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Advanced Techniques in Operational Research: The Simplex Method for Business Efficiency

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ABSTRACT

Beauty salon is a type of business related to facial and hair care, for both men and women. This study aims to determine the profit of a business using the simplex method. The subject of this study is one of the hair salons located in Pontianak, Indonesia, namely Amanda Salon. The type of research conducted is qualitative research. Linear programming is a branch of mathematics applicable in daily life. It involves formulating mathematical models with linear equations to determine optimal solutions by maximizing or minimizing objective functions subject to a set of constraints. The result obtained by Amanda Salon using the simplex method and linear program solver, comparing the service of smoothing long and short hair, is Rp675,000 with 0 short hair smoothing and 9/8 long hair smoothing.

1. Introduction

Amanda Salon has been in operation for nearly a decade since its establishment in 2014. Initially launched as a small venture, the salon has experienced significant growth over the years due to the strategic initiatives implemented by its management. By 2024, these strategies have led to substantial progress, supported by a consistent mission that has been adhered to year after year. This commitment has resulted in a loyal customer base, with many clients traveling considerable distances to visit Amanda Salon for their beauty treatments. Service booking, according to Jannah and Syafitri (2019), is the process of ordering a product or service, an essential activity within any business process conducted by consumers. Beauty salons, as defined by Dewi et al. (2019), are public service facilities offering hair and skin care treatments using both traditional and modern cosmetic methods. The role of beauty care therapists involves economic activities that engage in numerous interactions with clients without transferring ownership. The societal perception of beauty, particularly the notion that fair skin is synonymous with beauty, influences the beauty industry significantly. This standard, perpetuated by the media and societal norms, creates a demand for services that enhance such features, prompting entrepreneurs to establish various types of beauty salons based on their capital. The concept of self-image is developed through social interactions, as posited by Mead and cited by West and Turner (2018).

This theory of symbolic interactionism suggests that self-concept drives individual behavior. Inner beauty, a widely recognized term, refers to genuine beauty emanating from positive behavior and a virtuous personality, as described by Nuraeni (2020). High self-esteem contributes to confidence, self-worth, and a sense of purpose, whereas low self-esteem can lead to feelings of inadequacy, as noted by Khumaira (2018). The high cost of consultations and treatments at beauty clinics often drives individuals to seek more affordable options like beauty salons, according to Sirapanji & Hansun (2014). Prabasmoro & Priyatna (2013) discuss how societal standards of beauty often equate fair skin with superior beauty, shaping the definition of femininity and sexuality.

Hakim (2001) describes salons as public service venues providing non-surgical beauty treatments. Given these insights, the present study aims to address several research questions: How do beauty salon SMEs in Pontianak city increase their income? What measures can be taken to meet customer demand for beauty salon services? How can maximum profit be calculated using linear programming? Linear programming, a sophisticated technique for resource allocation amidst competing activities, is widely used in various industries (Ari Irawan, 2016).

This method, particularly the Simplex method, is instrumental in decision-making, offering optimal solutions for complex problems. It involves key components such as decision variables, objective functions, and constraints. This study employs linear programming solver software to accurately determine and maximize profits for a beauty salon in Pontianak. Based on interviews and data collection, the linear programming problem is formulated as follows: A beauty salon offers smoothing services for short and long hair, priced at IDR 300,000 and IDR 600,000 respectively. The process involves three stages: applying treatment, drying, and ironing. For short hair: 60 minutes for treatment, 30 minutes for drying, and 90 minutes for ironing. For long hair: 60 minutes for treatment, 60 minutes for drying, and 120 minutes for ironing. The maximum available time is 120 minutes for treatment, 75 minutes for drying, and 135 minutes for ironing. The problem is to determine the maximum profit achievable under these constraints.

The purpose of this study is to optimize Amanda Salon's profit through the application of the Simplex method in linear programming. This research aims to determine the most efficient allocation of resources and the optimal combination of services to maximize revenue. By using linear programming solver software, this research is expected to provide practical insights for beauty salon MSMEs in Pontianak City on how to increase revenue, meet customer demand, and calculate maximum profit accurately. The results of this study are expected to improve operational efficiency, financial performance, and customer satisfaction, and contribute to the growth of the beauty salon business in the region.

