The following are steps of Goal Programming model development process.

1) Goal programming model formulation

Before formulating goal programming model, model creation in linier programming is needed. The following is steps in creating model:

a) Determine decision variable

Decision variables that will be searched in optimization of goal programming method are:

$X_1 - X_{15}$ = Number of Takwa (T) moslem clothing size 0 – 14

$X_{16} - X_{30}$ = Number of Takwa Rompi (TR) moslem clothing size 0 – 14

$X_{31} - X_{45}$ = Number of Terusan (JOV) moslem clothing size 0 – 14

$X_{46} - X_{60}$ = Number of Jubah (J) moslem clothing size 0 – 14

$X_{61} - X_{75}$ = Number of Terusan Rompi (JR) moslem clothing size 0 – 14

$X_{76} - X_{90}$ = Number of Setelan Celana Rompi (SROM) moslem clothing size 0 – 14

$X_{91} - X_{105}$ = Number of Setelan Rok Rompi (SROK/ROM) moslem clothing size 0 – 14

$X_{106} - X_{120}$ = Number of Setelan Celana (S) moslem clothing size 0 – 14

$X_{121} - X_{135}$ = Number of Setelan Rok (SROK) moslem clothing size 0 – 14

$X_{136} - X_{141}$ = Number of Mukena (M) moslem clothing size XS – XXL

b) Constraints functions formulation

Raw material constraint:

$$\sum_{i=1}^{m} B_{ji} x_i \leq K_{bbj} \quad (6)$$

Explanation:

B_{ji} = sum of usage of raw material j for product i

X_i = sum of product i

m = quantity of product type

K_{bbj} = capacity of available raw material j

Machine Work time Constraint

$$\sum_{i=1}^{m} M_{ji} x_i \leq K_{mj} \quad (7)$$

Explanation:

M_{ji} = producing time of machine j to produce product i

X_i = sum of product i

m = quantity of product type

K_{mj} = capacity of labor work time on available machine j

Demand Constraint

$$X_i \geq K_p, i = 1...m \quad (8)$$

Explanation:

X_i = sum of product i

m = quantity of product type

K_{mj} = capacity of demand

c) Determine Goal Function

Maximize Sales income:

Goal function:

$$\text{Max } Z = \sum_{i=1}^{m} S_i X_i \quad (9)$$

Explanation:

X_i = sum of product i

m = quantity of product type

S_i = selling price per unit of product i

Minimize Production Cost:

Goal function:

$$\text{Min } Z = \sum_{i=1}^{m} C_i X_i \quad (10)$$

Explanation:

X_i = sum of product i

m = quantity of product type

C_i = cost per unit of product i

Maximize machine Usage:

Goal function:

$$\text{Max } Z = \sum_{i=1}^{m} O_i X_i \quad (11)$$

Explanation:

X_i = sum of product i

m = quantity of product type

O_i = process time per unit of product i

d) Goal Programming Goal Function Formulation

Maximize profit

Goal function:

$$\text{Max } Z = \sum_{i=1}^{m} S_i X_i \geq T_p \quad (12)$$

Explanation:

X_i = sum of product i

m = quantity of product type

S_i = selling price per unit of product i

T_p = income target

Minimize Production Cost:

Goal function:

$$\text{Min } Z = \sum_{i=1}^{m} C_i X_i \leq T_b \quad (13)$$

Explanation:

X_i = sum of product i

m = quantity of product type

C_i = cost per unit of product i

T_b = cost target

Maximize Machine Usage:

Goal function:

$$\text{Max } Z = \sum_{i=1}^{m} O_i X_i \leq T_m \quad (14)$$

Explanation:

X_i = sum of product i

m = quantity of product type

O_i = process time per unit of product i

T_m = total capacity of machine regular work time

With the addition of deviation variable, constraints from linear programming change into these.

$$\sum_{i=1}^{m} S_i X_i + d_1^- - d_1^+ = T_p \quad (15)$$

$$\sum_{i=1}^{m} C_i X_i + d_2^- - d_2^+ = T_b \quad (16)$$

$$\sum_{i=1}^{m} O_i X_i + d_3^- - d_3^+ = T_m \quad (17)$$

Explanation:

d_j^- = downward deviations

d_j^+ = upward deviations

The new goal functions consist of deviation variable. There are several rules in goal programming to determine new goal function. Those rules are

1. If the initial formula that will be added with deviation variable is $y \geq 0$, then the new goal function will minimize d_j^-.
2. If the initial formula that will be added with deviation variable is $y \leq 0$, then the new goal function will minimize d_j^+.

