Article

A Profit Optimization Using Linear Programming Method on XYZ Convection

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Abstract:

Optimal production planning is one of the essential aspects of achieving company targets. Errors in planning production result in non-maximum profit gains. Furthermore, there needs to be a method to avoid mistakes in production planning, and it is necessary to use the proper technique. XYZ Convection is one of the businesses producing unique clothing for pants. This study aims to determine the optimization of XYZ convection production in maximizing profits using linear programming. Surveys and interviews with business owners of XYZ Convection carried out data collection. The data obtained are in the form of data on the use of raw materials, operating costs, margins, and selling prices. The amount of raw material inventory of jeans fabric in the 1st week is 550, in the 2nd week is 775, in the 3rd week is 550, and in the 4th week is 650. The method used in this study is linear programming, using the simplex method. The optimal solution is to obtain maximum profit from the production of convection pants every week with a fund of 21,000,000 IDR to produce 1.167 pcs of cotton shorts, where the company will earn a profit of 35,010,000 IDR with expenses less than the existing funds, which is 20,982,147 IDR.

Keywords: Profit, Optimization, Linear Programming, Simplex Method, XYZ convection

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1. INTRODUCTION

Along with the development of increasingly advanced technology, the services, trade, and industry business world is showing rapid growth. Competition in the business world is also felt to be getting sharper, which causes companies to be able to manage their business fields well; one way that is taken is to make production planning appropriate. Companies need a strategic plan that can maximize the results to be achieved, whether in the form of maximum profits or minimal costs. Basically, every company has limitations on its resources, limitations in the number of raw materials, machinery, equipment, space, labor, and models. With these limitations, each company takes several ways to optimize the results achieved, one of which is Linear Programming.

Linear programming is a mathematical technique designed to assist managers in planning and making decisions in allocating limited resources to achieve company goals. The company's goal, in general, is to maximize profits. However, due to a limitation, the company can also minimize costs [1]. Linear programming is one of the mathematical models used to solve optimization problems, namely maximizing or minimizing the objective function that depends on several input variables. There are two kinds of linear programming functions: a) The objective function is to direct the analysis and detect the purpose of problem formulation. b) Constraint Function: To determine the available resources and the demand for these resources [2]. In Linear programming, there are two types of methods: the graphical method and the simplex method [3]. The simplex method is an algorithmic procedure used to calculate and store many numbers in the current iteration (iteration) and for decision-making in the next iteration. The Simplex method is a method for solving linear programming problems that include many inequalities and many variables. In using the simplex method to solve linear programming problems, the linear programming model must be converted into a general form called "standard form." The characteristics of the standard linear programming model are all constraints in the form of an equation with a non-negative right side, and the objective function can be maximized or minimized [4]. The graphical method is one way that can be used to solve optimization problems in linear programming. The graph method can be used for solving linear programming problems that have two variables [5]. In linear programming, there are several objectives, namely to solve optimization problems and issues quantitatively, formulate standard decision-making problems, and improve analytical skills.

There are several studies that have applied the linear programming method in solving problems including: 1) the optimal solution of solar cells using the simplex method [6] , 2) the estimation of the potential unit profit over a period of time as far as eight years in the future [7], 3) design a diet model that satisfies the nutritional limit level at minimal cost [8], 4) development of computational methods of diet to meet nutrition based on individual food preferences [9], 5) development of a particular power simplex algorithm to efficiently solve hourly CHP models [10], 6) minimize production costs and maximize profits [11], 7) optimization of production profits at Zenthe Furniture [12], 8) evaluation of parking lot conditions to produce a safe and comfortable layout for visitors [13], 9) estimate of effectiveness production to maximize profit [14], 10) determination of product mix in efficient resource utilization in Ethiopian apparel industry [15] , 11) development of approaches in designing population-specific FBDG [16], 12) decision making using linear programming and fuzzy sets in solving the weight of company criteria [17] [29], 13) completion of programming in the Engineering curriculum [18], 14) maximizing product mix in small to medium-sized companies[19], 15) minimizing transportation costs from multiple supplies to a number of demand destinations [20], 16) establishing a data mining association method to create new sales strategies for cross selling [21], 17) creating a selection decision support system Islamic boarding schools in Purwokerto using AHP [22], and 18) making daily network traffic approaches using Artificial Neural Networks (ANN) [23].

