Minimizing production cost for kendang djembe production through goal programming model

Nabila Puspanola *, Sumiati

Industrial Engineering Department, Universitas Pembangunan Nasional Veteran Jawa Timur, Indonesia
*Corresponding Author: 18032010088@student.upnjatim.ac.id

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ABSTRACT

Kendang djembe is a percussion instrument played by striking with the fingers and palms. The body of the kendang djembe is generally made of wood and shaped like a cup or mug, carved either by machine or traditionally only by hand. This problem affects the production costs, the employee working house, and the profit of kendang djembe. Customer orders and requirements determine the production process for kendang djembe. It leads to fluctuations in market demand, affecting production costs and the working hours of kendang djembe employees. As a result, employees work overtime when orders rush in, resulting in poor product finishes such as crude engraving and painting. This research aims to minimize the production cost of kendang djembe, maximize the employee working hours, and maximize the profit by using the goal programming method. Goal programming is applied to decide the number of kendang djembe, the minimum production cost, and the time for each kendang djembe. The result of this research is that the company has to make 237 units of kendang djembe paintings, 1266 kendang djembe carvings, 870 kendang djembe painting carvings, and 91 kendang djembe deep carvings. The company spent a production cost of Rp 399,413,400, with the employee working 1846.36 hours, and obtained a maximum profit of Rp 126,526,600. This research helps the company to avoid unprofitable options in the production process of kendang djembe.

INTRODUCTION

Production planning is an activity to evaluate past and present facts, anticipate future changes and trends to determine appropriate production strategies, and also the schedules to effectively and efficiently achieve the goals of meeting demand [1]. Production planning involves estimating the demand for products or services the company expects to provide in the future [2]. Production planning must be achieved with an effort till the targets can be achieved [3]. Surachman et al.[4] mentioned that the implementation of optimization may have multiple

objective functions, so the objective function should be prioritized. The way to solve this condition is a dual-purpose programming practice when the objective function has multiple goals to achieve [5]. There is much research on dual-purpose programs. There is much research on dual-purpose programs. Many applications of dual-purpose programs include cash management [6], debris flow initiation [7], and vehicle route issues [8]. In planning, it is necessary to analyze future targets using forecasting techniques. Many applications in forecasting in the optimization of dual-purpose programs include forecasting electrical loads [9], wind speed [10], regional economy [11], and water irrigation [12]. Time, cost, and quality are priority goals of every project, which project managers always try to complete in the shortest possible time, with the lowest cost and the high-quality to succeed in the project. One of the main challenges in this regard is choosing the right approach to achieve this goal [13].

Kendang Djembe is a percussion instrument played by striking with the fingers and palms. The Kendang djembe is generally made of wood and shaped like a cup or mug, carved by machine or traditionally only by hand. The top acts as a membrane that produces vibration. It is usually made of dried animal skin such as a goat, cow, or another animal. The production process of kendang djembe is as follows by cutting the wood a pattern has been drawn using a clack. After that, the wood is shaved, sanded, and carved according to the paper pattern drawn earlier, then the wood is painted to prevent weathering and last assembled with a complementary component. The complementary materials include goat skin, ropes, and an iron ring for the top and bottom of the body of the kendang djembe. Currently, the kendang djembe model that produced by company is painting, carving, painting carving, and deep carving. The kendang djembe painting model is a drum designed by painting with pictures according to the buyer's request. A kendang djembe carving is a drum that has carvings on the sides. A kendang djembe painting carving is a drum with a combination design of a painting model drum with a carving model, and A kendang djembe deep carving is a drum with a fully carved design on each side.

In the current market era, industrial competition is getting strict, which makes every industry competitor should survive and maintain its existence during intense competition. Kendang djembe product is still not popularly known in the international market, which causes kendang djembe production to be customized by orders and demands depending on the consumers. It leads to fluctuations in market demand, affecting the cost of production and employee' working time of kendang djembe. If the market demand is few, the cost and production time will be low. Therefore, employees will work overtime whenever there is a massive increase in orders, resulting in less-than-ideal product results such as sloppy carvings, sloppy painting, etc. The company will get a claim for 30% from the results of the defective product, there are approximately 100 defective products produced from all types of kendang djembe. A goal-programming mathematical model can be used to solve these problems and plan product production. The goal programming objective function is to obtain the optimal number of kendang djembe productions, minimize production costs, maximize employee working hours and maximize profit.