According to those rules, goal programming goal will change into:

Goal 1:

$$\text{Min } Z = \sum d_1^- \quad (18)$$

Goal 2:

$$\text{Min } Z = \sum d_2^+ \quad (19)$$

Goal 3:

$$\text{Min } Z = \sum d_3^- \quad (20)$$

So goal function Z change into:

$$\text{Min } \quad Z = \sum d_1^- + \sum d_2^+ + \sum d_3^- \quad (21)$$

In the course of determining goal function, weighing method chosen with weight for every goal equals to one. This is caused by wish and goal of the company. According to the company, these three goals have same rate of importance so every goal has one weight.

e) Goal programming model constraint

The followings are goal programming model constraints.

1. Raw material
2. Machine
3. Demand
4. Income Target
5. Cost Target
6. Machine Target
7. Deviation variable constraints :

- $d_1^- \geq 0$
- $d_2^+ \geq 0$
- $d_3^- \geq 0$

2) Translating model to matlab software

To get the result from the created model, computer software is needed. The software that will be used is Matlab.

III. Result and Study

A. Goal Programming Result

Goal Programming model's program analysis is an important process in company's production planning. From this analysis, it can be seen how total product that need to be produced influenced other factors. Fig. 2 shows optimized result that has been rounded up. In this figure, the obtained D1, D2, and D3 values become deviation variable that become goal function of goal programming. Then the line under deviation variable becomes decision variable value.

To simplify the view, a graph that portrays the optimal sales value for every type of product in six months. The following is explanation for one product, Takwa Moslem clothing.

	A	B	C	D	E	F	G	H	I
1			Optimization Result						
2	Num	Product Type	1st Month	2nd Month	3rd Month	4th Month	5th Month	6th Month	Decision Variable
3	D1	D1	0	0	0	0	0	0	D1
4	D2	D2	0	0	0	0	0	0	D2
5	D3	D3	0	0	0	0	0	0	D3
6	1	T/0	12	6	10	21	49	92	x1
7	2	T/1	12	7	17	74	182	181	x2
8	3	T/2	12	13	31	99	132	273	x3

Figure 2. Optimized result after rounding up

From Fig. 3 and Fig. 4, it can be seen that forecasting result and optimized result are similar. Month with highest demand is June. June has the highest demand because June is very close to Ramadan and Idul Fitri. From perspective of size, sizes with high demand are size 5, 6, 7, 8, and 9. On January, February, and March can be known that demand is low.

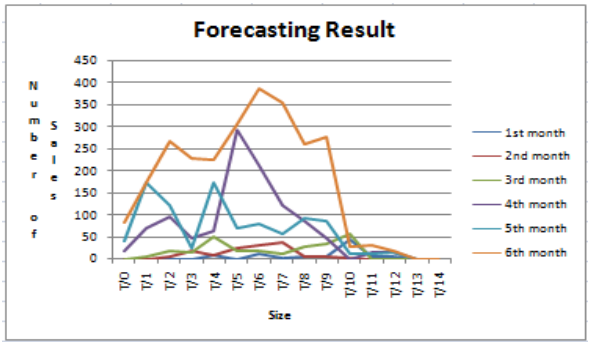

Figure 3. Takwa forecasting result

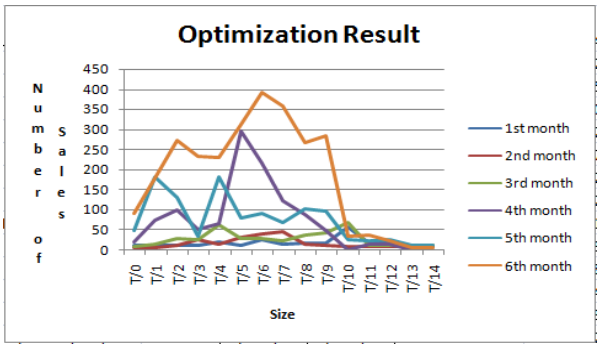

Figure 4. Takwa optimized result

To ascertain the achievement of optimized result towards goal that wants to be reached, comparison between goals with optimal point. In reviewing, this can be seen from deviation variable value because the goal of goal programming is to minimize deviation variable value. If deviation variable value is zero, it can be said that the goal is reached. The greater the value of deviation variable, goal achievement is smaller. From Fig. 4, it can be seen that the value of those three deviation variable are zero. Therefore, it can be concluded that all three goals are achieved. The followings are comparisons between target and optimized result.

