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IMPLEMENTATION OF LINEAR PROGRAM USING SIMPLEX METHOD TO OPTIMIZE PRODUCTION RESULTS IN A CONVECTION SHOP

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ABSTRACT

This study aims to optimize production at the Belva Busana convection shop using a linear programming method with a simplex approach. This study considers production constraints such as raw material availability, working hours, and labor capacity, and focuses on maximizing profits. Data were collected through online interviews with the production team for six days, from October 27 to November 3, 2024. The linear programming model built showed optimization results with an optimal production composition of 9.6 shirts and 19.2 housedresses, resulting in a maximum profit of IDR 300,000. The results of the study prove that the simplex method is effective in allocating resources efficiently, reducing waste, and increasing productivity. This method has also proven to be practical in making production decisions to increase efficiency and profitability

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1. INTRODUCTION

Linear programming is a mathematical method used to find the best solution (maximum or minimum) of an objective function that is limited by certain constraints. This method is applied in various fields such as economics, production management, logistics, and others to maximize profits or resource efficiency.

In linear programming, the simplex method is one of the most common techniques used to solve all linear programming problems, whether involving two decision variables or more than two decision variables. The solution of this simplex method is through recalculation, which means repeating the same calculation steps before finding the optimal solution. The application of linear programming in the context of convection induction can be used to optimize a product with the aim of minimizing or maximizing the objective function. In this case, maximizing profit or minimizing production costs takes into account a number of constraints, such as raw materials, production capacity, and labor.

In this study, the researcher took Belva Busana as a research location using the simplex method used to find the optimal solution to a linear optimization problem. In its application in Belva Busana, the simplex method can be used to determine the optimal production quantity of various types of clothing such as shirts, house dresses, and dresses, by considering existing limitations, such as machine capacity and employee working hours.

The research entitled "Implementation of Linear Programs Using the Simplex Method to Optimize Production Results in a Convection Shop" has a relevant focus with three other journals, namely on production optimization using the simplex method. Saryoko's (2016) journal provides concrete and applicable solutions in determining the optimal production quantity, although it is limited to the analysis of two products without considering market dynamics. Hani & Harahap's (2021) journal expands the scope to multi-product design with measurable results, but does not integrate labor efficiency or other external variables.

Meanwhile, the journal Rosyidaa et al. (2020) shows advantages in multi-product optimization with more complex resource constraints, but is less flexible to market changes and is static. Compared to the convection shop research, the approach taken has considered specific constraints such as production capacity and raw materials, but this study can be stronger by including market demand analysis, labor efficiency, and product diversification to increase its relevance and application.

Then the research on CV Irah Sidarasa. This research aims to optimize the profit of CV Irah Sidarasa through the application of the simplex method in the production process of two types of cakes, namely panada cakes and ragout balls, using POM-QM for Windows software. The main findings are: Panada cakes provide higher profits, which are IDR 2000 per unit, compared to ragout balls which are only IDR 1000 per unit. To achieve maximum profit of IDR 40,000 per day, the company should produce 70 panada cakes per day and stop the production of ragout balls (Saryoko, 2016).

2. RESEARCH METHOD

1. Place and Time of Research
   This research was conducted through online interviews with the production team at Belva Busana, which is a convection shop located in Rembes Tengah, Tegalgubug Blok 3, Arjawiguna District, Cirebon Regency, West Java. The research was conducted for one week, from October 27, 2024 to November 03, 2024. During this period, various data regarding the production process, use of raw materials, and employee working hours will be collected and analyzed.
2. Types of research
   This study uses a quantitative approach with linear programming methods and simplex techniques as a tool to optimize production at Belva Busana. This study aims to determine the most efficient production strategy and optimize the use of available resources.
3. Linear Programming Model Formulation
   The objective function and constraints above will be formulated into a linear programming model and then solved using the simplex method.
   a. Simplex Solution
      Once the model is formulated, the simplex method will be used to find the optimal solution, namely the production combination that maximizes profits and minimizes costs, while taking into account existing constraints.
   b. Validation and Interpretation of Results
      The results of the simplex solution will be validated with field data and interpreted to see whether the solution can be applied in Belva Busana.
4. Data Types
   a. Primary Data: Data obtained directly from the field, such as information on the amount of production per type of clothing, use of raw materials, time required to complete one product, and production capacity per week.
   b. Secondary Data: Data obtained from Belva Busana's internal documentation, such as financial reports, production reports, and raw material inventory. This data is used to validate the results of the optimization model developed.

