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Optimizing the Quantity of Pile Production Using Goal Programming Method

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Abstract

Goal Programming (GP) is a mathematical model that is used as a basis for making a decision to analyze and make solutions to problems that involve many objectives so that optimal alternative problem solving is obtained. PT X is a telecommunication network contractor company established on December 24, 2018. PT X focuses on the production of poles for fiber optic networks. this company only produces 250 pcs of poles every month with a production target that should be 300 pcs of poles every month, with a production cost of IDR 1,500,000 per pcs of poles and with a sales profit of IDR 300,000 per pcs of poles. The revenue obtained by the company in real terms for the period August 2023 to October 2023 is IDR 261,800,000, - and the revenue obtained from the calculation results using the Goal Programming method is IDR 403,900,000, -, so it can be concluded that the Goal Programming method can provide the best solution and the revenue obtained is greater than the company's real income.

A. Introduction

In a rapidly developing era where consumers find it increasingly easy to access the products they desire, all companies must innovate continually to meet consumer needs[1]. Every company strives to enhance its quality in all aspects to remain competitive. Companies are required to operate effectively and efficiently to achieve optimal results [2]. Thus, companies must be capable of addressing several challenges, such as minimizing production costs as much as possible and optimizing production planning, which may not be optimal. In the industrial sector, various methods can be employed to improve and develop the potential of the industry [3]. Many aspects need careful planning, including production planning, where production plans must align with consumer demand and take into account the company's resource capacities. Resources include machine capacity, workforce, technology, and others[4]. Production planning aims to maximize profits[5]. There are several methods in optimization that a company can use to plan production to run optimally, and one of them is the goal programming method [6]–[8].

Optimization is the attainment of an optimal state, achieving a solution to a problem directed towards maximum and minimum limits[9]. Optimization problems include unconstrained optimization and constrained optimization[10]. In unconstrained optimization, factors that constrain an objective function are ignored, so in determining the maximum or minimum value, there are no restrictions on various choices of available variables. In constrained optimization, factors that constrain the objective function are considered and contribute to determining the maximum and minimum points of the objective function [11], [12]. Constrained optimization is essentially a problem in determining the values of variables in a function to be maximized or minimized, taking into account existing limitations. These limitations include all production factors used in the production process, such as land, labor, and capital.

PT. X is a telecommunication network contractor company that focuses on producing pile foundations for fiber optic networks. The company is currently only able to produce 250 pcs of piles per month with a production target of 300 pcs per month. Factors causing the failure to achieve the production target include frequent machine breakdowns and suboptimal working hours because PT. X does not implement additional working hours or overtime when machine breakdowns occur. To address this issue, this research will apply the Goal Programming method to model production planning for maximum efficiency.

Goal Programming (GP) is a mathematical model used as a basis for decision-making to analyze and generate solutions for problems involving multiple objectives, thereby obtaining optimal alternative solutions. The Goal Programming method is effective for determining the optimal product combination while simultaneously achieving the desired company goals. This method can be used to obtain the optimal answers that come closest to the desired targets[13].

The purpose of this research is to plan the optimal production quantity and achieve maximum sales profit at PT. X using the Goal Programming method. The goal of optimization is to minimize the effort required or operational costs and maximize the desired outcomes. If the effort required can be expressed as a function of decision variables, optimization can be defined as the process of

achieving the maximum or minimum condition of that objective function. The objective function, in general, involves minimizing costs or the use of raw materials and maximizing the efficiency of utilizing production materials.

B. Research Methodology

1) Variable Identification

The dependent variable is a variable influenced by independent variables. In this study, the dependent variable is to obtain the maximum total sales profit at PT X. Independent variables are variables that influence changes in the value of the dependent variable. The independent variables in this study are:

1.1. Product Type Data
1.2. Product Demand Data
1.3. Production Quantity Data
1.4. Raw Material Availability Capacity Data
1.5. Production Capacity Data
1.6. Production Cost Data
1.7. Sales Profit Data

