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The Implementation of Goal Programming Method in the Optimization of Furniture Production at UD JK Aluminium in Blitar Regency

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ABSTRACT

Goal Programming is a method of solving problems by allocating company resources with several objectives to obtain an optimal solution. The solution can be obtained by using the QM for Windows program. The results showed that the objective function could be achieved well. The solution to the problem obtained from the QM For Windows application was that the optimal value for the budget cost of the window, storefront, and wardrobe raw materials was the same as the budget cost that had been issued by the furniture production owner, which was Rp. 22,850.000,00 per month. Then the upper limit can be minimized to raw material from aluminum (b1), which was 28.1 meters from the original 610 meters. In order to reach the target of the production process, the average working hours was 55 hours. For a good and correct production volume recommendation, the number of products produced must be optimal to produce 20 units of products consisting of 10 units of windows, five units of show windows, and five wardrobe units per month.

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INTRODUCTION

Mathematics is one of the essential disciplines that grows along with the development of science and technology and the company [1]. UD JK Aluminum Company is one of the furniture companies formed by individuals who have goals and constraints in the company's production process. A furniture company is a company whose management is held directly by the company owner and has the resources due to consumer production demands that must be met [2]. In other words, resources are elements that exist in a process that aims to avoid the possibility caused by the demand and scarcity of inventory, resulting in the company experiencing a slowdown in fulfilling consumer needs [3]. Resource inventory is the inventory of goods that are still in the

production process or raw material inventory that will be used in a production process in a certain period [4]. Production process of furniture companies needs optimization at the production planning stage with limited available resources [5]. The production timelines require good planning to avoid wasting production costs incurred by the company in the production process [6]. Production planning is essential and is used to manage the company's production process [7]. Production planning aims to regulate the process carried out in production as a stage of future activities to avoid company constraints such as waste of production costs incurred by the company and timeliness of production [8]. With good production planning and control, the company will get optimal revenue and save on raw material costs for production [9]. The types of furniture produced are windows, wardrobes, and storefronts. In manufacturing the furniture, UD JK. Aluminum has its management system to manage the company without using specific methods, which causes some problems. A company must have a strategy to maximize production effectively and efficiently [10]. Another obstacle must be resolved in order to achieve optimal conditions. It includes the inventory of raw materials, which is carried out only based on estimates without any calculations in the production process when raw materials are used. Furniture owners are always looking for strategies to minimize costs, one of which is by minimizing the cost of the raw material budget and minimizing the use of raw materials without reducing demand. The types of furniture produced are windows, storefronts, and wardrobes.

Goal Programming is a method that aims to minimize or maximize deviations from specific goals [11]. The Goal Programming method is very effective in optimization because this method has the potential to solve planning aspects such as consumers, products, and manufacturing processes [12]. Qm for Windows will solve the problems that have been formulated in the Goal Programming model [13]. Qm for Windows provides modules in the business decision-making area [14].

Based on the description above, it is known that Goal Programming plays a vital role in the process of solving problems. Therefore, research that will be conducted entitled "Application of Goal Programming Method in Optimizing Furniture Production at UD. JK Aluminum, Blitar Regency".

METHODOLOGY

This research employed a quantitative approach. It applied the Goal Programming method to optimize furniture production of UD. JK Aluminum Blitar Regency. The research area was a furniture production place of JK Aluminum Trade Business, Blitar Regency, East Java. The main objective of this research was to minimize the total cost of the raw material budget, minimize the use of raw materials, minimize working hours, and maximize production results. The steps in achieving the objectives included preliminary activities carried out by determining the research area and then conducting a literature study by seeking relevant information according to the topic or problem to be studied. Next, a research instrument in the form of interview guidelines was made and a permission letter was proposed. The next stage was contacting the validator to test the validity of the interview instrument used for research. Then, coordination with the furniture owner was carried out to propose the research permission and scheduled data collection. The research was conducted to obtain data following the desired objectives. After the data collection, the data obtained through interviews were simplified in tabular form to facilitate understanding. After the data were analyzed, the next step was determining the decision variables, function limit or constraints, and objective functions and creating a linear program model. Following this, a mathematical model from the data that has

been obtained in the company was created and then formed into a Goal Programming model. It was then followed by searching for the optimal solution using Qm for Windows. The data analysis stage was carried out based on the calculation with the POM-QM application, which was compared with data obtained from furniture owners to find the best optimal solution for determining the amount of furniture to be produced.

