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Optimization Of Sandal Production Using Linear Programming

Muammar Khadapi[1]*, Suci Ramadani[2]

[1,2]STMIK Kaputama
khdafi5@gmail.com[1], suci.ramdani23@gmail.com[2]

Abstract

In order to maximize income and minimize material costs, sandal manufacture involves other operational expenditures in addition to raw material costs that must be calculated. The goal of this study is to maximize earnings by optimizing sandal production costs, with a focus on the Diona Shoes home sector. By identifying the restrictions and inequalities present in the linear program, you can utilize linear programming to solve production cost optimization challenges. The simplex method is a technique for solving linear programming problems that involve numerous inequalities and variables by doing iterative calculations until the most optimal solution is found. The simplex approach (iteration) of production result optimization, data collection and observation, mathematical model creation, production result optimization employing Lindo software tools that are anticipated to yield results, and production result optimization are the stages taken to optimize overall production costs. optimally with the lowest possible manufacturing costs for sandals with heel, pansus, and back straps and can optimize the earnings from all sandal goods.

Keywords: Linear, Optimization, Production, Sandal, Simplex

1. Introduction

The issue of identifying funding sources and resources, such as labor, capital, and raw materials, is closely associated with linear programming [1]. Since these resources are all essentially finite, the best approach to make decisions that represent selections from a range of options must be taken. accessible [2]. Production managers sometimes struggle to figure out how much work a firm can produce with its limited resources, and they also need to be able to optimize earnings [3].

Solving linear programming problems requires determining the constraints contained in linear programming in the form of a mathematical model [4]. Mathematical models are used to determine the objective function and constraints that must be met in linear programming, such as in the sandal production process in the Diona Shoes Home Industry which has several obstacles in minimizing production costs, so linear programming can be used as a way to solve cost optimization cases the production [5].

In solving the problem in this research, the research uses the simplex method where this research contains three variables. This research aims to solve problems in the Diona Shoes Home Industry, especially the problem of minimizing the cost of raw materials for making sandals based on the types of back strap sandals, heel sandals and pansus pancung sandals. This problem is one of the problems that can be solved using linear programming, so it is hoped that with the help of the LINDO (Linear, Interactive and Discrete Optimizer) program, the problem of minimizing raw material costs can be solved quickly and precisely [6].

With this research, it is hoped that we can solve the problem by knowing what the model for minimizing sandal production costs is like so that the home industry can produce each type of sandal optimally to get maximum profits after calculating using the simplex method so that it can be seen whether the production costs of Diona Shoes sandals are based on materials. whether the manufacturing raw materials are optimal or not, and so that the Diona Shoes home industry can get more optimal profits than before [7], [8].

2. Research Methods

The following is an illustration of the research flow diagram for implementing the fuzzy logic method to determine students' skill aptitude, depicted in fig.1 below

