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# Goal Programming Model in Tackling The Optimal Building Material for Production Planning

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**Abstract**

The goal achieved in the preparation of production planning is more than one. UD Rezeki Berkah is a small business medium-sized enterprise engaged in the production of building materials. UD Rezeki Berkah aims to meet market demand and must consider the costs used during production to maximize profit. Because of these problems, it will be solved with a goal programming model where this method can solve more than one goal to get a model with optimal goal priority. This research provides an optimal solution, namely achieving the target sales volume and production costs within the Rp limit target. 929,128,971, and profit targets reached Rp. 562,751,890 for a period of one year.

***Keywords***: *Profit, Production Planning, Goal Programming, Optimal Goal Priority.*

## 1. Introduction

Advances in the industrial sector are proliferating today. The industry is progressing, so much existing problems will be more complex. Every growing industry needs experts to help develop its industry in solving emerging problems [1]. Many methods in the industrial sector are used to repair and build industry. Various ways are expected to be able to make the industry and business that they live to grow, keep it running, and make a profit [2]. Every operation in the ideal goods industry will produce enough products but get optimal profit and minimal costs, so its operations remain to walk. In the goods industry, things that need attention need to be corrected. One is the product, starting from a large number of production, quality, and quality [3]-[4]. To optimize profits, one of them is by determining the production planning optimal. The company can prepare production estimates that will be carried out to be precise and optimal at minimum cost.

Production planning is one of the determinants of company success [5]. Production planning determines the amount of product to be produced and the material for consideration obtained from the data beforehand to suit market demands [6]. Fulfilling market demand must also be followed by utilizing zation optimal resource availability. Condition resources such as raw materials, labor, machinery, and other equipment are required for the process production. In the preparation of production planning, many things are considered due to planning optimization production so that the lowest cost level for carrying out production activities is achieved. Optimizing the production planning process enables goals you want to achieve more than one [7].

To solve optimization problems, production planning can use various programming methods [1], [8]. This method has the potential to solve multiple aspects of the conflict between the elements in the plan production [9]. Besides that, The decision maker and the level the aspirations of the decision maker must be taken into account. Goal programming is a method that solves linear programming problems with more than one goal [10]-[11]. In linear programming, the objective function is to maximize or minimize so that the whole management objectives will be formulated into one function purpose [12]. As a result, the system can be optimal conditions for one goal and must ignore the other [13]. Unlike the linear program, on-goal programming minimizes the deviation from each plan to be achieved so that the results are optimally achieved without neglecting other purposes [14].

UD Rezeki Berkah, located in Tanjung Pura, North Sumatra, is a small-medium business that produces building materials. Building materials are made from sand, cement, and stone as raw materials. Building materials include adobe bricks, block bricks, round and split rails, well bus, and close the bus. In the production process, UD Rezeki Blessings plan based on the number of existing requests and try to fulfill market demand. The market demand is characteristic of fluctuating between the number of businesses engaged in the same field. However, in planning the production, UD Rezeki Berkah is concerned with fulfilling requests existing in the market and must pay attention to the cost already issued in the production process so that profits are the maximum.

Goal programming method to optimize production planning, which aims to determine a combination of types of products, minimize production costs, and maximize machine utilization. The research found that the goal programming method effectively solves multi-purpose problems with different goals to achieve the desired profit targeted.

## 2. Literature Review

### 2.1. Single Exponential smoothing

This method assumes that there is no uptrend or only a horizontal change in the surroundings or fixed. In this method, additional parameters serve to reduce the randomness factor. Shape generally can be written [15]-[16]:

$$F_{t+1} = \alpha X_t + (1-\alpha) F_t \tag{1}$$

### 2.2. Double Exponential Smoothing

This method will be more able to complete forecasting data with line changes straight or trending. Strategies that can be used include the double exponential smoothing method. Holt's dual exponential smoothing forecast is obtained using two smoothing constants, namely, and (with values between 0 and 1). The general form is [17]:

$$S_t = \alpha X_t + (1-\alpha)(S_{t-1} + b_{t-1}) \tag{2}$$

$$b_t = \gamma (S_t - S_{t-1}) + (1-\gamma)(b_{t-1}) \tag{3}$$

$$F_{t+m} = S_t + b_t m \tag{4}$$

### 2.3. Winter's Exponential Smoothing

This forecasting method can be used if the data pattern is seasonal. If the data shows static data, then the average process moving and a single exponential is appropriate. If the data shows a linear trend, then the exponential method double is just right. This method is based on three equations, namely the trend element, stationary and seasonal, which can be written [18]:

$$S_t = \alpha \left( \frac{X_t}{I_{t-L}} \right) + (1-\alpha)(S_{t-1} + b_{t-1}) \tag{5}$$

$$I_t = \beta \left( \frac{X_t}{S_t} \right) + (1-\gamma) b_{t-1} \tag{6}$$

$$F_{t+m} = (S_t + b_t m) I_{t-L+m} \tag{7}$$

### 2.4. Goal Programming Model

The patterns of goal programming models [10], [19]:

Minimize:

$$Z = \sum_{i=1}^{m} \left( d_i^+ + d_i^- \right) \tag{8}$$

Constraints:

$$\sum_{j=1}^{n} a_{ij} X_j - d_i^+ + d_i^- = b_i \tag{9}$$

for $i = 1,2,..,m$ (constraints),

$$\sum_{j=1}^{n} g_{kj} X_j \le or \le C_k \tag{10}$$

for $i = 1,2,..,p$ and $j = 1,2,..,n$ (optional constraints),

$$X_j \ge 0 \tag{11}$$

$$d_i^+, d_i^- \ge 0 \tag{12}$$

### 2.5. Goal Programming Model for Priority

The objective function of the goal programming model for priority using the equation [8], [20]:

$$MinZ = \sum_{\substack{i=1 \\ k=1}}^{m} P_k \left( d_i^+ + d_i^- \right) \tag{13}$$

## 3. Methods

Data obtained from UD Rezeki Berkah will be processed with steps:

1. Make a sales forecast to determine the boundaries of sales volume targets, production costs, and target profits that will be used to create a goal programming model. The forecasting method used will be according to the data pattern. The data pattern and plot will

be made first with Minitab 18 software assistance. If the data tends to be stationary, then it will use equation (1); for patterned trend, then it will use equation (4); and if it has a seasonal pattern, it will use equation (7) in its sales forecasting.

2. Create a Goal Programming formulation with the following:
   a. Decision variables used (types of building material)
      $X_1$ = Amount of brick production
      $X_2$ = Number of brick block production
      $X_3$ = Total production of round reels
      $X_4$ = Total production of split reels
      $X_5$ = Number of healthy bus production
      $X_6$ = total production of closed bus
   b. Determine and formulate the objective constraint function using equation (9)
   c. Prioritization
      Priority 1: Maximizing production volume.
      Priority 2: Minimizing production costs.
      Priority 3: Maximizing profit targets from sales.
   d. Determination of the objective function using equation (13)
   e. Model completion will be completed using simplex and POM-QM Software.

## 4. Results and Discussion

### 4.1. Data Descriptions

**Table 1**. Data on Building Material Sales in 2022

| No | Month | Product Type (piece) | | | | | | Amount |
|---|---|---|---|---|---|---|---|---|
| | | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | |
| 1 | January | 20500 | 20500 | 475 | 435 | 326 | 289 | 42525 |
| 2 | February | 23400 | 21000 | 543 | 456 | 320 | 289 | 46008 |
| 3 | March | 24000 | 23500 | 555 | 476 | 350 | 276 | 49157 |
| 4 | Apri | 26500 | 26500 | 550 | 450 | 340 | 266 | 54606 |
| 5 | May | 28500 | 28000 | 461 | 420 | 330 | 258 | 57969 |
| 6 | June | 31000 | 29500 | 615 | 435 | 335 | 278 | 62163 |
| 7 | July | 27000 | 27500 | 545 | 420 | 320 | 280 | 56065 |
| 8 | August | 26500 | 27000 | 600 | 380 | 285 | 265 | 55030 |
| 9 | September | 27500 | 26500 | 575 | 445 | 365 | 255 | 55640 |
| 10 | October | 27800 | 28000 | 480 | 420 | 358 | 248 | 57306 |
| 11 | November | 27750 | 28500 | 680 | 396 | 345 | 225 | 57896 |
| 12 | December | 28100 | 28000 | 560 | 410 | 362 | 230 | 57662 |
| | Total | 318550 | 314500 | 6639 | 5143 | 4036 | 3159 | 65202 |