2. Critical Riview

The operational success and growth of Amanda Salon over the past decade highlight the importance of strategic planning and consistent mission adherence. Jannah and Syafitri (2019) emphasize the significance of service booking as a critical business process, which is evident in Amanda Salon's approach to customer engagement and satisfaction. This strategic focus has helped the salon build a strong customer base, even attracting clients from distant locations.

Dewi et al. (2019) provide a comprehensive definition of beauty salons, encompassing both traditional and modern cosmetic treatments. This dual approach allows salons like Amanda to cater to a broad demographic, aligning with societal standards of beauty as discussed by Prabasmoro & Priyatna (2013). The perception that fair skin equates to beauty influences consumer preferences and demands, creating opportunities for salons to offer specialized treatments.

The symbolic interactionism theory, as highlighted by Mead and cited by West and Turner (2018), offers valuable insights into how self-concept and social interactions drive behavior. Amanda Salon's focus on enhancing both outer and inner beauty resonates with Nuraeni's (2020) concept of inner beauty, promoting a holistic approach to beauty that extends beyond physical appearance.

The challenges associated with high consultation and treatment costs at beauty clinics, mentioned by Sirapanji & Hansun (2014), underscore the value of more accessible salon services. By providing affordable beauty treatments, Amanda Salon addresses a critical market need, making beauty care more accessible to a wider audience.

Linear programming, particularly the Simplex method, is highlighted by Ari Irawan (2016) as a powerful tool for optimizing resource allocation. The application of this method in calculating maximum profits for Amanda Salon illustrates its practical benefits in real-world business scenarios. By leveraging linear programming solver software, the study ensures precise and efficient profit maximization, aligning with contemporary business optimization techniques. Overall, the integration of strategic planning, understanding of societal beauty standards, and the application of advanced mathematical techniques positions Amanda Salon for continued success and profitability. This approach not only enhances the salon's operational efficiency but also ensures it meets the evolving demands of its clientele.

3. Method

This research is classified as qualitative research that focuses on profit optimization using the Simplex method. The first step in this research is problem identification, where the researcher examines how Salon Amanda can utilize each operational hour to achieve maximum profit. At this stage, an in-depth analysis was conducted of the salon's operational processes and potential efficiency improvements.

Furthermore, the selection of the problem solving model was carried out by choosing a linear program using the Simplex method. This method was chosen due to its effectiveness in optimizing the use of limited resources to achieve the goal of profit maximization.

The data collection process was conducted through direct observation and interviews with the management and staff of Salon Amanda. The data collected includes the time required for various service stages such as drug application, drying, and hair tattooing, as well as price information for smoothing services for short and long hair.

The collected data was then processed and analyzed using the Simplex method in linear programming. This step involves creating a mathematical model of the salon's operational data and applying the Simplex algorithm to find the optimal solution.

Once the analysis is complete, the linear programming model is applied to determine the most efficient allocation of time and resources. The implementation of this model is carried out under real conditions at Salon Amanda to ensure its accuracy and effectiveness in maximizing profits.

With this approach, the research is expected to provide practical and measurable solutions for Salon Amanda to improve operational efficiency and financial returns. This method is not only relevant for Salon Amanda but can also be applied to other MSMEs that face similar challenges in resource management and profit optimization.

4. Result and Discussion

Based on interviews, a linear programming challenge arose from a beauty salon in Pontianak City, Indonesia. The salon wanted to optimize its services in two variants, namely smoothing short hair and long hair, with prices of IDR 300,000 and IDR 600,000 respectively. The service process consists of three stages, namely drug application, drying, and tattooing. For short hair, the smoothing process takes 60 minutes of drug application, 30 minutes of drying, and 90 minutes of tattooing, while long hair takes 60 minutes of drug application, 60 minutes of drying, and 120 minutes of tattooing. One of the constraints that had to be overcome was the maximum time limit for each stage, which was 120 minutes for drug application, 75 minutes for drying, and 135 minutes for tattooing. In this context, the main objective is to determine the maximum profit that can be earned from selling hair smoothing services.

Ask: what is the maximum profit that can be obtained?