Goal programming is used to solve problems with multiple goals by setting goals with or without priority [14]. In making decisions sometimes have to pay attention to the priority goals [15]. Goal programming is an extension of linear programming. The difference lies in a pair of deviational variables that appear in the objective and constraint functions [16]. In general, goal programming use to solve problems that has multiple goals or more than one goal [17]. Based on previous research by Gupta [18], goal programming is a solution process that balances many conflicting goals at different priority levels. The result of this research is that goal programming could reduce the computational complexities involved in reorientating the model involved in the decision process is the main advantage of this proposed approach compared to the traditional approaches.

According to Titilias [19], goal programming is used to demonstrate how genetic algorithms are applied to goal programming for resource planning to improve quality, specifically the optimization of PT.XXX plywood production planning using the goal programming method from research and discussions conducted in this study, goal programming can be used to create

optimal production plans and determine the attainment of goals and priorities indicated by the value of the goal attainment function. Therefore, the use of goal programming makes production schedule can be to improve a more optimal production planning schedule. Furthermore, according to Gita [20], the goal programming method was to optimize ground coffee production planning. Then, in IKM 3G Bareng-Jombang, Marine [21] conducted a study titled optimization of production planning with the goal programming method. Goal programming is often used in supplier selection to optimize product procurement [22]. Making decisions must be faced with several priority goals that need attention. So analysis is needed in decision-making due to limited resource factors, including market demand fulfillment factor, operational cost limit factor, and profit target factors [23].

In many aspects, the aspect program and the target program are the same as the linear program. This program has the primary constraints, assumptions, and conditions as shown in a regular linear program. This problem-solving method also uses the graphical or the simplex method (as modified). For example: planning for human resources (labor), production planning, inventory control, financial analysis, economic policy analysis, transportation logistics, and others [24]. According to Rangkuti [25], stated that the basic approach to goal programming is to set a goal that is stated with a certain number for each goal, formulate a goal function for each, and then look for a solution that can minimize the number of deviations in the objective function. The contribution of research for the company is to advise on the optimal production amount with fewer production costs than usual and get more profit from the previous period's profits. The novelty of this research is the application of the goal programming method in kedang djambe production. In this study, the goal programming method uses fixed data to determine the constant quantity of kendang djembe that have to produce because the total monthly output of kendang djembe is based on customers' orders. This research also uses the Lingo software to ensure the constant quantity of kendang djembe products. Lingo is software that is used to solve linear programming, nonlinear programming, and integer programming problems. Lingo is many used to create production schedules that aim to achieve optimal profits and the lowest costs for business.

METHOD

1. Goal Programming

This research is using goal programming, because the main focus is obtaining the minimum production cost, the maximum employee working hours, and the maximum profit with fixed data, and has not considered the price of raw materials, distribution of raw materials, electricity, etc. Another method that can solve similar problems is fuzzy, but this method cannot be used for this research because the fuzzy method requires dynamic research data. Goal programming is used to solve problems with multiple goals by setting goals with or without priority [14]. In making decisions sometimes have to pay attention to the priority goals [15]. In general, goal programming solves problems with multiple goals or more than one goal [17]. To formulate the goal programming model from the problems in the production planning of kendang djembe, the desired goals have been identified: minimizing production costs, maximizing employee working hours, and maximizing profit. The following are the steps for implementing the goal programming method:

1.1. Determination of decision variables

The dependent variable in this research is optimal production results, maximum income, minimal production costs, and maximum working hours. The independent variables are product price, the number of product demand, production costs, and working hours capacity. A decision variable is the type of product that is manufactured and optimized to meet target criteria and constraints. The decision variables used in this research are X_1 (kendang djembe painting), X_2 (kendang djembe carving), X_3 (kendang djembe painting carving), X_4 (kendang djembe deep carving).