**Table 2**. Cost of Production (In Rupiah)

| No | Type Product | Cost of Raw material | Cost of Live Work | Overheads Cost | Total cost Production |
|---|---|---|---|---|---|
| 1 | $X_1$ | 650 | 300 | 20 | 970 |
| 2 | $X_2$ | 450 | 250 | 20 | 720 |
| 3 | $X_3$ | 8500 | 3000 | 500 | 12000 |
| 4 | $X_4$ | 5200 | 3500 | 400 | 9100 |
| 5 | $X_5$ | 28500 | 7500 | 500 | 36500 |
| 6 | X6 | 26000 | 5000 | 500 | 31500 |

**Table 3**. Selling Price Data for Each Type of Product (In Rupiah)

| Type of Product | Selling Price |
|---|---|
| $X_1$ | 1500 |
| $X_2$ | 1300 |
| $X_3$ | 20000 |
| $X_4$ | 15000 |
| $X_5$ | 60000 |
| $X_6$ | 55000 |

## 4.2. Forecasting Results of Building Materials

Forecasting Building Materials Results using equation (5)-(7).

**Table 4**. Sales Forecasting Results for Each Type of Product in 2022

| No | Month | Product Type (piece) | | | | | | Amount |
|---|---|---|---|---|---|---|---|---|
| | | $X_1$ (48%) | $X_2$ (48%) | $X_3$ (1%) | $X_4$ (80%) | $X_5$ (70%) | $X_6$ (60%) | |
| 1 | January | 20788,8 | 20788,8 | 433,1 | 34648 | 30317 | 25986 | 20788,8 |
| 2 | February | 25353,6 | 25353,6 | 528,2 | 42256 | 36974 | 31692 | 25353,6 |
| 3 | March | 24305,28 | 24305,28 | 506,36 | 40508,8 | 35445,2 | 30381,6 | 24305,28 |
| 4 | Apri | 24373,44 | 24373,44 | 507,78 | 40622,4 | 35544,6 | 30466,8 | 24373,44 |
| 5 | May | 29206,08 | 29206,08 | 608,46 | 48676,8 | 42592,2 | 36507,6 | 29206,08 |
| 6 | June | 30869,76 | 30869,76 | 643,12 | 51449,6 | 45018,4 | 38587,2 | 30869,76 |
| 7 | July | 20595,84 | 20595,84 | 429,08 | 34326,4 | 30035,6 | 25744,8 | 20595,84 |
| 8 | August | 22824 | 22824 | 475,5 | 38040 | 33285 | 28530 | 22824 |
| 9 | September | 21893,28 | 21893,28 | 456,11 | 36488,8 | 31927,7 | 27366,6 | 21893,28 |
| 10 | October | 25615,68 | 25615,68 | 533,66 | 42692,8 | 37356,2 | 32019,6 | 25615,68 |
| 11 | November | 28332,48 | 28332,48 | 590,26 | 47220,8 | 41318,2 | 35415,6 | 28332,48 |
| 12 | December | 27795,84 | 27795,84 | 579,08 | 46326,4 | 40535,6 | 34744,8 | 27795,84 |

### 4.3. Calculation of Goal Programming Model

1. Constraint functions for each product are:

$$X_1 + d_1^- - d_1^+ = a_{ik}$$
$$X_2 + d_2^- - d_2^+ = a_{2k}$$
$$X_3 + d_3^- - d_3^+ = a_{3k}$$
$$X_4 + d_4^- - d_4^+ = a_{4k}$$
$$X_5 + d_5^- - d_5^+ = a_{5k}$$
$$X_6 + d_6^- - d_6^+ = a_{6k}$$

The objective function is:

$$Min\ Z = \sum_{i=1}^{6} \left( d_i^- + d_i^+ \right)$$

2. Production Cost Constraints

Function model constraints:

$$970X_1 + 720X_2 + 12000970X_3 + 9100X_4 + 36500X_5 + 31500X_6 + d_7^- - d_7^+ = b_k$$