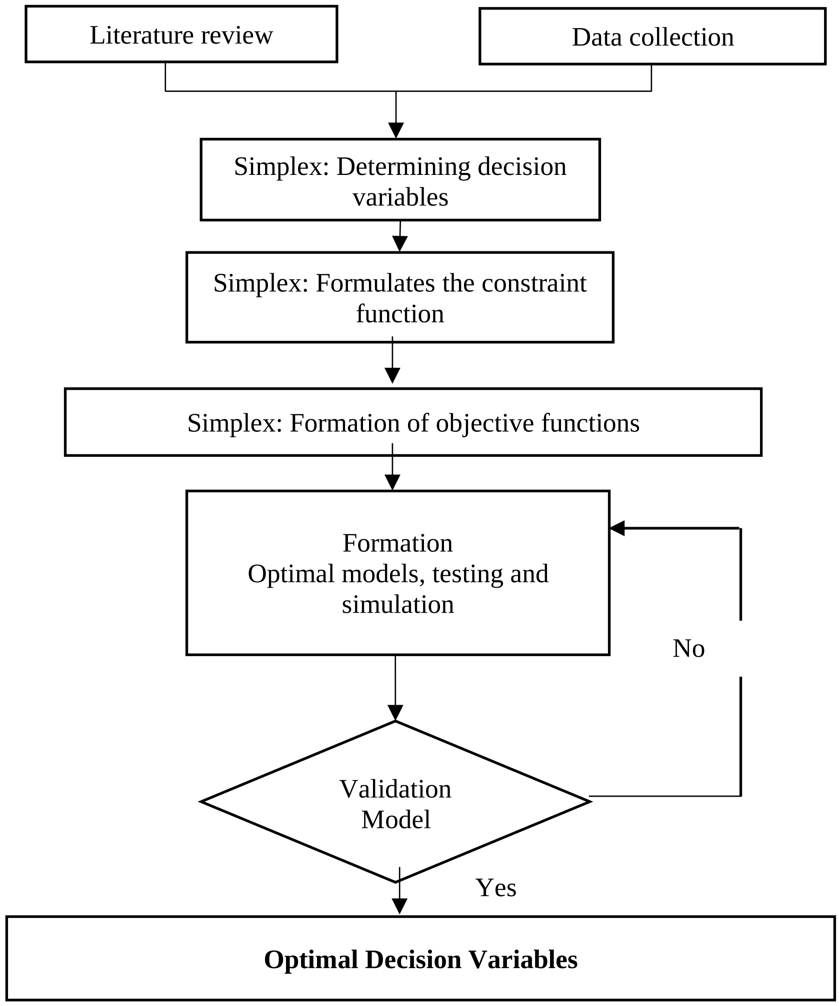

Fig.1 Research Flow Chart

Integer Linear Programming Process

1. Definition of Decision Variables
   As indicators of decision variables in this research are as follows [9]:

   a. Back strap sandals (X1)
      Sandals are processed using certain raw materials which are produced within a one month period. The value used is the rupiah currency unit (Rp).
   b. Pansus pansus sandals (X2)
      Sandals are processed using certain raw materials which are produced within a one month period. The value used is the rupiah currency unit (Rp).
   c. Heel Sandals (X3)
      Sandals are processed using certain raw materials which are produced within a one month period. The value used is the rupiah currency unit (Rp).
2. Definition of Constraint Function Elements
   The limitations in this research are:
   a. Plastic Cloth (S1)
      Raw materials are available according to company regulations which are used to coat the soles of sandals which are produced within a one month period in meters (M).
   b. Rights And Soles (S2)
      Tread and sole raw materials are available according to company provisions within a one month period in units (Kodi).
   c. Labor (S3)
      The number of workers used in sandal production activities in a one month period in working days (Rupiah).
   d. Operational Costs (S4)
      Costs used in production activities in a one month period. Operational costs consist of raw materials, electricity and labor salaries in rupiah (Rp).
   e. Production Limitations x1 (S5)
      Production limits are used to limit the production process within a one month period.
   f. Production Limitations x2 (S6)
      Production limits are used to limit the production process within a one month period.

g. x3 (S7) Production Limitations
Production limits are used to limit the production process within a one month period.

3. Objective Function

The objective function is a linear mathematical relationship that describes the company in terms of decision variables. The profit obtained is the company's goal, namely to maximize the profits obtained from the decision variables in the form of back strap sandals (X1) and special committee sandals (X2). The value used is the rupiah currency unit (Rp).

2.1. Literature review

Study the theory and concepts of linear programming and the simplex method, as well as various related research.

2.2. Simplex Method

The initial steps that must be determined in solving simplex method problems are as follows:

a. Determine the decision variables of the problem:
b. Determine the objective function of the problem:
c. Determine the constraints of these problems: Plastic Fabric, Tread and Sole, Labor, Operational Costs, Production Limits
d. Change the inequality (≤) to (=) by adding a slack variable and an artificial variable for the inequality (≥) to the left side of the constraint.

Create a simplex table by entering all the coefficients of the decision variables and slack variables.

2.3. Simplex Method

Data collection in the research was carried out by observing the Diona Shoes Home Industry and conducting interviews with business owners. The information obtained is data regarding the production costs of sandals based on the raw materials and the factors that influence them. The analysis steps carried out are as follows [10]:

1. Determine the objective function by knowing the list of production costs for each sandal so that it can be modeled in a linear program.
2. Determining decision variables includes the number of each type of sandal produced with constraints in the form of the composition of the raw materials for making each type of sandal, the amount of raw material for making sandals, the production capacity of the sandals produced, and others.
3. Modeling problems into linear programming mathematical models.
4. Input all linear programming models into the LINDO program.
5. Analyze the resulting output.