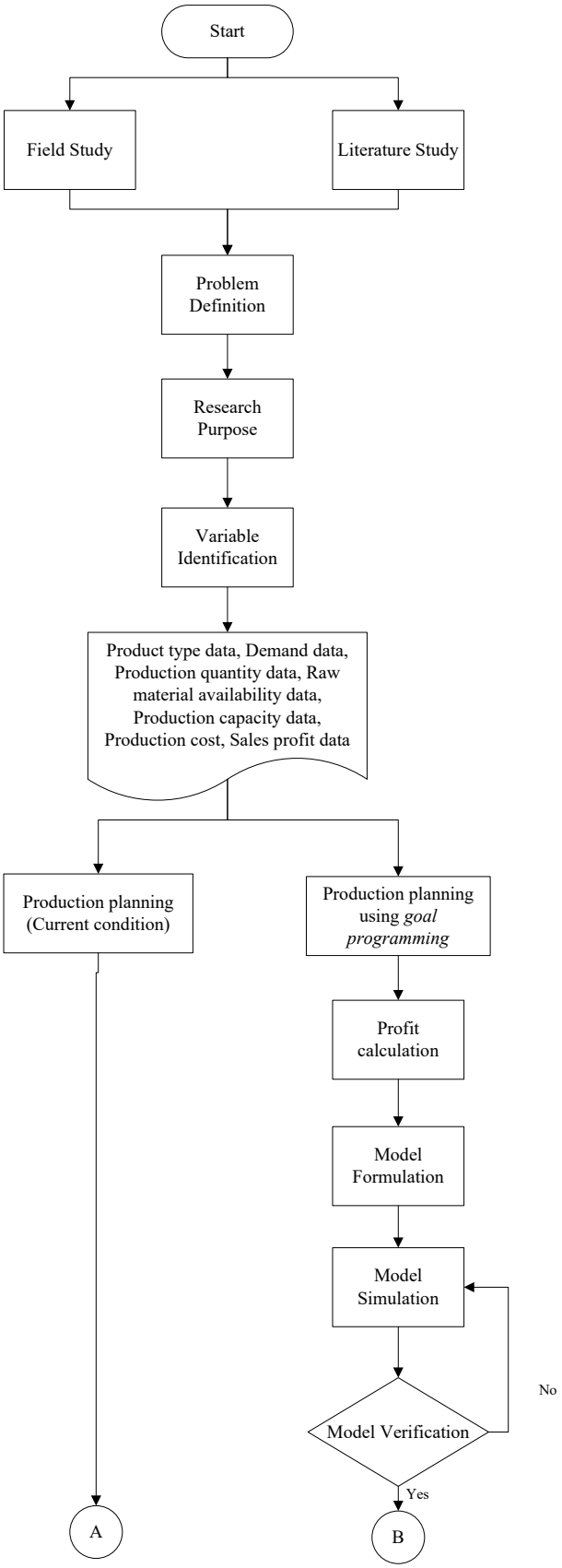


Figure 1. Research Flowchart

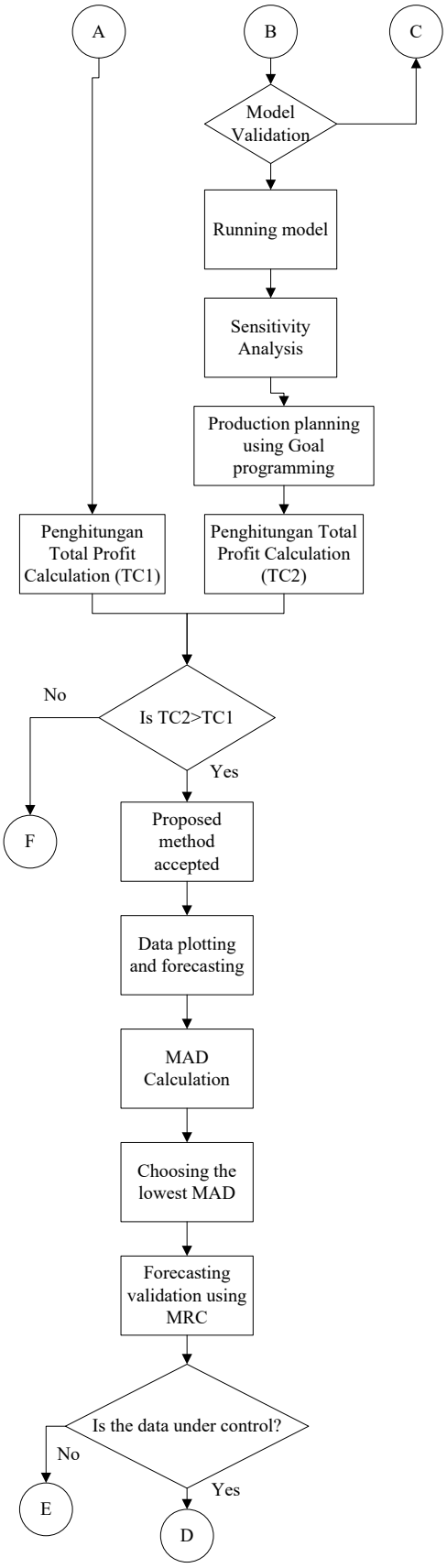


Figure 1. Research Flowchart (Continue)

