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Profit Maximization in a Product Mix Bakery Using Linear Programming Technique

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Abstract: Linear Programming is one of the optimization techniques in finding solutions to managerial decisions making. Linear Programming is a widely used mathematical modelling technique designed to help managers in planning and decisions making relative to resource allocation. This study applied linear programming technique to decision making problem in university of Benin Bakery, Benin city, Edo state, Nigeria, and intended to determine the quantity of Bread that the firm should produce in a day to maximize profit, subject to constraints in the production process. Data on quantity of major raw material used in production of large, medium and small size bread per day were collected from the extract of the financial record of the bakery. The problem was formulated in mathematical term and solved using computer software known as Linear Programming Solver (LIPS). The solution obtained from a single iteration showed that 667 units of extra- large bread should be produced daily for the firm to achieve a maximum daily profit of #100,000. It is therefore recommended that the firm should concentrate more on production of extra- large bread to obtain maximum profit of #100,000 per day.

Keywords: Linear Programming, Optimization Problem, Simplex Method, Linear Programming Solver

1. Introduction

Decision making in today's social and business environment has become a complex task. In reality, however, the decision maker often attempts to attain a set of multiple objectives in an environment of conflicting interests, incomplete information, limited resources, and limited analytic ability ([11]). High cost of technology, materials, labour, competitive pressures, energy consumption and so many different viewpoint greatly increase the difficulty of managerial decision – making. Knowledge and technology are changing rapidly, the new problems with little or no precedents continually rise ([12]).

To effectively address the problem of optimization of the limited resources in this advancing global age, decision makers cannot afford to make decision by simply applying their personal experiences, guess work or intuition, because the consequences of wrong decisions are serious and costly.

Hence, an understanding of the applicability of quantitative methods to decision making is of fundamental importance to decision makers. For example, entering the wrong markets, producing the wrong products, providing inappropriate services will have bad consequence on the organizations ([6]).

The practice of Operations Research (OR) approach must maintain stride with above said trends in the global age. It is said that OR approach doesn't adequately meet the needs of business and industry. Often the reason for the failure is lack of implementation process.

Linear programming according to ([9]) is a mathematical technique used to rationalize many managerial decision as regards the allocation of economic resources. Linear programming (LP) can be defined as a mathematical technique for determining the best allocation of a firm's limited resources to achieve optimum goal. ([2]) also defined it as an optimization instrument used to analyzed constrained optimization problems in which the objective function is a linear function which can be maximized or minimized subject to linear constraints. Linear programming is a

mathematical technique used in Operations Research or Management Sciences to solve specific types of problems such as allocation, transportation and assignment problems that permits a choice or choices between alternatives courses of action ([13]).

Generally, the objective function may be of maximization of profit (which is the focus of this paper) or minimization of costs or labour hours. Moreover, the model also consists of certain structural constraints which are set of conditions that optimal solution should justify. Examples of the structural constraints include the raw material constraint, production time constraint and skilled labour constraints to mention a few. An optimal solution is a solution that fulfils both the constraints of the problem and the set of objectives to be met (Umar, Oluwafemi & Rafiyatu, 2015).

The main purpose of this study is to demonstrate the pragmatic use of linear programming methods in a manufacturing firm, and also to effectively estimate which of the organization's products should be given more attention or produce more in other to maximize profit.

2. Literature Review

([10]) solved transportation problems using linear programming in services company. The paper reveals that an evaluation of 500 largest companies in the world showed that 85% of them have used linear programming.

Study by ([5]) on application of Linear programming in a manufacturing company in Feed master based on the analysis carried out in the organization. The result showed that 25kg layer mash, 25kg of grower mash, 25kg of Broiler starter mash and 25kg of Broiler mash should be produced but more of 25kg of layer mash, 25kg of Grower mash and 25kg of Broiler finisher mash should be produced in order to attain maximum profit because they contribute mainly to profit earned.

In the study by Yahya, Garba and Ige (2013) on application of LP techniques in soap manufacturing firm, the study showed that the firm should produce 1 soap tablets, 12 soap tablets and 120 tablets but more 1 soap tablet in order to optimize their profit.

In the study by ([4]) on the use of linear programming for optimal production in a production line in Coca- cola Bottling company, Ilorin. The analysis revealed that Fanta orange 50cl and 35cl, coke 50cl and 35cl, Fanta lemon 35cl, sprite 50cl, Schweppes, krest soda 35cl should be produced but more of coke 50cl and Fanta orange 50cl in other to satisfy their customers. Also, more of coke 50cl and Fanta orange 50cl should be produced in order to attain maximum profit because they contribute usually to the profit earned.

Felix, Judith, Jonathan and Munashe (2013) applied linear program that reflects choices of selection that is feasible given a set of fixed farm constraints and maximizing income while achieving other goals such as food security. Their result obtained using linear programming is compared with the traditional method. Their result obtained using the linear programming model shows that they are more superior.

([3]) applied linear programming technique to determine optimum production of Usmer Water Company, Uyo. They employed Tora software in the analysis of the data using M-method. Their results showed that the values of the decision variables X_1, X_2, X_3, X_4, and X_5 are 95, 0, 5, 9, 10 and 17 respectively.

In the study by ([1]), LP was applied to the management of loan portfolio of banks, where an answer is provided to question of how to avoid possible occurrence of non-performing loans, bad and doubtful debts in bank.