RESULT AND DISCUSSION

The analysis of interviews conducted with the research subjects covers four aspects, including the budget for raw materials, the use of raw materials, working hours, and production results. In the first data analysis, based on interviews with S1, it was known that there were three kinds of furniture produced, namely windows, storefronts, and wardrobes.

The research entitled "Applying Goal Programming Method to Optimize the Multiple Objectives pursued by Company with Working Hours, Demands, and Raw Materials Constraints" was carried out by Fauziah (2016) and talked about the total value of sales and the cost of production. Maria Yosefa Kabosu and Kartiko (2020) did further research entitled "Analyzing *Goal Programming* (GP) to Optimize UD. *Latanza* Furniture Production Planning"; they brought up minimizing the production cost, maximizing revenue, and the optimal working hours. In these researches, the purposes emphasized were minimizing production cost and the optimal working hours.

This research aimed at minimizing the total cost of raw material budget, using raw materials, working hours, and maximizing the production results. The problems were the amounts of raw material budget, the limits on using raw materials, working hours, and the recommended number of products in monthly production. The problems encountered in the business of aluminum furniture were used as a mathematical model formulation by determining the decision variables, the objective function, and the constraint function. The decision variables used in this research were the number of windows, storefronts, and wardrobes produced in units.

The data analyzed from the interview and literature review covered budget costs, raw materials, and production results in 2020. The following are the data needed to create the Goal Programming model:

Table 1. The data of Budget Cost of Raw Material for UD. JK Aluminum furniture production 2020

No.	Name of Product	Selling Price (Rp/Unit)	Raw Materials			The Cost of Raw Material (Rp/Unit)	Working Hours (hours)	The Number of Productions (unit)
			Aluminum (m)	Glasses (sheet)	complement (pcs)			
1	Window	400.000	2,4	1	5	260.000	0,75	1
2.	Storefront	1.725.000	25	4	50	1.200.000	5	1
3.	Wardrobe	3.750.000	36	6	90	2.850.000	4,5	1

Table 1 informed that the time spent to produce the storefronts was more than the wardrobe production did since producing the storefronts took time to find out the calculation of

the upper and lower elbows at four corners and file them for precision and tightness while angle calculation was unnecessary in producing wardrobe.

Table 2. The Data on The Average Capacity limit of Raw Material Inventory at UD. JK Aluminum in 2020 per month

Raw Materials	Window	Storefront	Wardrobe	Capacity	Unit
Aluminum (b1)	2,4	25	36	610	meter
Glasses (b2)	1	4	6	60	sheet
Complement (b3)	5	50	90	750	pcs

Table 2 shows that the average use of aluminum raw materials was in meters, glass in sheets, and complement in pcs for manufacturing windows, storefronts, and wardrobes per unit. The raw materials for complement at the UD JK aluminum production were quite a lot, including hinges, latch locks, elbows, spigots, locks, glass, skewers, matex wheels, handles, and screws, eyelets, and rubber. Capacity = raw material requirements/unit (x_1, x_2, x_3) \times number of products (x_1, x_2, x_3) units/production.

Table 3. The data on the results of UD JK Aluminum Furniture Production

No.	Year	The Production Needs	1 Production (unit)
1.	2019	Rp155.760.000,00	132
2.	2020	Rp137.300.000,00	128
3.	2021	Rp141.120.000,00	130

Table 3 shows the production needs from 2019 to 2021 were stable. This data showed the stability of the price of raw materials and aluminum production resources.