1.2. Determining the Target Constraint Function

- Demand Product

The constraint function to obtain the optimal number of products in the company is as follows:

$$X_i + d_i^- - d_i^+ = P \qquad (1)$$

where i is the types of products, Xi is the number of kendang djembe produced, P is the number of demand product, and di the is deviation value above P.

- Minimizing production cost

The constraint function to obtain the minimum production cost in the company is as follows:

$$A_i X_i + d_i^- - d_i^+ = F \qquad (2)$$

where i is the types of products, Ai is the production cost of kendang djembe models, Xi is the number of kendang djembe produced, d_i^+ is the deviation value above F, d_i^- is the deviation value under F and F is the total of production cost.

- Maximizing employee working hours

The constraint function to obtain the minimum production cost in the company is as follows:

$$WX_i + d_i^- - d_i^+ = JK \qquad (3)$$

where i is the types of products , Wi is the processing per unit type of product, Xi is the number of kendang djembe produced, d_i^+ is the deviation value above JK, d_i^- is the deviation value under JK and JK is an availability of employee working time.

- Maximizing profit

The constraint function to obtain the minimum production cost in the company is as follows:

$$D_i X_i + d_i^- - d_i^+ = E \qquad (4)$$

Where i is the types of products , Di is the profit time per unit type of product, Xi is the number of kendang djembe produced, d_i^+ is the deviation value above E, d_i^- is the deviation value under E and E is a total profit.

1.3. Determining the Objective Function

- Demand product

So the objective function for demand product is as follows:

$$Min\ Z = d_1^- + d_2^- + d_3^- + d_4^- \qquad (5)$$

where, $d_1^- + d_2^- + d_3^- + d_4^-$ is the deviation value below the demand for product types 1,2,3,4

- Minimizing production costs

Because of the purpose of the company minimizes production costs, so the positive deviation amounts to zero. So the objective function is as follows:

$$Min\ Z = d_5^+ \qquad (6)$$

where d_5^+ is the deviation value below the production costs

- Maximizing employee working hours

Because of the purpose of the company maximizes the employee working hours so negative deviations amount to zero. So the objective function is as follows:

$$Min\ Z = d_6^- \qquad (7)$$

where d_6^- is the deviation value below the employee working hours

- Maximizing profit

Because of the purpose of the company maximizes the profits, so negative deviations (the profits below projected profits) amount to zero. So the objective function is as follows:

$$Min\ Z = d_7^- \qquad (8)$$

Where d_7^- is the deviation value below the profits

1.4. Determining the Priority

The order of priority in this problem is as follows:

- First priority

The production amount of each type of kendang djembe product is expected to be produced in optimal quantities and can meet consumer demand

- Second priority

The production process cost of kendang djembe per month is expected not to exceed the limit of production costs per month

- Third priority

Employee working hours of the company every day is expected not to exceed the limit of working hours that should be

- Fourth priority

The total profit from sales is expected to be maximum and can reach the set targets

RESULTS AND DISCUSSION

The company produces four models of kendang djembe products: painting, carving, painting carving, and deep carving. For this reason, the data needed to optimize bare core production planning is data on demand for kendang djembe products obtained from monthly product demand data. The total of product demand in 2021 is presented in Table 1.

Table 1. The total of product demand in 2021

Months	Style			
	Painting	Carving	Painting carving	Deep carving
January 2021	280	1210	869	80
February 2021	270	1228	850	80
March 2021	255	1220	869	80
April 2021	267	1208	869	80
May 2021	350	1238	854	80
June 2021	380	1260	850	100
July 2021	380	1300	880	100
August 2021	380	1330	880	100
September 2021	350	1300	880	100
October 2021	300	1300	880	100
November 2021	380	1300	880	100
December 2021	380	1300	880	100
Total	3972	15194	10441	1100
Average	331	1266	870	91