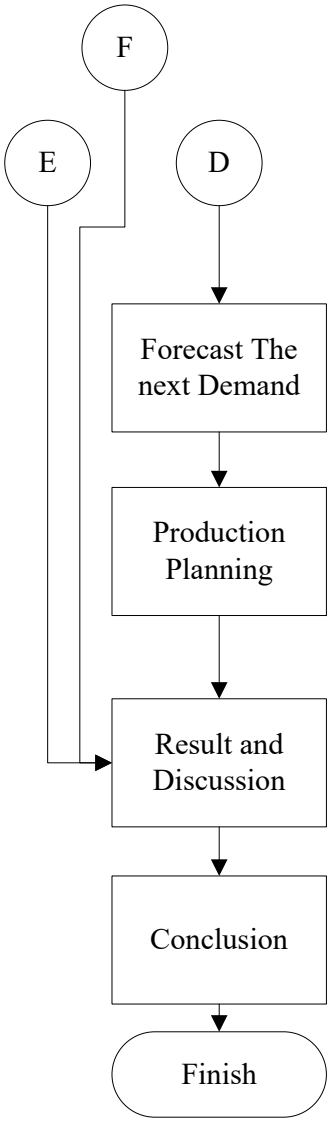


Figure 1. Research Flowchart (Continue)

The primary data collection was obtained through interviews and observations with the company. Meanwhile, secondary data were obtained from the company's historical data [14]. The data available for production planning include product type data, actual production data, actual product demand data, machine production capacity data, production cost data, and profit margin data for each product at PT. X. Validation is carried out by applying the model and existing data using other tools such as Ms. Excel and Lingo 20 [15]. If the results obtained deviate significantly from the actual results, data excavation, data modeling, model testing, and validation need to be carried out until optimal results are obtained in line with the results obtained by the company [16]. Solving the model built using Lingo certainly requires a considerable amount of time and becomes impractical in terms of computational time when dealing with a large amount of data [17]. Additionally, there are several variable limitations, so the computation can only be performed on a small sample [18].

C. Result and Discussion

PT X is a company that manufactures several sizes of pile foundations. However, this study is limited to only two sizes of pile foundations. These two products are the most sought after by consumers due to their usefulness. The two sizes of pile foundations are:

X1 = Pile Foundation With a size of 7 meters s

X2 = Pile Foundation With a size of 9 meters s

After outlining the results of this research on the production of pile foundations with sizes 7 meters and 8 meters, based on production and demand data from August 2023 to October 2023, the conclusions from this research are as follows:

1. Calculations with two models have been conducted so that the results of production planning and revenue can be compared [19]. The table below shows a comparison of the sales revenue of pile foundation products obtained from the actual company calculations and calculations using Goal Programming.

Table 1. Comparison of Profits Between the Actual Company Method and Goal Programming

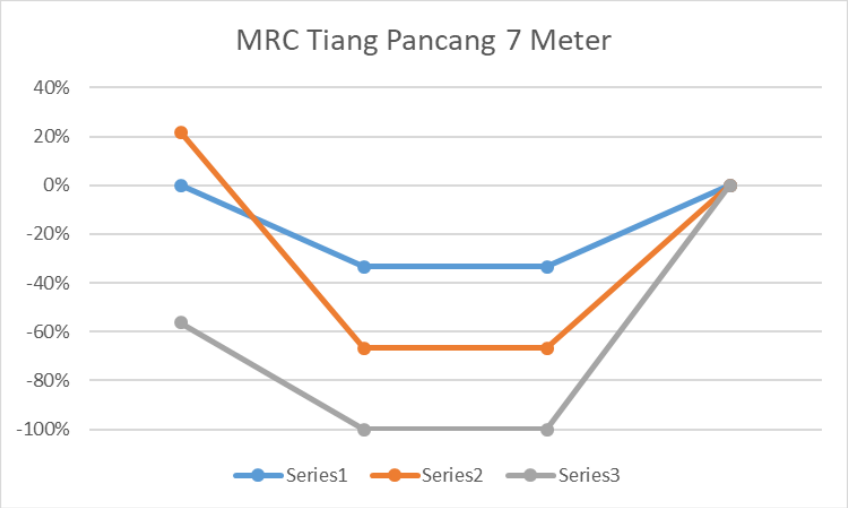
Current profit (Rp)	Profit using Goal Programming (Rp)
Rp 261.800.000	Rp 403.900.000

Based on Table 1 above, the revenue obtained by the company through actual calculations from August 2023 to October 2023 is Rp 261,800,000, while the profit obtained from the calculation using goal programming is Rp 403,900,000. Thus, it can be concluded that the goal programming method can be considered the best solution, and the revenue obtained is also greater than the actual company revenue. This proves that goal programming is highly appropriate when used to plan production for maximum profitability.