5. Variables and Operational Definitions
This research will involve a series of simulation experiments to test several production scenarios at Belva Busana using the simplex method. The experimental design includes the following steps:
   a. Variable Definition:
      i. Objective Function: Maximize profits from production.
      ii. Decision Variable: The amount of production of each type of clothing (shirts, house dresses, dresses).
      iii. Constraints: availability of raw materials, production time, and number of workers.
   b. Linear Programming Model Formulation
   The objective function will be expressed as:
   {Maximize}

$$Z_{maks} = 20.000x_1 + 15.000x_2 + 25.000x_3$$

   From the calculation of the last iteration, the maximum profit obtained is RP300,000. Calculated from the optimal value of the objective function:

$$\text{Zmax} = 20{,}000 + 15{,}000 \text{ with } 9.6 \text{ and} x_1 x_2 \; X_1 = X_2 = 19.2 :$$

$$Z = 20{,}000(9.6) + 15{,}000(19.2) = 192{,}000 + 288{,}000 = 300{,}000$$

6. Data analysis
The data analysis technique used in this study is quantitative analysis because the results of the study aim to maximize production profits in convection shops (such as shirts, house dresses, dresses). The stages of analysis carried out include several steps as follows:
   a. Simplex method: This technique is used to maximize profits from production in a convection shop based on simplex method analysis, the formula used is

$$Z= \; + \; +c_1x_1c_2x_2\cdots+ c_nx_n$$

   Where:
   Z: the value to be maximized (e.g. profit)
   c_1 ,…, : coefficients of the decision variables (e.g. profit per unit of product). $c_{2,}\, c_n$
   x_1 ,…, : decision variables (e.g. quantity of products produced). $x_{2,}\, x_n$
   b. Constraint Function
   The constraint function is written in the form of a linear inequality:

$$a_{11} + + \dots + x_1 a_{12}\; x_2 a_{1n} x_n \leq b_1$$
$$a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}\, x_n \leq b_2$$
$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n \leq b_m$$

   Where:
   a_{ij}: the i-th constraint coefficient for the j-th variable.
   b_i: maximum limit of i-th constraint
   $x_j \geq 0$: all decision variables must be non-negative.
   c. Initial Simplex Table
   Rows for the objective function Z. A
   row for each constraint.
   Columns for decision variables (,,…). x_1x_2
   Columns for slack variables (,,…) s_1s_2
   Solution column (b).
   d. Simplex Iteration
      a. Select input variables: Select the variables with the largest coefficient values $C_j{-}Z_j$ C_j - Z_j $C_j{-}Z_j$ in the objective function (largest positive for max)
      b. Select the output variable: Calculate the ratio for each row.
      c. Pivot: Change the table to make the pivot element 1 and the other elements in the pivot column 0.
      d. Repeat iteration: Repeat the process until all values of $C_j{-}Z_j \leq 0$ indicating that the optimal solution has been reached.
   e. Iteration Formula New pivot elements:

3. RESULT AND ANALYSIS

Research with the Linear Programming method is used to solve a problem such as resource allocation with the ultimate goal of determining the minimum or maximum value. Linear Programs are widely used to solve optimization problems in the fields of economics, industry, banking, education and problems in other fields that can be expressed in linear form.

This study uses a quantitative approach with linear programming methods and simplex techniques as a tool to optimize production at Belva Busana. This study aims to determine the most efficient production strategy and optimize the use of available resources.

This research was conducted by researchers for six days, namely from October 27 to November 3, 2024. The method used was an online interview with the production team at Belva Busana, a convection shop located in Rembes Tengah, Tegalgubug Block 3, Arjawiguna District, Cirebon Regency, West Java. During this period, data related to the production process, use of raw materials, and employee working hours were collected for further analysis.

In its application at Belva Busana, the simplex method can be used to determine the optimal production quantity of various types of clothing such as shirts, housedresses, and dresses, by considering existing limitations, such as machine capacity and employee working hours.