Production data is an important element in production activities which will be presented in the following table

Table 1: Data Types

No	Data Description	Indicator	Symbol	Units of measurement	Data source
1	Decision Variables	Back Strap Sandals	X1	Score	Resource Person / Owner
		Special Committee sandals	X2	Score	
		Heel Sandals	X3	Score	
2	Constraint Function Elements	Plastic Cloth	S1	Meters	Resource Person / Owner
		Rights And Soles	S2	Score	
		Labor	S3	Rupiah	
		Operating costs	S4	Rupiah	
		X1 Limitation	S5		
		Limitation X2	S6		
		X3 Limitations	S7		
3	Establishment of the Objective Function	Maximize the profits obtained from back strap sandals, heel sandals and special committee sandals	C1X1+C2X2+ C3X3	Rupiah	Resource Person / Owner

2.4. Model Establishment, Testing and Opti Simulation

Next, carry out iterations to find the maximum Z value. Namely by:

a. Look for the key column, for that we only need to look at the largest negative value in column Z and in the initial simplex table it can be found in column X3.
b. Looking for the Key Row, for this we need to fill in the Ratio in the table by first doing the division, namely (Right Value (NK): Key Column) which we got at the beginning, and after that we will get the Key Row by selecting the smallest positive value in Ratio column. And in the initial simplex table it can be found in line Artc3.
c. To find the Key Element we only need to look at the value that intersects the Key Column with the Key Row

3. Results and Discussion

In this chapter, data processing and analysis will be presented with the help of the LINDO program to examine whether the cost of raw materials in making sandals in the Diona Shoes Home Industry is optimal or not, so that we can see optimal profits in the production carried out by the Diona Shoes home industry. In this thesis, the products that will be researched are Back Strap Sandals, Pancung Pancung Sandals, and Heel Sandals. These three types of sandals are produced in one location with a production period of 1 month.

3.1. Discussion

In data collection, data has been obtained regarding sandal production costs, sandal production capacity, and the amount of inventory of sandal making materials. All data taken is based on each production period. These data are used as tools to create a mathematical model in the form of a linear program, namely using the simplex method as was done in Chapter III, and will then be completed using the help of the LINDO program so that an output will be produced that provides information on the optimal value along with sensitivity analysis. from existing problems.

3.2. Data source

Fig.2: Back Strap Sandals

In figure IV.1 above is a type of back strap sandal which is referred to as Variable X1 in this case

Fig.3: Pansuns Special Committee sandals

- In figure IV.2 above is a type of pansus pansus sandal which is referred to as Variable X2 in this case.

Fig.4: Heel sandals

- In figure IV.3 above is a type of heel sandal which is referred to as Variable X3 in this case.

The data contained in this research was obtained from observations and conducting interviews with business owners, where the researchers visited the location where Diona Shoes sandal production is located at Jalan SM.Raja/Penjuangan Kel.Nangka, North Binjai, and the production of these sandals itself has been founded in 2013 by Mr. Ilham Muharya.

3.3. Implementation

The main use of the Lindo program is to find solutions to linear problems quickly by entering data in the form of formulas in linear form. Lindo provides many benefits and conveniences in solving optimization and minimization problems. Therefore, this research will solve the problem with the following steps:

a. In the first step, we enter the initial display of the Lindo program and are ready to type in the formation.
b. Next, the mathematical model created in the previous chapter is written on the LINDO board to find an optimal solution.
   - For the first step of the objective function, the formula typed into the Lindo board, namely MAX or MIN, is called the objective function. As follows :
     Max 440,000 x1 + 500,000 x2 + 600,000 x3
   - The second step is the constraint function
     This variable is very important, lindo cannot be run without including existing constraints and limitations such as limits on raw materials, cost limits, and production limits. In this case there are problems as follows:
     2x1 + 2x2 + 2x3 <= 300 (Plastic Cloth)
     1x1 + 1x2 + 1x3 <= 130 (Heel and Sole)
     240,000x1 + 270,000x2 + 290,000x3<= 4500000 (Labor)
     660,000x1 + 900,000x2 +1,000000x3<=124200000 (Operational)
     x1 >= 70 (Production X1)
     x2 >= 35 (Production X2)
     x3 >= 15 (X3 Production)
   - After the constraint function is typed, then type Subject to or ST to start typing the constraint, and on the next line, end it with the word END.
     So the formulation is written in the LINDO program as follows:
     Max 440,000 x1 + 500,000 x2 + 600,000 x3
     Subject To
     2 x1 + 2 x2 + 2 x3 <= 300
     1 x1 + 1 x2 + 1 x3 <= 130
     240,000 x1 + 270,000 x2 + 290,000 x3 <= 4500000
     660,000 x1 + 900,000 x2 + 1,000000 x3 <= 124200000
     x1 >= 70
     x2 >= 35
     x3 >= 15
     end
c. After the formula has been typed, it is ready to find the solution by selecting the solve command or clicking the solve button on the toolbar. Then a dialog box will appear as follows:

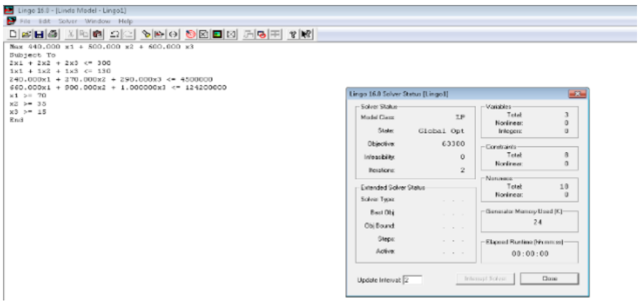

Fig.4: Display of the Solve command in Lindo

If there is an error, Lindo will compile (correct the error) the formula first. If an error occurs in typing (it cannot be read by the computer) a dialog box will appear and the cursor will point to the wrong line. And if no error occurs, the Lindo status will appear as shown in the image above.

a. From all the steps that have been carried out and there are no errors, the output produced from the LINDO program for solving the mathematical model above is as shown in the following image:

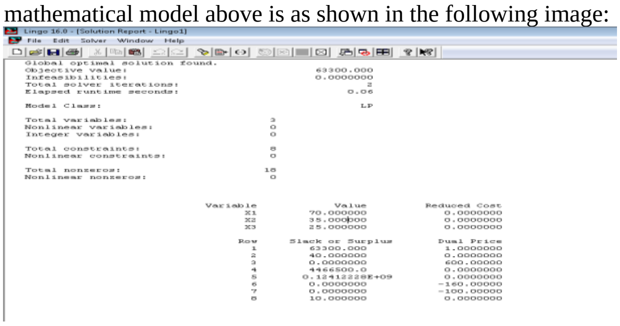

Fig.5: Solution Report Display

b. The objective function value shown by the LINDO program output is 63,300,000. This value is the minimum total cost based on the raw materials for making the three types of sandals where x1 = 70, x2 = 35, and x3 = 25.

c. The value of Reduced Cost is also very meaningful if the decision variable in question has a value of 0 (zero), because the function of Reduced Cost is to show how much the cost per code of a variable can be reduced so that the optimal solution obtained from that variable is positive. Based on the output above, none of the decision variable values have a value of zero, so Reduced Cost also has a value of zero.

d. The Slack Or Plus and Dual Price sections show that the active constraints are on lines 6 and 7 with Dual Prices values of -160 and -100. This value shows that adding each unit of the right-hand side value to these constraints will cause the objective function value to decrease by 160 and 100. Meanwhile, inactive constraints with a Dual Prices value of zero can be ignored.

The following sensitivity test of the optimal solution that has been produced by the LINDO program is very useful for improving the model because with the existing information, the model that has been obtained can be analyzed again so that a more optimal solution will be obtained than the previous solution. The following is the information obtained from the sensitivity test above.

1. *Obj Coefficient Ranges*

Lingo 16.0 - [Range Report - Lingo1]
File Edit Solver Window Help

Ranges in which the basis is unchanged:

Objective Coefficient Ranges:

Variable	Current Coefficient	Allowable Increase	Allowable Decrease
X1	440.0000	160.0000	INFINITY
X2	500.0000	100.0000	INFINITY
X3	600.0000	INFINITY	100.0000

Fig.6: Range report display (*Obj Coefficient Ranges*)

*Obj Coefficient Ranges*is an area that contains the coefficient value of each decision variable where there is a limit to the interval of change in value that is allowed, so that the previously produced solution remains optimal.

a. In the Current Coef column, it shows that the coefficient values of the variables x1, x2, and x3 are 440, 500, and 600. Meanwhile, in the Allowable Increase column, it is clear that the variables x1 and x2 have values of 160 and 100, which means that the coefficient value can be increased as long as do not exceed the existing value so as not to affect the value of the optimal solution, while the variable x3 is infinity, meaning that any addition to the coefficient value of this variable will not affect the value of the optimal solution.

b. The Allowable Decrease column provides information that the variables x1, x2 are infinity, which means any reduction can be made to the coefficient value, and the variable x3 has a value of 100, which means the coefficient value can be reduced as long as it does not exceed 100, so as not to change the value of the optimal solution.