2. THEORY

2.1 Linear Programming

Linear programming is one of the most widely used operations research techniques in practice and is best known for being easy to understand when using linear programming. We can achieve the optimum output (maximum or minimum) based on the available inputs [24]. In linear programming, maximizing or minimizing the objective function depends on several input variables. The objective function (constraint function) is the formulation of the function that is the target to achieve the optimum solution (maximization or minimization), while the constraint function is the formulation of the resource inventory that limits the optimization process [25].

Assumptions in Linear Programs:

- Linearity implies a straight line or proportional relationship between the relevant variables.
- Additivity, all functions, both objective and constraint functions, are arranged in such a way that they show the nature of addition by increasing or decreasing the number of inputs that are aligned, then the number of outputs will increase or decrease with the corresponding ratio.
- Divisibility, the output produced by each activity can be in the form of fractions.
- Deterministic, linear programming can only be used as a problem-solving tool if the parameters of the analysis function are known with certainty.
- Proportionality is that the rise and fall of destination values and the use of available resources/facilities will change proportionally with the level of activity.

The mathematical model of the linear programming problem can be formulated as follows: The function to be maximized or minimized is called the objective function. Minimize (maximize) mathematical model formulation in equations 1 and 2.

$$Z = \sum_{j=1}^{n} C_j X_j \quad [1]$$

$$Z = C_1 X_1 + C_2 X_2 + \ldots\ldots C_n X_n \quad [2]$$

Limitation functions (constraints) are grouped into two types, i.e., Functional limits, with the formulation.

$$\sum_{j=1}^{n} a_{ij} X_j \leq or = or \geq b_i \quad [3]$$

$$a_{11}X_1 + a_{12}X_2 + \cdots a_{1n}X_n \leq,=,\geq b_1$$
$$a_{21}X_1 + a_{22}X_2 + \cdots a_{2n}X_n \leq,=,\geq b_2$$
$$.$$
$$.$$
$$a_{m1}X_1 + a_{m2}X_2 + \cdots a_{mn}X_n \leq,=,\geq b_n \quad [4]$$

Non-negative constraint function (non-negative constraint), with population : (i =1,2,3...m; j = 1,2,3,..n), Information:

Z = total cost or profit
Cj = cost or profit /unit of output
Xj = number of outputs to j
aij = resource i used for output j

2.2 Simplex Method

The simplex method determines the optimal combination of two or more variables. Several terms are often used in the simplex method, including [26]:

- Iteration is a calculation stage where the value in the calculation depends on the value of the previous table
- A non-basic variable is a variable whose value is set to zero at any iteration
- A base variable is a variable whose value is not zero at any iteration.
- The solution or right value is the limiting resource value that is still available.
- Slack variables are added to the mathematical model of the constraint to convert the inequality into an equation (=).
- Surplus variables are subtracted from the mathematical model of the constraint to convert the inequality into an equation (=).
- Artificial variables are variables added to the mathematical model of constraints with the form or = to function as initial basis variables.
- The key column (working column) is the column that contains the input variable.
- The key row (work row) is one of the rows from among the base variables that contains the exit variable.
- Key elements (work elements) are located at the intersection of the key column and row. The key features will form the basis of calculations for the next simplex table. The entry variable is the variable chosen to be the basis variable in the next iteration. The entry variable is selected as one of the non-basic variables in each iteration. This variable in the next iteration will be positive. The exit variable is the variable that comes out of the base variable in the next iteration and is replaced by the incoming variable. The exit variable is selected from one of the base variables in each iteration. This variable in the next iteration will be zero.

2.3 Simplex Method Steps

- Changing the objective function with the constraints of this inequality function must be changed to equality by adding a slack variable. This slack variable is Xn+1, Xn+2,….., Xn+m. Because X1 and X2 represent the level or results of existing activities, the slack variable starts from X3, X4, and so on.
- Arrange the equations in the table after the formulation is changed, and then arrange them into a table.
- Create a key column; in this case, what is done is to find the column that has the largest negative value
- Create key lines in solving problems. Creating the key row in this problem is to use the formula below
- Changing the key row is done by dividing by the result of the key number obtained.
- Continuing the value of changes carried out following the steps above.

2.4 Graphic Method

The graphical method is a method that exists in linear programming and is used to solve problems that contain two problems. The general procedure is to convert a descriptive into a linear programming problem by determining variables, constants, functions, objective functions, and constraint constraints [27]. In the graphical method, several stages are carried out:

1. Identification of decision variables.
2. Identify the objective function.
3. Identify constraints.
4. Draw a graphic form of all constraints.
5. Identify feasible solution areas on the graph.
6. Draw a graphic form of the objective function and determine the point that gives the optimal objective value in the feasible solution area.