([7]) carried out a research on maximization of profit in manufacturing industry using linear programming technique in GEEPEE Nigeria Limited specializes in production of tanks of various types. Four different types of tank were sampled for the study, which are Combo, Atlas, Rambo and Jumbo tanks of various sizes. Based on the analysis of the data collected, it was observed that given the amount of materials available, polyethylene (Rubber), and Oxy-acetylene (gas) used in the production of the different sizes of the objectives value contribution and gave maximum profit at a given level of production capacity.

3. Methodology

The source of data for this study was collected from University of Benin Bakery, Benin City. The data collected was based on the types of bread been produced by the bakery which are medium bread, large bread and extra - large bread respectively.

The data collected were based on the major material used per unit of production of the type of breads produced in the bakery as shown table 1 below:

Table 1. *Major Raw Material per unit of production of bread.*

	Medium	**Large**	**Extra large**	**Material available**
Flour	5kg	10kg	15kg	10,000kg
Sugar	0.5kg	0.10kg	0.15kg	2000kg
Butter	0.10kg	0.15kg	0.25kg	1000kg
Profit	#30	#50	#150	

4. Data Analysis

A linear programming model for maximisation of objective function type can be stated mathematically as follows:

$$\text{Maximise } Z = C_1X_1 + C_2x_2 + C_3X_3 + \ldots\ldots\ldots + C_nX_n \quad (1)$$

Subject to

$$a_{11}X_1 + a_{12}X_2 + \text{----------} a_{1n}X_n \leq b_{1\_} \quad (2)$$

$$a_{21}X_1 + a_{22}x_2 + \ldots\ldots\ldots\ldots\ldots a_{2n}X_n \leq b_{2\_} \quad (3)$$

$$a_mX_1 + a_mX_2 + \ldots\ldots\ldots\ldots\ldots a_{mn}X_n \leq b_{m\_} \quad (4)$$

and

$$X_1 \geq 0,\ X_2 \geq 0;\ \text{----------} X_n \geq 0\_ \quad (5)$$

where X_1, X_2, X_3 …….. X_n are decision variable to be maximized.

They represented the various type of bread production i.e X_1 = medium, X_2 = Large, X_3 = extra large

(ii) C_1, C_2, C_3 ---------C_n are the unit profit of the different type of bread production

(iii) a_{ij} are the input- output coefficient

(iv) b_1, b_2, b_m are the available limited resources.

(v) Z is the objective function to be maximized. The maximization of Z is carried out so that the m constraints are satisfied

$$\text{Maximize } (Z) = 30X_1 + 50X_2 + 150X_3 \_ \quad (6)$$

Subject to:

$$10X_1 + 15X_2 + 25X_3 \leq 10{,}000 \_ \quad (7)$$

$$0.5X_1 + 0.10X_2 + 0.15X_3 \leq 2000 \_ \quad (8)$$

$$0.10X_1 + 0.15X_2 + 0.25X_3 \leq 1000 \quad (9)$$

$$X_1, X_2, X_3 \geq 0 \_ \quad (10)$$

Linear programming solver software is used in analyzing the formulated equation and the result is displayed as shown below:

*** Phase II --- Start ***

Basis	X1	X2	X3	s4	s5	s6	RHS
s4	5	10	15	1	0	0	10000
s5	0.5	0.1	0.15	0	1	0	2000
s6	0.1	0.15	0.25	0	0	1	1000
Obj.	30	50	150	0	0	0	0

Figure 1. *Initial solution.*

Variable to be made basic -> X3
Ratios: RHS/Column X3 -> { 2000/3 13333.3 4000 }
Variable out of the basic set -> s4

*** Phase II --- Iteration 1 ***

Basis	X1	X2	X3	s4	s5	s6	RHS
X3	1/3	2/3	1	1/15	0	0	2000/3
s5	0.45	0	0	-0.01	1	0	1900
s6	1/60	-1/60	0	-1/60	0	1	2500/3
Obj.	-20	-50	0	-10	0	0	100000

Figure 2. *Optimal solution.*

*** Phase II --- Iteration 1 ***
>> Optimal solution FOUND
>> Maximum = 100000

*** RESULTS - VARIABLES ***

Variable	Value	Obj. Cost	Reduced Cost
X1	0	30	20
X2	0	50	50
X3	2000/3	150	0

*** RESULTS - CONSTRAINTS ***

Constraint	Value	RHS	Dual Price
Row1	10000	10000	10
Row2	100	2000	0
Row3	500/3	1000	0

Figure 3. *Variables and constraints.*

5. Conclusion

This study has been able to analyses the current activity of bread production in Uniben Bakery adopting Linear Programming Technique. From the analysis and optimality test carried out using Lips software, it is observed that optimal solution is being attained at $X_3 = 667$ and $Z_{max=}$ 100,000 from single iteration, while X_1 and X_2 did not have any significant impact on the optimal solution. It is worthy of note that X_1, X_2, X_3 are the decision variables which represent medium bread, large bread and extra- large respectively. The slack variables S5 and S6 were not taking into consideration in the final result as they have no economic value.

From the findings, for the bakery to make a maximum profit of # 100, 000, they should produce 667 loaves of extra-large bread and reduce or stop the production of medium and large bread as they do not contribute to the maximum profit the bakery makes in the face of the constraints they operate upon.

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