The objective function is:

$$Min\ Z = d_7^+$$

3. Profit target constraints

Function model constraints:

$$485,5X_1 + 450,5X_2 + 8920X_3 + 6530X_4 + 20500X_5 + 25450X_6 + d_8^+ - d_8^+ = c_k$$

The objective function is:

$$Min\ Z = d_8^-$$

4. Calculation of Goal Programming Model using POM-QM Software

Based on the results of data analysis assisted by POM-QM software, the results obtained were optimum in its solution. The optimal value can be known from the deviation variable or deviation value or predetermined target limit production in volume, production costs, and profit targets. Here are the deviation values between the target limits from January to December 2022.

**Table 5**. Deviations Between Production Cost Constraints With Optimal Solution

| No | Month | Cost of Product | | | |
|---|---|---|---|---|---|
| | | Target | $d_7^-$ | $d_7^+$ | Optimal Solution |
| 1 | January | 64.125.205 | 0 | 0 | 64.125.205 |
| 2 | February | 78.070.520 | 0 | 0 | 78.070.520 |
| 3 | March | 74.850.051 | 0 | 0 | 74.850.051 |
| 4 | Apri | 75.065.990 | 0 | 0 | 75.065.990 |
| 5 | May | 89.950.345 | 0 | 0 | 89.950.345 |
| 6 | June | 76.965.800 | 0 | 0 | 76.965.800 |
| 7 | July | 81.540.207 | 0 | 0 | 81.540.207 |
| 8 | August | 70.250.568 | 0 | 0 | 70.250.568 |
| 9 | September | 67.583.535 | 0 | 0 | 67.583.535 |
| 10 | October | 78.880.250 | 0 | 0 | 78.880.250 |
| 11 | November | 86.250.800 | 0 | 0 | 86.250.800 |
| 12 | December | 85.595.700 | 0 | 0 | 85.595.700 |
| | Total | 929.128.97 | | | 929.128.97 |

**Table 6.** Deviations Between Profit Targets With Optimal Solution

| No | Month | Cost of Product | | | |
|---|---|---|---|---|---|
| | | Target | $d_8^-$ | $d_8^+$ | Optimal Solution |
| 1 | January | 39.550.960 | 0 | 0 | 39.550.960 |
| 2 | February | 47.250.300 | 0 | 0 | 47.250.300 |
| 3 | March | 44.820.760 | 0 | 0 | 44.820.760 |
| 4 | Apri | 45.290.120 | 0 | 0 | 45.290.120 |
| 5 | May | 54.340.850 | 0 | 0 | 54.340.850 |
| 6 | June | 47.835.760 | 0 | 0 | 47.835.760 |
| 7 | July | 46.785.780 | 0 | 0 | 46.785.780 |
| 8 | August | 43.420.180 | 0 | 0 | 43.420.180 |
| 9 | September | 40.890.560 | 0 | 0 | 40.890.560 |
| 10 | October | 47.465.280 | 0 | 0 | 47.465.280 |
| 11 | November | 53.540.450 | 0 | 0 | 53.540.450 |
| 12 | December | 51.560.890 | 0 | 0 | 51.560.890 |
| | Total | 562.751.890 | | | 562.751.890 |

## 4.4. Discussion

In table 5, the value for each month. The zero deviation value indicates that the excess and product shortages did not occur, so UD Rezeki Berkah will be able to meet market demand in 2022. Table 5 to shows that value $d_7^+ = 0$ for every month means the goal of minimizing production costs above the target is reached so the company will not experience excess production costs that have been targeted previously during the year, that is, Rp. 929.128.971,-. Table 6 also shows that value $d_8^- = 0$ means the achievement of the goal to minimize profits below targets that have been planned, then the profit UD Rezeki Berkah will be at least Rp. 562,751,890 during 2022.

## 5. Conclusion

Based on the previous discussion, it can be concluded that the preparation of planning production is to consider three objective constraints, namely sales volume to meet market demand every month and production costs within the target limit of Rp. 929.128.971 for one year, and the profit target is also achieved Rp. 562,751,890 for a period of one year. Obtained the three objectives get a zero deviation value towards the target to be achieved.

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