Based on Table 1, a production target was made using forecasting using POM QM software which resulted in a production target of kendang djembe as follows, 453 units of kendang djembe painting, 1396 units of kendang djembe carving, 896 units of kendang djembe painting carving, 121 unit of kendang djembe deep carving. Then the product demand target constraint function is generated as follows :

$$X_1 + d_1^- - d_1^+ = 453 \qquad (9)$$
$$X_2 + d_2^- - d_2^+ = 1396 \qquad (10)$$
$$X_3 + d_3^- - d_3^+ = 896 \qquad (11)$$
$$X_4 + d_4^- - d_4^+ = 121 \qquad (12)$$

where $X_{1,2,3,4}$ is the total of types of products 1,2,3,4 produced, $d_{1,2,3,4}^+$ is deviation value above product demand, and $d_{1,2,3,4}^-$ is deviation value under product demand In order to minimize the production cost of the kendang djembe product, detailed production costs for each type of kendang djembe product are needed, as presented in Table 2.

Table 2. The calculation of production cost

Types of product	Raw material costs (Rp/pcs)	Labor costs (Rp/pcs)	Other costs (Rp/unit)	Total production costs (Rp/unit)
Kendang djembe painting	Rp 120,600	Rp 20,200	Rp 8,000	Rp 148,800
Kendang djembe carving	Rp 120,600	Rp 24,200	Rp 10,000	Rp 154,800
Kendang djembe painting carving	Rp 120,600	Rp 28,200	Rp 11,000	Rp 159,800
Kendang djembe deep carving	Rp 120,600	Rp 34,200	Rp 13,000	Rp 167,800

Based on table 2, target constraint function to minimize production cost is generated as follows :

$$148,800X_1 + 154,800X_2 + 159,800X_3 + 167,800X_4 + d_5^- - d_5^+ = 399,525,400 \qquad (13)$$

Where $X_{1,2,3,4}$ is the total of types of products 1,2,3,4 produced, d_5^+ is the deviation value above production costs, and d_5^- is the deviation value under production costs. Then, the required employee working hours for each type of kendang djembe product are as presented in Table 3.
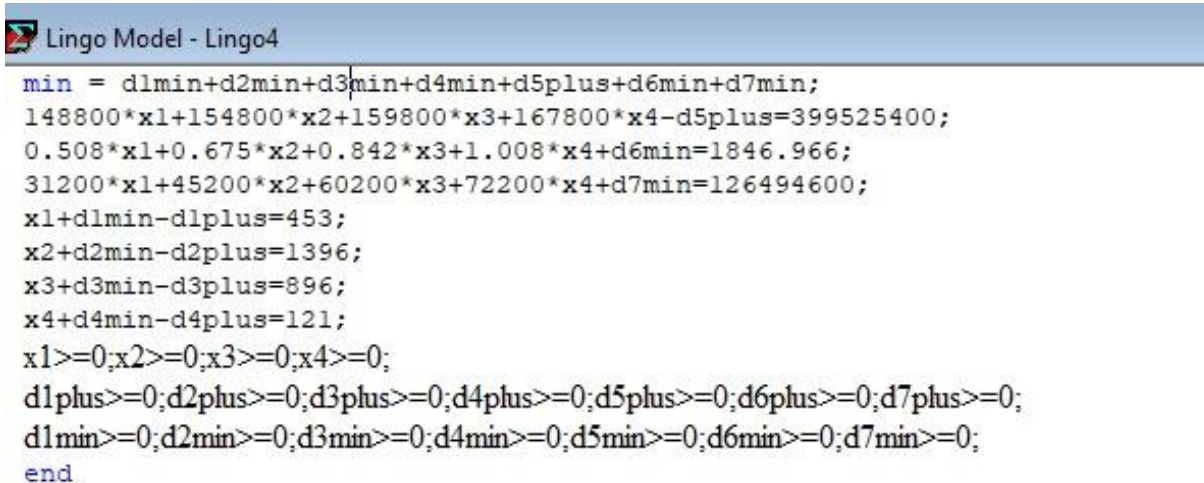
Table 3. Employee working hours