X = Short hair, Y = Long Hair (1)

Constraint function:

$60x + 60\ y \leq 120$ = minimized: 60, $30x + 60y \leq 75$ => minimized: 15, $90x + 120y \leq 13$ = minimized: 15,

Objective function: 300,000X + 600,000Y (2)

The mathematical model is obtained:

Objective function:

$x + y \leq 2$, Z= 300.000X + 600.000Y, $2x + 4y \leq 5$, $6x + 8y \leq 9$ (3)

Using the simplex method:

Objective function:

Maximizing Z = 300.000X + 600.000Y. Nilai kanan (NK/RHS) fungsi tujuan harus (0), maka:

Z-300.000x - 600.000y = 0 (4)

The mathematical model is a constraint function:

$x+y \leq 2$, $2x + 4y \leq 5$, $6x + 8y \leq 9$ (5)

To find the maximum optimal value of a linear programming using the simplex method, there are steps/algorithms for its completion, as follows:

Convert the objective function and constraint function into standard/implicit form.

Objective function: z-300,000x-600,000y 0 0 0 0 0, Constraint function 1) x y 1 0 0 2, 2) 2x 4y 0 1 0 5, 3) 6x 8x 0 0 1 9.

In the simplex table compiled, there are the following values:

The variable ZZZ indicates the objective function to be maximized. The coefficient for ZZZ is 1, while for variable XXX (short hair) is -300 and for variable YYY (long hair) is -600. The variables S1S1S1, S2S2S2, and S3S3S3 are the balancing variables introduced for each constraint function. The variables XXX and YYY represent the number of smoothing services for short hair and long hair, respectively. The variable NKNKNK (right value) indicates the limit or maximum value allowed for each constraint function.

In this step, we determine the variable that will be the base in the solution, which is based on the largest negative coefficient in the objective function (Z). In the table provided, the variable (Y) is chosen as the key variable because it has the largest coefficient in the objective function (Z), which is -600, compared to the coefficient of the variable \(X \) which is only -300.

Determines the row that will be the key, indicating the variable that will exit the solution. This is based on the smallest positive index in each row. In the given table, the row that has the smallest positive index value is S3, with an index value of 1.125. Therefore, row S3 is chosen as the key row as it has the smallest positive index value.

In this step, we change the values in the key row by dividing them by the corresponding key number. The key number is the value that is at the intersection between the key column and the key row. In the given example, the key number for the key row (S3) is 8. Therefore, the values in that key row are divided by that key number. By performing this operation, the variable from the corresponding column will take the place of the variable from the key row.

The values in the key row are changed by dividing them by a predefined key number. The key number is the value at the intersection of the key column and key row. In the given example, the key number for the key row (S3) is 8. By dividing the values in the key row by the key number, we get the new key row. Thus, the variable from the corresponding column will replace the position of the variable from the key row.

The result is the determination of the new value for variable Y (Long Hair) after the first iteration process in the simplex method. By dividing the values in the old key row by the corresponding key number, we can find the new value for variable Y.

In this case, the values are as follows: The value in column Z remains unchanged because the introduced variables are non-base variables (S1, S2, S3), which means that column Z is not changed at this stage. The values in columns X and S1 also remain unchanged because they are not key columns. The values in column Y (Long Hair) in the key row (S3) are divided by the key number, which is 8. Thus the new values for variable Y are obtained: 3/4 and 1. The values in column NK (Right Value) also change according to the division of the old key row by the key number. Here, the new value is 9/8. Thus, this step results in an updated value for variable Y (Long Hair), which will be used in the next iteration of the simplex method to find the optimal solution of the given linear program problem.

The result of the last iteration of the simplex method shows the optimal solution of the given linear program problem. The steps are as follows:

1. Calculating the New Row: For Row Z, the new value of Z is calculated by subtracting the values in the old row Z by the product of the Key Column Number Coefficient (KAKK) with the New Key Row Value (NBBK). After calculation, the new value of Z becomes (150 0 0 0 75 675).

For Row S1, the new value of S1 is calculated by subtracting the values in the old row S1 with the result of multiplying KAKK with NBBK. After the calculation, the new value of S1 becomes (¼ 0 1 0 -1/8 7/8).

For Row S2, the new value of S2 is calculated by subtracting the values in the old row S2 with the multiplication result of KAKK with NBBK. After the calculation, the new value of S2 becomes (-1 0 0 1 -1/2 1/2).