2.5 Excel Solver

Solver is one of the additional or optional facilities (add-in) provided by Microsoft Excel that functions to find the optimal formula value in only one cell (target cell) on the worksheet. Microsoft Excel Solver combines Graphical User Interface (GUI) functions, an algebraic modeling language such as GAMS or AMPL, and optimizers for linear, nonlinear, and integer programs. Each of these functions is integrated into the spreadsheet program[28].

The solver is part of a series of commands, commonly called a what-if analysis tool. This function works with cells of a group that are connected, either directly or indirectly (directly-indirectly), to be formulated in the target cell. Basically, the solver consists of three parts, i.e.:

1. Adjustable cells
   The solver adjusts the value changes to a specific cell; to produce results, it is necessary to specify the formula for the target el.
2. Constrained cells/limiting cells

Constraints are used to limit the solver value that can be used in a particular model, and constraint refers to other cells that affect the formula in the target cell.

3. Target cells/target cells
   The solver section is the place where the final result of the processing/execution of a formula is placed.

3. METHOD

The steps taken in data analysis in this study are, among others:

1. *Identify the problem*
   Analysis of the optimization of production profits on XYZ convection, as well as knowing the effect of changes in raw materials and the profits obtained for each product.
2. ***Data collection***
   The data needed is quantitative data obtained from surveys and interviews with XYZ convection owners: data on the use of raw materials, operating costs, margins, and selling prices.
3. ***Data processing***

- Determine the profit optimization objective to obtain maximum profit to realize the maximization of available raw materials with minimal costs.
- Make a table of the availability of raw materials, the use of raw materials, operational costs, and the benefits of each product.

4. *Determine the optimization method*

- *Determine the decision variables*
  - X1 = number of jeans to be produced
  - X2 = number of street jeans that must be produced
  - X3 = number of cotton trousers to be produced
  - X4 = number of cotton shorts to be produced

- *Determine the constraint function*
  - XYZ Convection uses raw materials to produce various pants products based on existing regulations.

- *Determine the objective function*
  - Maximize the profit earned based on the amount of capital available in the production of XYZ convection.
  - Change the sign of into an equation by adding the slack variable.
  - Change the sign of into an equation by adding the surplus variable.

4. RESULT AND DISCUSSION

XYZ Convection is a production business that is engaged in the convection of special clothing for pants. During the convection production process, XYZ makes various kinds of products, including (1) jeans, (2) street jeans, (3) long cotton pants, and (4) short cotton pants. In this study, four real conditions in XYZ convection were taken, namely in the 1st week, 2nd week, 3rd week, and 4th week in 2022, to determine the cost of raw materials and production operational costs. Then it will be analyzed, and the most optimal solution for maximizing XYZ convection revenue will be selected. Table 1 is the expenditure of the raw material costs of fabric every week, and it can be seen that XYZ Convection buys Jeans fabric in the 1st week, then buys Jeans Street fabric in the 2nd week, then buys the long cotton fabric in the 3rd week, and buy short cotton fabric in the 4th week.

TABLE I

FABRIC PRICE ESTIMATION DATA PER UNIT (IDR)

Staple				
Fabric	**Jeans (x1)**	**Jeans Street(x2)**	**Long Cotton (x3)**	**Short Cotton (x4)**
Amount	550	775	550	650
Price	11.160.000	16.730.000	11.950.000	7.965.000
Unit price	20.291	21.587	21.727	12.254

TABLE II

FABRIC PRICE ESTIMATION DATA PER UNIT (IDR)

Estimated Price of Supporting Materials per Unit					
Ingredient	**price**	**x1**	**x2**	**x3**	**x4**
Pocket	900	1800	1800	1800	1800
Zipper	2800	2800	2800	0	0
Jeans Yarn	8500	2125	2125	0	0
Cotton Yarn	10700	0	0	2675	2140
Overlock Yarn	9500	1900	2375	1900	1357
Electricity	300000	429	429	429	429
Total		**9054**	**9529**	**6804**	**5726**

Based on the data in Table 2, it can be seen that the estimated costs of supporting materials that need to be spent for each product are: x1 of 9,054 IDR, x2 of 9,529 IDR, x3 of 6,804 IDR, and x4 of 5,726 IDR.