Types of product	Employee working hours (hour/unit)
Kendang djembe painting	0.508
Kendang djembe carving	0.675
Kendang djembe painting carving	0.842
Kendang djembe deep carving	1.008

Based on Table 3, the target constraint function to maximize employee working hours is generated as follows :

$$0.508X_1 + 0.675X_2 + 0.842X_3 + 1.008X_4 + d_6^- - d_6^+ = 1846.966 \qquad (14)$$

Where $X_{1,2,3,4}$ is the total of types of products 1,2,3,4 produced, d_6^+ is the deviation value above employee working hours, and d_6^- is the deviation value under employee working hours

According to the data implemented into the goal programming model that has been formulated above, then the model will be analyzed using the LINGO software. The result of the lingo software is in Figure 1 and Figure 2.
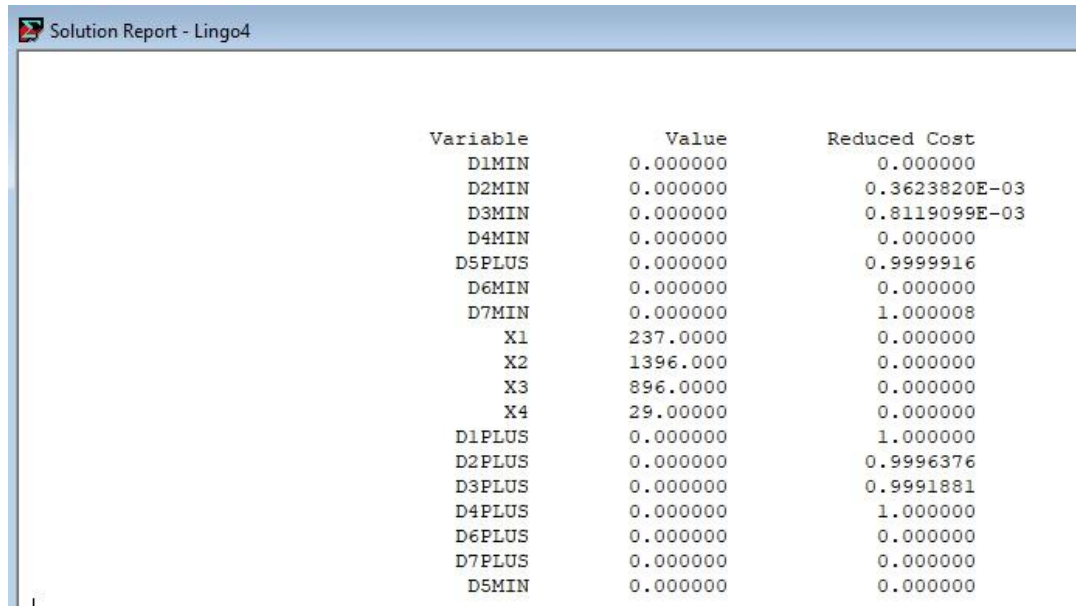
```
Lingo Model - Lingo4
min = d1min+d2min+d3min+d4min+d5plus+d6min+d7min;
148800*x1+154800*x2+159800*x3+167800*x4-d5plus=399525400;
0.508*x1+0.675*x2+0.842*x3+1.008*x4+d6min=1846.966;
31200*x1+45200*x2+60200*x3+72200*x4+d7min=126494600;
x1+d1min-d1plus=453;
x2+d2min-d2plus=1396;
x3+d3min-d3plus=896;
x4+d4min-d4plus=121;
x1>=0;x2>=0;x3>=0;x4>=0;
d1plus>=0;d2plus>=0;d3plus>=0;d4plus>=0;d5plus>=0;d6plus>=0;d7plus>=0;
d1min>=0;d2min>=0;d3min>=0;d4min>=0;d5min>=0;d6min>=0;d7min>=0;
end
```

Figure 1 Syntax of objective function and target constraint function

After formulating the goal and target function formulations using a linear goal programming model, the next step is to enter all the functions into the Lingo software.