1) Income

In Table I, it can be seen that for every months all of optimized incomes exceeded target. To reach optimal value, company must make harder efforts. Comparison between target value and optimal value are very high, especially on June and January.

TABLE I. COMPARISON BETWEEN TARGET AND OPTIMAL INCOME

Month	Total Product	Income Target (Rp)	Total of Optimal Product	Income (Rp)
January	482	92.709.000	2017	401.465.000
February	819	158.020.000	1302	257.679.000
March	1350	251.322.000	2314	457.274.000
April	1770	334.724.000	2999	560.464.000
May	4502	858.233.000	5145	970.455.000
June	2783	514.657.000	7608	1.414.725.000

2) Cost

In Table II it can be seen that costs to reach optimal result did not exceed the target. June is month with the biggest differences between optimal cost and target.

TABLE II. COMPARISON BETWEEN TARGET AND OPTIMAL COST

Month	Total Product	Cost Target (Rp)	Total of Optimal Product	Cost (Rp)
January	2369	196.214.814	2017	193.644.068
February	1537	125.197.528	1302	124.307.726
March	2636	220.295.233	2314	219.478.305
April	2995	260.390.803	2999	259.314.079
May	5159	442.586.129	5145	442.016.804
June	8745	732.738.571	7608	651.144.248

3) Machine usage

In Table III it can be seen that no machine usage has exceed the target. There are several months where differences between optimal usage and target very high. It can be company's consideration in labor management because all machines in this company is operated by labors. In this case, company already manages the machine usage well because almost all of the labors are daily labors therefore their received salaries are based on how much job they finished.

TABLE III. COMPARISON BETWEEN TARGET AND OPTIMAL MACHINE USAGE

Month	Machine Usage Target(minute)	Total of Optimal Product	Machine Usage
January	1006278	2017	257429
February	1006278	1302	165440
March	1006278	2314	293333
April	1006278	2999	366531
May	1006278	5145	637214
June	1006278	7608	933274

B. Scenario

Scenario is an alternative other solution searching process against optimal result. Scenario performed against goal function weighting. The followings are several created scenario.

1) Scenario 1

$$\text{Min } Z = 3\sum d_1^- + 2\sum d_2^+ + \sum d_3^- \qquad (22)$$

2) Scenario 2

$$\text{Min } Z = 2\sum d_1^- + 3\sum d_2^+ + \sum d_3^- \quad (23)$$

3) Scenario 3

$$\text{Min } Z = 2\sum d_1^- + \sum d_2^+ + 3\sum d_3^- \quad (24)$$

To know comparison between real conditions optimized result and optimized scenario, it can be seen from income, production cost, and machine usage perspective. Before reviewing those three perspectives, total production comparison between real condition model and scenario can be looked at Fig. 5. Based upon Fig. 5, it can be seen that scenario that has the highest optimal total income is scenario 2.

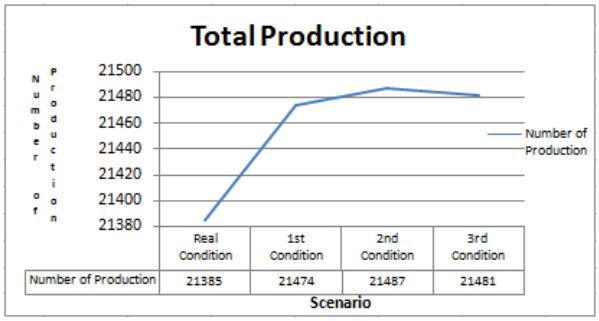

Figure 5. Optimal total production comparison between real condition and scenario 1, 2, and 3

a) Income

Fig. 6 shows graph with comparison of total production and total income that obtained from each respective scenario with real condition.