Obtained:

$$x_1 = \text{Shirt}$$

$$x_2 = \text{Daster}$$

$$x_3 = \text{Dress}$$

$$Z_{maks} = 20.000x_1 + 15.000x_2 + 25.000x_3$$

The machine is available for 480 minutes (8 hours) per day, and the time required for each product for production is as follows:

- Machine time for one shirt = 20 minutes
- Machine time for one daster = 15 minutes
- Machine time for one dress = 30 minutes So that:

$$20x_1 + 15x_2 + 30x_3 \leq 480$$

Suppose the employee also works 480 minutes per day, with working time for each product as follows:

- Machine time for one shirt = 10 minutes
- Machine time for one daster = 20 minutes
- Machine time for one dress = 25 minutes

So that:

$$10x_1 + 20x_2 + 25x_3 \leq 480$$

So we get:

Objective
(•) Maximize
( ) Minimize

Instruction
There are more results available in additional windows. These may be opene

Linear Programming Results

(untitled) Solution

	X1	X2	X3		RHS	Dual
Maximize	20000	15000	25000			
kapasitas mesin	20	15	30	<=	480	1000
waktu kerja karyawan	10	20	25	<=	480	0
Solution->	9.6	19.2	0		480000	

Figure 1 : linear programming results determining maximum profit using POM application

Objective
Maximize
Minimize

Instruction
There are more results available in additional windows. Thes

output4

(untitled) Solution

Cj	Basic Variables	20000 X1	15000 X2	25000 X3	0 slack 1	0 slack 2	Quantity
Iteration 1							
0	slack 1	20	15	30	1	0	480
0	slack 2	10	20	25	0	1	480
	zj	0	0	0	0	0	0
	cj-zj	20,000	15,000	25,000	0	0	
Iteration 2							
25000	X3	0.6667	0.5	1	0.0333	0	16
0	slack 2	-6.6667	7.5	0	-0.8333	1	80
	zj	16666.67	12500	25000	833.3333	0	400,000
	cj-zj	3,333.3333	2,500	0	-833.3333	0	
Iteration 3							
20000	X1	1	0.75	1.5	0.05	0	24
0	slack 2	0	12.5	10.0	-0.5	1	240.0
	zj	20000	15000	30000	1000	0	
	cj-zj	0	0.0001		-1,000.0	0	
Iteration 4							
20000	X1	1	0	0.9	0.08	-0.06	9.6
15000	X2	0	1	0.8	-0.04	0.08	19.2
	zj	20000	15000	30000	1000	0	
	cj-zj	0	0		-1,000.0	0.0	

Figure 2 : output results of iterations 1 to 4 using the POM application

Iteration 1:

Initially, slack variables (slack 1 and slack 2) are used to transform the constraints into equation form. The initial values of the decision variables, are zero. $X_1 X_2 X_3$

- Column C_j-Z_j:
  The C_j-Z_j values indicate how much the value of the objective function can be improved if the related variables are included in the basis.
  The values of C_j-Z_j for, and are positive, so the next iteration selects the variables that will enter the basis.$X_1 X_2 X_3$

Iteration 2

- Selection of Entry Variables:
  The variable was chosen because it has the largest C_j-Z_j (25,000). This means that inserting it into the basis can provide the greatest improvement in the objective function. $X_3 X_3$
- Pivot Calculation:
  The pivot row is determined by dividing the quantity column value by the pivot column element (corresponding to) to ensure the solution remains feasible. The pivot is the element that will be changed to 1, while the other elements in the same column are made to zero. X_3
- Iteration Results:
  X_3 is now part of the base variables, replacing one of the slack variables.

Iteration 3

- Selection of Entry Variables:
  The variables are chosen because their C_j-Z_j remain positive and provide an improvement in the objective function. X_1
- Pivot Calculation:
  Just like the previous step, the pivot row is calculated, and the values in the pivot column are adjusted.
- Iteration Results:
  X_3enters the base, while the slack variables remain in the base.

Iteration 4

- Selection of Entry Variables:
  The variables were selected because they have positive C_j-Z_j. X_2
- The final result:
  All C_j-Z_j are zero or negative after this iteration, indicating that the optimal solution has been reached.
- Optimal Solution Interpretation:
  The optimal solution shows values = 9.6, = 19.2, and the maximum objective function value is 20,000() + 15,000() = 300,000. $X_1 X_2$ $X_1 X_2$

Each iteration in the Simplex method is a step to refine the solution until an optimal solution is found. At each step, new variables are introduced into the basis (active variables) while suboptimal variables are removed. This process stops when C_j-Z_j, indicating that no further improvement is possible in the objective function ≤ 0.

4. CONCLUSION

The results of this study indicate that the application of linear programming with the simplex method successfully optimizes the production process at the Belva Busana convection shop. The linear programming model developed in this study is designed to maximize profits, taking into account constraints such as raw material availability, production time, and labor capacity. From the optimization results, it was obtained that optimal production includes 9.6 units of shirts and 19.2 units of house dresses, with a maximum profit of Rp300,000. The simplex method has proven to be effective in allocating resources efficiently, reducing waste, and increasing productivity. In addition, this study proves that the simplex method can be used practically in making production decisions to increase efficiency and profitability.

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