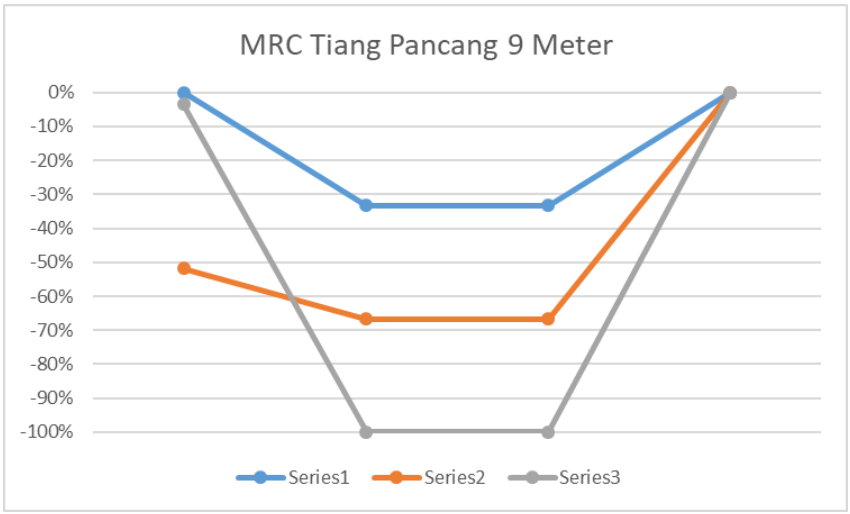
2. The results of the demand forecast for the period of August 2024 to October 2024 show sales profit amounting to Rp 527,300,000. The forecasted quantities for pile foundation products with a size of 7 meters are 659 units, and for pile foundations with a size of 9 meters, the forecasted quantity is 824 units

Performing a Moving Range Chart Test for the Forecasting Method Used

If the selection of the smallest MSE value from the forecasting method has been done, the next step is to conduct an MRC test, which aims to determine whether the demand is under control and stable based on the forecast used [20]. The following are the results of the Moving Range Chart (MRC) test for the two products under investigation:



Gambar 1. *Multiplicative Decomposition* pile foundation with a size of 7 meters



Gambar 2. *Multiplicative Decomposition* pile foundation with a size of 9 meters

Using Goal Programming to solve the problem

With the completion of this Goal Programming, the production plan results for each packaging are as follows:

Table 2. Production planning result using Goal Programming

Decision Variables	Definition	Result
X1	The quantity of pile foundations with a length of 7 meters produced	659
X2	The quantity of pile foundations with a length of 7 meters produced	824

The calculations below aim to determine the profit obtained from the planning data using Goal Programming. The calculations are as follows:

Z = C1X1 + C2 X2
Z = Rp 300.000 X1 + Rp 400.000 X2
Z = (Rp 300.000 x 659) + (Rp 400.000 x 824)
Z = Rp 527.300.000

Model Validation

Based on the goal programming equation above, with the help of Lingo 20, the program output with the goal as validation for the established objective functions above is as follows:

a. Maximizing Production Volume Based on the goal programming equation above, the program output is obtained as follows:

X1 ≤ 659
X2 ≤ 824

b. Maximizing Profit Based on the Lingo 20 output for X1, X2 is plugged into the following equation:

Z = C1X1 + C2 X2
Z = Rp 300.000 X1 + Rp 400.000 X2
Z = (Rp 300.000 x 659) + (Rp 400.000 x 824)
Z = Rp 527.300.000

The results above are in accordance with the results obtained from running Lingo 20 = Rp 527.300.000 → The model valid

c. Minimizing Raw Materials From the Lingo 20 output for X1, X2 is plugged into the following equation:

B = (8 x 629) + (10 x 824)
B = 13.512

The results above are in accordance with the results obtained from running Lingo 20= 13.512 → The model valid

d. Maximizing Machine Utilization From the Lingo 20 output for X1, X2 is plugged into the following equation:

(659 x 7) + (824 x 9)
= 4.613 + 7.41116

The results above are in accordance with the results obtained from running Lingo 20= 9.222 pcs ≤ 12.029 → The model valid

D. Conclusion

The actual revenue obtained by the company for the period from August 2023 to October 2023 is IDR 261,800,000, and the revenue obtained from the calculation using the Goal Programming method is IDR 403,900,000. Therefore, it can be concluded that the Goal Programming method can provide the best solution, and the revenue obtained is higher than the actual company revenue. The production planning results for March 2022 - February 2023 using the Goal Programming method yielded a more optimal production plan, amounting to IDR 527,300,000. The forecast results for demand from August 2024 to October 2024

resulted in sales revenue of IDR 527,300,000. The forecast for the 7-meter pole products is 659 units, and for the 9-meter pole products, it is 824 units, meeting all consumer demands. Thus, it can be concluded that the Goal Programming method can provide the best solution to fulfill all demands.

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