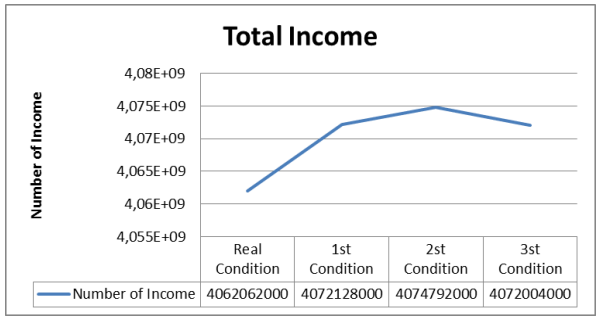

Figure 6. Optimal total income comparison between real condition and scenario 1, 2, and 3

Model with the highest optimal total income is scenario 2.

b) Production cost

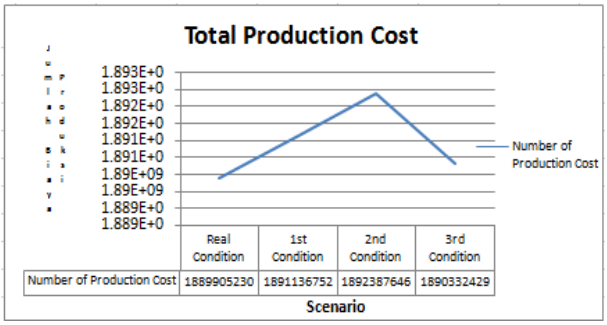

Figure 7. Optimal total production cost comparison between real condition and scenario 1, 2, and 3

From perspective of production cost, comparison between real condition and scenario is showed in Fig. 7.

From production cost perspective, real condition model is the most optimal model because it has the lowest production cost.

c) Machine usage

From machine usage perspective, comparison between real condition and scenario is showed in Fig. 8.

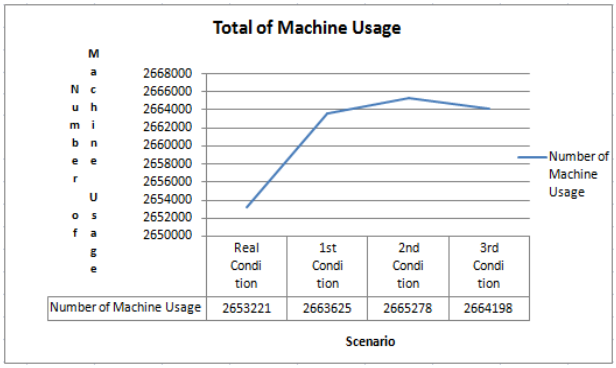

Figure 8. Optimal total machine usage comparison between real condition and scenario 1, 2, and 3

According to the graph, it can be see that from machine usage perspective, the most optimal model is scenario 2 because at that scenario, machine usage is at the most optimal.

d) Profit

Profit is one of indicator of company's success. That is why, to know the most optimal model. It can be seen from profit perspective. Fig. 9 show a graph of total income comparison between real condition and it's respective scenarios.

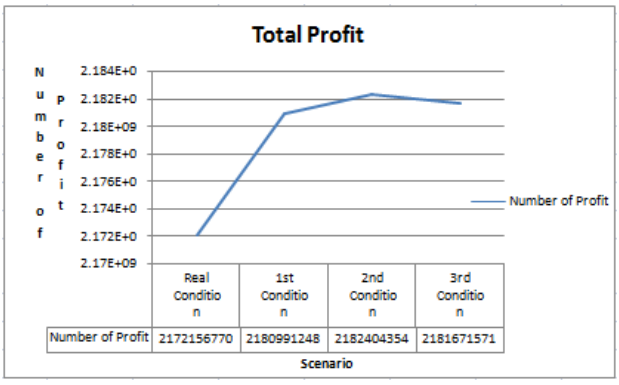

Figure 9. Optimal total profit comparison between real condition and scenario 1, 2, and 3

According to the graph, it can be concluded that the most optimal model is model with goal function that suitable with scenario 2 because when compared with other model, this model can make higher profit.

IV. Conclusion

Based upon processes that have been done in this research, there are several conclusions that can be taken. Those conclusions are:

- Based upon sales data, it can be seen that company's income is greatly influenced by Ramadhan and Idul Fitri. This can be seen from high number of sales on months that near those months. As we know, Ramadhan and Idul Fitri always come one month earlier from its former year.
- Winter forecasting method which is the best basic method for company data type turns out still have a high MAPE value. This is because sales pattern that follow the changing of Ramadhan and Idul Fitri approach.
- From program's output it can be seen that the value of all three deviation variables are zero, so it can be concluded that all three goals are achieved.
- Total sales increase is needed especially for products that have a low desire among consumer than products that has higher desire among consumer.
- Weighting Method in every goals can affect how high the result that outputted.

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