TABLE III

DATA ON THE TOTAL PURCHASE PRICE OF MATERIALS PER UNIT

Purchase	Jeans (x1)	Jeans Street (x2)	Long Cotton (x3)	Short Cotton (x4)
Price per Unit	29.344 IDR	31.116 IDR	28.531 IDR	17.980 IDR

From table 1,2,3, it can be seen that in the 1st week of XYZ convection, it costs 11,160,000 IDR in producing 550 jeans material, then in the 2nd week, it costs 16,730,000 IDR to produce 775 street jeans material, then in the second week it costs 16,730,000 IDR in producing 775 street jeans. In the 3rd week, spent 11,950,000 IDR in producing 550 cotton trousers, and finally, in the 4th week, spent 7,965,000 IDR in creating 650 cotton shorts. So it is known that the total material costs per unit are: x1 of 29,344 IDR, x2 of 31,116 IDR, x3 of 28,531 IDR, and x4 of 17,980 IDR.

TABLE IV

SIMPLEX VARIABLE CELLS

Variable Cells				
Cell	**Name**	**Original Value**	**Final Value**	**Integer**
$I$31	Unit Jeans	0	0	Integer
$J$31	Unit Street	0	0	Integer
$K$31	Long Cotton Unit	0	0	Integer
$L$31	Short Cotton Unit	0	1167	Integer

Based on data obtained from XYZ Convection that all products produced provide profit margins per unit of goods of: (x1) 40,000 IDR, (x2) 40,000 IDR, (x3) R35,000, and (x4) IDR 30,000. In addition, it is known that the amount of capital owned to make all products from semi-finished materials into finished goods is 21,000,000 IDR. Based on this analysis, a linear equation can be made to maximize the profit of the product based on the profit performance from the sale of the product so that the objective function is to maximize profit.

Based on Table 4, the decision variables in this study are related to the number of product units that must be produced by XYZ convection:

X1 = number of jeans to be produced
X2 = number of street jeans that must be produced
X3 = number of cotton trousers to be produced
X4 = number of cotton shorts to be produced

TABLE V

LINEAR PROGRAMMING CONSTRAINT LOCK

Constraint					
Cell	**Name**	**Cell Value**	**Formula**	**Status**	**Slack**
$M$33	Maximum Destination Price	Rp20.982.147	$M$33<=$J$29	Not Binding	17852,96703
$I$31	Unit Jeans	0	$I$31>=0	Binding	0
$J$31	Unit Street	0	$J$31>=0	Binding	0
$K$31	Long Cotton Unit	0	$K$31>=0	Binding	0
$L$31	Short Cotton Unit	1167	$L$31>=0	Not Binding	1167
$I$31:$L$31=Integer					

TABLE VI

SIMPLEX LP CALCULATION SOLUTION

Objective Cell (Max)			
Cell	**Name**	**Original Value**	**Final Value**
$M$32	Maximum Goal Profit	Rp0	Rp35.010.000

The next step is to categorize the constraints to produce pants with maximum benefits; several constraints can be included in the constraints category. The available funds must be <= the maximum expenditure goal, and the product units produced must be >= 0. Therefore, the optimal solution to achieve the maximum profit that the company can obtain is by optimizing the limit of available funds of 21,000,000 IDR, namely by only producing 1167 pcs of cotton shorts. With the maximum profit obtained is 35.010,000 IDR.

4. CONCLUSIONS

The simplex method is often used to formulate problems using linear programming. This method is a popular formulation method that is often used., which includes solving real problems such as optimization, transportation, planning, assignment, and finding the shortest path using mathematical models. In principle, solving problems using the simplex method requires high accuracy, which utilizes the iteration formula (repetition) using a matrix table to find the maximum result gradually. One way to solve real problems consisting of objective functions and constraint functions is to use the solver tools in Microsoft Excel as a substitute for manual optimization of maximum or minimal functions and constraint functions in the form of linear functions. In this study, it can be concluded that this research has proven effective in calculating the maximum production profit optimization at XYZ convection, which is 35,010,000.00 IDR with a minimum expenditure of 20,982,147 IDR.

AUTHOR CONTRIBUTIONS

Conceptualization; Putri Isma Nabila[PIN], Imam Tahyudin [IT], Aris Munandar[AM], Fahesta Ananda[FA], methodology;[PIN],[IT],[AM],[FA]; validation; [PIN],[IT],[AM],[FA]; formal analysis; [PIN],[IT],[AM],[FA]; investigation; [PIN],[IT],[AM],[FA]; data curation; [PIN],[IT],[AM],[FA]; writing—original draft preparation; [PIN],[IT],[AM],[FA]; writing—review and editing; [PIN],[IT],[AM],[FA]; visualization; [PIN],[IT],[AM],[FA]; supervision [PIN],[IT],[AM],[FA]; project administration; [PIN],[IT],[AM],[FA];, funding acquisition; [PIN],[IT],[AM],[FA], have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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