2. Inserting the New Values into the Simplex Table: After the calculation, the new values for Z, S1, and S2 are entered into the simplex table.

The simplex table after calculation shows that the right value (NK) of row Z is Rp675,000, the right value of variable X (Short Hair) is 0, and the right value of variable Y (Long Hair) is 9/8.

Thus, the optimal solution of the linear program problem is to obtain a profit of Rp675,000 by not smoothing for short hair (X = 0) and smoothing 9/8 times for long hair (Y = 9/8).

The study made effective use of information technology, particularly linear programming solver applications, to facilitate the calculation of Salon Amanda's maximum profit. By employing linear programming issues with the simplex approach, decision-making was streamlined, and optimal solutions for problem-solving were identified efficiently. This methodology revealed three key findings: choice factors, the objective function, and constraints.

To determine the maximum optimal data from the linear program narrative problem involving Salon Amanda, a beauty parlor in Pontianak, the simplex approach was employed. While alternative approaches exist, such as converting the objective and constraint functions into standard or implicit forms, the simplex method was chosen for its effectiveness. The process involved arranging all tables into a simplex table and identifying the key column yielding the highest negative value and the lowest positive index value. Subsequently, the key row's value was altered by performing division with the key number, resulting in the creation of a new row that affected the values in all rows except for the key row.

Linear programming, a branch of mathematical science, finds practical applications in everyday life. The simplex technique, in particular, serves as a valuable tool for decision-making. Leveraging information technology, including linear program solvers, proves highly advantageous for calculations due to their rapidity, precision, and efficiency. The results achieved by Salon Amanda utilizing the simplex approach and linear program solver amount to IDR 675,000. This underscores the significance of employing mathematical techniques and technological tools in real-world scenarios to optimize outcomes and enhance decision-making processes.

5. Conclusion

In conclusion, the application of linear programming solver applications, particularly utilizing the simplex approach, proved instrumental in optimizing Salon Amanda's profit calculation. Through this study, we identified key factors influencing decision-making, formulated the objective function, and delineated constraints. By employing the simplex method, we efficiently determined the maximum optimal data, facilitating streamlined decision-making processes. This underscores the practical applications of mathematical techniques and information technology in real-world scenarios, enhancing efficiency and optimizing outcomes. The results obtained, amounting to IDR 675,000 in profit for Salon Amanda, highlight the efficacy of employing mathematical tools to inform decision-making processes and drive business success.

6. Table and Image

Tabel 1. Calculation of constraint function and objective function

	Hair Size		
Process	Short Hair (X)	Long Hair (Y)	Total
Drug Application	60	60	120
Drying	30	60	75
Tattooing	90	120	135
Price	300.000.00	600.000.00	

Table 2. simpleks NK

VD	**Z**	**X**	**Y**	**S1**	**S2**	**S3**	**NK**
Z	1	-300	-600	0	0	0	0
S1	0	1	1	1	0	0	2

S2	0	2	4	0	1	0	5
S3	0	6	8	0	0	1	9

Table 3. Entering Variable

VD	Z	X	Y	S1	S2	S3	NK
Z	1	-300	-600	0	0	0	0
S1	0	1	1	1	0	0	2
S2	0	2	4	0	1	0	5
S3	0	6	8	0	0	1	9

Table 4. Leaving variable

VD	Z	X	Y	S1	S2	S	NK	Indeks
Z	1	-300	-600	0	0	0	0	0
S1	0	1	1	1	0	0	2	2
S2	0	2	4	0	1	0	5	1,25
S3	0	6	8	0	0	2	9	1,124

Table 5. Key new row values

VD	Z	X	Y	S1	S2	S3	NK	Indeks
Z	1	-300	-600	0	0	0	0	0
S1	0	1	1	1	0	0	2	2
S2	0	2	4	0	1	0	5	1,25
S3	0	6	8	0	0	1	9	1,125

Table 6. Advanced Simplex Indexk Data

VD	Z	X	Y	S1	S2	S3	NK	INDEKS
Z	1	-300	-600	0	0	0	0	0
S1	0	1	1	1	0	0	2	2
S2	0	2	4	0	1	0	5	1,25
Y	0	3/4	1	0	0	1/8	9/8	1,125

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