Figure 2 Output software lingo

The results of the lingo software obtained X_1 as many as 237 products, X_2 1396 products, X_3 896 products, and X_4 as many as 29 products. The results obtained in the form of the value of the decision variables for the four types of kendang djembe products and the results of reaching each goal which is minimizing production cost and maximizing employee working hours are presented in Table 4 and Table 5

Table 4. Summary of the results obtained from the lingo software

Types of products	Value
X_1 = Kendang djembe painting	237
X_2 = Kendang djembe carving	1396
X_3 = Kendang djembe painting carving	896
X_4 = Kendang djembe deep carving	29

Based on the amount obtained from goal programming, the value of each goal is as follows:

a) Production process cost
$$= 148{,}800X_1 + 154{,}800X_2 + 159{,}800X_3 + 167{,}800X_4$$
$$= 148{,}800(237) + 154{,}800(1396) + 159{,}800(896) + 167{,}800(29)$$
$$= 35{,}265{,}600 + 216{,}100{,}800 + 143{,}180{,}800 + 4{,}866{,}200$$
$$= 399{,}413{,}400$$

b) The required employee hours
$$= 0.508X_1 + 0.675X_2 + 0.842X_3 + 1.008X_4$$
$$= 0.508(237) + 0.675(1396) + 0.842(896) + 1.008(29)$$
$$= 120.396 + 942.3 + 754.432 + 29.232$$
$$= 1846.36$$

c) Total profit
$$= 31{,}200X_1 + 45{,}200X_2 + 60{,}200X_3 + 72{,}200X_4$$
$$= 31{,}200(237) + 45{,}200(1396) + 60{,}200(896) + 72{,}200(29)$$
$$= 7{,}394{,}400 + 63{,}09{,}200 + 53{,}939{,}200 + 2{,}093{,}800$$
$$= 126{,}526{,}600$$

Table 5. Optimal decision variable value based on lingo software output

Objective	Current Production System	Goal Programming Result
Product demand	331	237
	1266	1396
	870	896
	91	29
Minimizing production costs	Rp 399,525,400	Rp 399,413,400
Maximizing employee working hours	1846.66 hours	1846.36 hours
Maximizing profit	Rp 126,494,600	Rp 126,526,600

Based on Table 5, the company has to produce 237 units of kendang djembe painting, 1396 units of kendang djembe carving, 896 units of kendang djembe painting carving, and 121 units of kendang djembe deep carving. The research aims for production costs have been achieved where production costs are Rp 399,413,400 and reduced production cost by 0.014 % compared to previous production costs. Goal programming also achieved in maximizing employee working hours to 1887.65 hours and increased by 0.008 % compared to the previous employee's working hours, the maximum profit obtained by Rp 126,526,600 and increased the profit by 0.12%.The result proves that goal programming is a method that can optimize the production planning. This is in accordance with research conducted by Titilias [19] , which in this study is to minimize production cost, maximize employee working hours, and maximize profit. This study's results help the company avoid unprofitable options in the production process of kendang djembe by determining the number of kendang djembe that must be produced using fixed data. Therefore, goal programming is the proper method to solve the problem in this research and decide the amount of product of kendang djembe, LINGO software also helps to make the calculation and decision easier, which can be identified as potentially attractive for development.

CONCLUSION

This paper has focused on minimizing the production cost and maximizing kendang djembe's working hours using the goal programming method. Goal programming is used to solve problems with multiple goals by setting goals with or without priority. Previous research stated that the basic approach to goal programming is to set a goal that is stated with a certain number for each goal, formulate a goal function for each goal, and then look for a solution that can minimize the number of deviations in the objective function. From the results of calculations using LINGO software, to obtain the minimum production cost and maximum employee working hours, the company must be produced 237 units of kendang djembe painting, 1266 kendang djembe carving, 870 kendang djembe painting carving, and 91 kendang djembe deep carving. The company spent a production cost of Rp 399,413,400 with employee working hours for 1846.36 hours and the maximum profit obtained by Rp 126,526,600. In terms of future research directions, it is suggested to develop production planning calculations and multi-criteria decision-making with data that has uncertainty or changes using fuzzy goal programming with the MODM approach and the MADM approach.

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