Based on table 1 and table 2, the formulations were as follows:

1) Decision Variables

The decision variable for the optimization of UD JK Aluminum furniture production covers:

x_1 = the number of windows to be produced (unit)

x_2 = the number of storefronts to be produced (unit)

x_3 = the number of wardrobes to be produced (unit)

2) Priority

Determining the priority was adjusted to the objective function model with the Priority Scale used in the research. The order of priority (P_i) in this research was:

- Priority I: minimizing the amount of raw material budget cost
- Priority II: minimizing the use of raw materials
- Priority III: minimizing working hours
- Priority IV: maximizing production results

3) Objective Function

This made the decision variable to be maximized or minimized. The three objective functions used in this research were as follows:

- Minimizing the total cost of raw material budget
- Minimizing the use of raw materials
- Minimizing the working hours
- Maximizing the production results

4) Constraint Function

According to the data, the constraint functions were arranged into:

- The total raw material cost budget

The total raw material cost budget = the price of raw material

$Rp(x_1, x_2, x_3) \times$ the number of products (x_1, x_2, x_3) unit/production; as much as Rp22.850.000,00 /production

The goal equation was written:

$$260000x_1 + 1200000x_2 + 2850000x_3 + d_1^- - d_1^+ = 22850000 \quad (1)$$

- Average limit of raw material usage.

The upper limit for raw materials.

(upper limit for raw materials of aluminum (b1))

$$2,4x_1 + 25x_2 + 36x_3 \leq 610$$

The goal equation is written as:

$$2,4x_1 + 25x_2 + 36x_3 + d_2^- - d_2^+ = 610 \quad (2)$$

(upper limit for glass material (b2))

$$x_1 + 4x_2 + 6x_3 \leq 60$$

The goal equation is written as:

$$x_1 + 4x_2 + 6x_3 + d_3^- - d_3^+ = 60 \quad (3)$$

(upper limit for equipment raw materials (b3))

$$5x_1 + 50x_2 + 90x_3 \leq 750$$

The goal equation is written as:

$$5x_1 + 50x_2 + 90x_3 + d_4^- - d_4^+ = 750 \quad (4)$$

Lower limit for raw materials.

(lower limit for raw materials of aluminum (b1))

$$2,4x_1 + 25x_2 + 36x_3 \geq 305$$

The goal equation is written as:

$$2,4x_1 + 25x_2 + 36x_3 + d_5^- - d_5^+ = 305 \quad (5)$$

(upper limit for glass material (b2))

$$x_1 + 4x_2 + 6x_3 \geq 30$$

The goal equation is written as:

$$x_1 + 4x_2 + 6x_3 + d_6^- - d_6^+ = 30 \quad (6)$$

(upper limit for equipment raw materials (b3))

$$5x_1 + 50x_2 + 90x_3 \geq 375$$

The goal equation is written as:

$$5x_1 + 50x_2 + 90x_3 + d_7^- - d_7^+ = 375 \quad (7)$$

c. Average working hours

$$0.75x_1 + 5x_2 + 4.5x_3 \leq 55$$

The goal equation is written as:

$$0.75x_1 + 5x_2 + 4.5x_3 + d_8^- - d_8^+ = 55 \quad (8)$$

d. Recommended production amount for each raw material obtained

$$x_1 \geq 10$$

$$x_2 \geq 5$$

$$x_3 \geq 5$$

The goal equation is written as:

$$x_1 + d_9^- - d_9^+ = 10 \quad (9)$$

$$x_2 + d_{10}^- - d_{10}^+ = 5 \quad (10)$$

$$x_3 + d_{11}^- - d_{11}^+ = 5 \quad (11)$$

The formulation of the Goal Programming mathematical model was carried out by using data obtained from the results of observations and interviews. Several expected goals were obtained, namely:

Minimize

$$Z = P_1d_1^+ + P_2d_2^+ + P_3d_3^+ + P_4d_4^+ + P_5d_5^+ + P_6d_6^- + P_7d_7^- + P_8d_8^- + P_9d_9^- + P_{10}d_{10}^- + P_{11}d_{11}^-$$