2. *Righthand Side Ranges*

Righthand Side Ranges:

Row	Current RHS	Allowable Increase	Allowable Decrease
2	300.0000	INFINITY	40.00000
3	130.0000	20.00000	10.00000
4	4500000.	INFINITY	4466500.
5	0.5500000E+08	INFINITY	0.5492228E+08
6	70.00000	10.00000	70.00000
7	35.00000	10.00000	35.00000
8	15.00000	10.00000	INFINITY

Fig.7: Range report display (*Righthand Side Ranges)*

a. The Current RHS column consists of the Right Side Value (NRK) of each decision variable. The Allowable Increase for constraints 2, 4, and 5 is infinity, this means that any increase in the NRK value for these constraints will remain valid. For limits on adding NRK values, other obstacles can be seen below.
   - NRK constraint 3 can only add a maximum of 20,000 to the dual price value of 600.
   - NRK constraint 6 can only be added to a maximum of 10,000 at a dual price value of -160.
   - NRK constraint 7 can only add a maximum of 10,000 to the dual price value of -100.
   - NRK constraint 8 can only add a maximum of 10,000 to the dual price value of 0.

b. *Allowable Decrease*For all constraints there is no infinity except for constraint 8, meaning that there is a limit for reducing the NRK value for all constraints except constraint 8. The following is a description of the limit for reducing the NRK value for all constraints.
   - NRK constraint 1 can only be reduced by a maximum of 40,000 at a dual price value of 0.
   - NRK constraint 2 can only be reduced by a maximum of 10,000 on a dual price value of 600.

- NRK constraint 3 can only be reduced to a maximum of 4,466,500 at a dual price value of 0.
- NRK constraint 4 can only be reduced to a maximum of 0.5492 at a dual price value of 0.
- NRK constraint 5 can only be reduced to a maximum of 0.12412 at a dual price value of 0.
- NRK constraint 6 can only be reduced by a maximum of 70,000000 at a dual price value of -160.
- NRK constraint 7 can only be reduced by a maximum of 35,00000 at a dual price value of -100.

3.4.Analysis of Raw Material Costs for Making Sandals by Diona Shoes

The total cost of producing sandals based on raw materials produced by the Diona Shoes home industry is obtained from the calculation of the number of sandals produced per period multiplied by the cost of producing sandals per shoe, which is IDR 124,200,000, and with a profit of IDR 57,300,000 / month. The following is a table listing the number of each type of sandal produced and the results of other calculations.

Table 2: Sandal Production Table

No	Variable	Production Level	
		Factual	Optimal
1	X1	70	70
2	X2	35	35
3	X3	15	25

3.5 Analysis of raw material costs for making sandals using the LINDO program

Analysis of total production costs based on raw materials for sandals calculated by LINDO with a production cost of IDR 124,200,000 and a profit of IDR 57,300,000 can be seen in the output. The output produced by the LINDO program in solving the linear model above provides the information that Zmax = 63,300,000 where:
x1 = 70
x2 = 35
x3 = 25

That is, the calculation results of the program*LINDO*namely withcost of Rp. 124,200,000 which is the initial cost, it would be optimal if you don't produce sandals in the factual condition, namely 120 kodi, but you have to produce 130 kodi with each type of back strap sandal as much as 70 kodi, 35 kodi, and heel sandals as many as 124,200,000. 25 codes to get optimal conditions.

After a comparison was made in the manufacture of sandals carried out by the Diona Shoes home industry with factual conditions and also calculations using the program*LINDO*, apparently gives the same total production costs. So it can be said that the cost of producing sandals based on the raw materials for making them is optimal. However, it has different advantages, namely a profit of IDR 57,300,000/month in factual conditions, while the optimal results obtained in simplex and lindo calculations are IDR 63,300,000, this shows that if the Diona Shoes home industry produces sandals in the same condition. optimally, namely producing 130 kodi with each type of back strap sandals amounting to 70 kodi, pansus pancung sandals amounting to 35 kodi, and heel sandals amounting to 25 kodi, then you will get a profit greater than the factual profit of IDR 6,000,000.

4. Conclusion

Based on optimization calculations using the simplex method and assisted by Lindo 6.1 software, it can be concluded that the Diona Shoes Home Industry will obtain optimal results with a production cost of IDR 124,200,000 if it produces 70 back strap sandals, 35 bow sandals and 35 heel sandals. 25 codes. The profit achieved by producing sandals with calculations using the simplex method assisted by Lindo software is IDR 63,300,000 with the previous profit being IDR 57,300,000.
Based on the conclusions above, the author puts forward the following suggestions:

1. The production of sandals in the Diona Shoes home industry is not yet optimal, it is better to produce sandals according to optimal results using the simplex method, namely 70 sandals x1, 35 sandals x2, and 25 sandals x3.
2. So that the Diona Shoes home industry can slowly apply the simplex method to calculate optimal profits using this method.
3. Before restarting production, you should first pay attention to whether the inventory of goods and materials has run out or not, thereby reducing the risk of loss.

Readers can expand the study of the material in this thesis, one of which is by trying to use computer software other than LINDO.

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