By taking into account the constraints:

$$260000x_1 + 1200000x_2 + 2850000x_3 + d_1^- - d_1^+ = 22850000$$

$$2,4x_1 + 25x_2 + 36x_3 + d_2^- - d_2^+ = 610$$

$$x_1 + 4x_2 + 6x_3 + d_3^- - d_3^+ = 60$$

$$5x_1 + 50x_2 + 90x_3 + d_4^- - d_4^+ = 750$$

$$2,4x_1 + 25x_2 + 36x_3 + d_5^- - d_5^+ = 305$$

$$x_1 + 4x_2 + 6x_3 + d_6^- - d_6^+ = 30$$

$$5x_1 + 50x_2 + 90x_3 + d_7^- - d_7^+ = 375$$

$$0,75x_1 + 5x_2 + 4,5x_3 + d_8^- - d_8^+ = 55$$

$$x_1 + d_9^- - d_9^+ = 10$$

$$x_2 + d_{10}^- - d_{10}^+ = 5$$

$$x_3 + d_{11}^- - d_{11}^+ = 5$$

$$x_1, x_2, x_3, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+ \geq 0$$

$$d_1^- + d_1^+ = 0$$

$$d_2^- + d_2^+ = 0$$

$$d_3^- + d_3^+ = 0$$

5) Model Limiting Function

a. Priority I

The target to be achieved by the company was to minimize the amount of raw material budget costs. Then, the constraint function for the first priority is:

$$260000x_1 + 1200000x_2 + 2850000x_3 + d_1^- - d_1^+ \leq 22850000$$

The constraint formulation of the Goal Programming model is as follows:

$$260000x_1 + 1200000x_2 + 2850000x_3 + d_1^- - d_1^+ = 22850000$$

b. Priority II

The target to be achieved by the company was to minimize the amount of raw material budget cost. The number of raw materials was symbolized as b1 for aluminum raw materials, b2 for glass raw materials, and b3 for equipment raw materials must be less than or equal to the sum of the upper limit of raw material capacity that the company per month had prepared. The limit of raw materials' capacity must be less than or equal to the lower limit of the capacity of raw materials.

c. Priority III

The target to be achieved by the company was to minimize working hours. The supply capacity of working hours in furniture production is as follows

Total of average working hours capacity = hours worked hours/unit $(x_1, x_2, x_3) \times$ number of products (x_1, x_2, x_3) units/production, which is about 55 hours.

So, the constraint function for the third priority is:

$$0,75x_1 + 5x_2 + 4,5x_3 + d_8^- - d_8^+ \leq 55$$

The constraint formulation in the Goal Programming model is as follows:

$$0,75x_1 + 5x_2 + 4,5x_3 + d_8^- - d_8^+ = 55$$

d. Priority IV

The target to be achieved by the company was to maximize production results. The justified amount of production must exceed or be equal to the recommended amount of production for each raw material obtained.

The application aims to find the optimal solution to the problem of the Goal Programming model obtained from the furniture owner. Based on the programming goal model that has been obtained, to find the optimal solution or completion of the model will be completed by using an offline application, namely QM for Windows. The calculation results obtained from the QM For Windows application show that the optimal value for the raw materials budget costs of windows, storefronts, and wardrobes is the same as the budget costs incurred by the furniture production owner, which is IDR 22,850,000.00 per month. For the upper limit, it can be minimized to aluminum raw materials (b1), which is initially from 610 meters to 28.1 meters. To reach the production process, the target of the average working hours used is 55 hours. For a good and correct production volume recommendation, the products produced must be optimal to obtain 10 units of windows, 5 units of storefronts, and 5 units of wardrobes per month. This result indicates that using the Goal Programming method can minimize and maximize the objective function and has fulfilled the constraint function owned by the company. Compared to the results obtained by the furniture owner, using the Goal Programming method is more profitable because the owner, in tangible result, obtains 20 units of furniture production for

aluminum raw materials at more minimum. Therefore, the company can arrange for good customer service.

CONCLUSION

Based on the analysis and discussion results, the solution to the Goal Programming problem can be carried out by using QM for Windows. The results show that all the objective functions can be achieved well. The result of the problem, which is obtained from the QM For Windows application, can be seen that the optimal value for the raw materials budget cost of the windows, storefronts, and wardrobes is the same as the budget cost that has been incurred by the furniture production owner, which is IDR 22,850,000.00 per month. Then, the upper limit can be minimized to aluminum raw materials (b1), initially from 610 meters to 28.1 meters. For the production process to reach, the target of the average working hours used is 55 hours. For a good and correct production volume recommendation, the products produced must be optimal so that the product results are obtained 10 units of windows, 5 units of storefronts, and 5 units of wardrobes per month. This shows that all the objectives can be achieved optimally.

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