Volume 1: Issue 1
Year 2022-23

Application of Linear Programming for Profit Maximization in Lucky Bakery (Iqbal Foods), Mahuadanr, Latehar

Neha Minj* Anjna Ekka Aaliya Nadim*****
Department of Mathematics
St. Xavier's College Mahuadanr, Latehar, Jharkhand

Abstract

Linear programming is an operation research technique which is widely used in finding solutions to managerial decision making problems of allocating scarce resources in order to maximize profit and minimize cost. This paper deals with the application of the optimization principle. It examined unit cost of production, the selling price and the quantity of different raw materials used in production and the available raw materials in stock weekly to determine the optimal profit of a popular local bakery, Lucky Bakery, Mahuadanr using linear programming technique. Three types of bread produced by the bakery namely; small loaf, medium loaf and slice family loaf were considered in the research. A model for the problem was formulated and optimum results derived by simplex method. The result shows that the small loaf x_1 contributes more to the profit made and therefore, should be produced more by the Bakery.

Keywords: Optimization, linear programming, constraints, Objective function

Introduction

Profit making is the goal of every industry, company or firm, as it will guarantees its existence. The key to making profits in manufacturing industries lies in production of goods at minimum cost and maximum profit that are of the right standard, quantity and at the right time and more especially for sustainability and growth.

Linear programming (LP) is a technique used in determining the best allocation of a firm's limited resources mathematically to achieve optimum results. It is also a mathematical method or procedure employed in operations research or Management Sciences to deal with specific problems that allows a choice or selection between alternative courses of action. It is perhaps the most effective and widely used optimization technique.

LP is a way of obtaining the best outcome in a mathematical model whose requirements are represented by linear relationships. It is a technique for the maximization or minimization of a linear objective function subject to linear equality and inequality constraints. It has applications in various fields of study which include mathematics, business, economics and engineering. Industries that use linear programming models include transportation, energy, telecommunications and manufacturing. It is useful in modeling diverse types of problems in planning, routing, scheduling, assignment and design**.**

Many researchers have studied linear programming and its real life application in recent years.

Balogun (2012) used linear programming method in deriving the maximum gain from production of soft drink in Nigeria Bottling Company, Ilorin plant. Linear programming of the operations of the company was formulated and optimum results obtained using software that uses simplex method. Their results showed that two particular products should be produced even when the company should meet demands of the other-not-so profitable items in the surrounding of the plants.

Adebiyi (2014) focused on linear programming for achieving product-mix optimization in and optimum firm performance. Their result obtained showed that only two out of the five items they considered in their computational experiment are profitable. Ibitoye (2015) empirically examined the impact of linear programming in entrepreneur decision making process as an optimization technique for maximizing profit with the available resources.

Igbinehi (2015) used linear programming to obtain optimal profit in production of local soap. Raimi (2017) examined the optimization of bread production in Rufus Giwa Polytechnic Bakery, Owo, Ondo State, Nigeria using linear programming technique. Amit (2020) also apply linear programming to maximize profit and minimize cost of transportation at Mascot Herbals Ltd and Ashwini Herbal Pharmacy, India.

Zakariyya (2022) focused on linear programming to maximize profit in Shukura Bakery, Zaria, Kaduna, Nigeria. Their result obtained showed that only one out of the three items they considered in their computational experiment are profitable.

In this work, the researchers, through observation noted that most works carried out on LP has to do with large or medium scale firms while the local or small-scale firms are left with a trial and error method of production in order to minimize cost and maximize profit. This gap necessitated the need to practically demonstrate the reliability of LP model in Lucky bakery to enable the owner to improve his decision making capability. Therefore the researchers intend to demonstrate how the developed LP working model can assist the local bakery to optimize its resources for effective output decision.

Mathematical Formulation

A Linear Programming Problem (LPP) has the generic form
maximize/minimize the objective function

$$Z = c_1x_1 + c_2x_2 + c_3x_3 + \cdots + c_nx_n \text{\_\_\_\_\_\_\_\_} (1)$$

subject to the constraints:

$$\begin{aligned} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \cdots + a_{1n}x_n (\leq, =, \geq) b_1 \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \cdots + a_{2n}x_n (\leq, =, \geq) b_2 \\ a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + \cdots + a_{3n}x_n (\leq, =, \geq) b_3 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{m1}x_1 + a_{m2}x_2 + a_{m3}x_3 + \cdots + a_{mn}x_n (\leq, =, \geq) b_m \end{aligned}$$

And the non-negative restrictions $x_j \geq 0, j = 1,2, \ldots \ldots, n$
Where a_{ij}, b_i and c_i are constants and x_j are variables.

Methodology

The method adopted is the Simplex Algorithm. Simplex algorithm is an iterative procedure that examines the vertices of the feasible region to determine the optimal value of the objective function. This method is the principal algorithm used in solving LPP consisting of two or more decision variables. It involves a sequence of exchange so that the trial solution proceeds systematically from one vertex to another in k, each step produces a feasible solution. This procedure is stopped when the volume of c^TX is no longer increased as a result of the exchange. Listed below are the procedures required in the afore mentioned exchange:

Step 1: Setting up the Initial Simplex Table

In developing the initial simplex tableau, convert the constraints into equations by introducing slack variables to the inequalities. So that the problem can be re-written in standard form as a maximization problem. Such that, we can find the initial basic feasible solution by setting the decision variables $x_1, x_2, \ldots \ldots \ldots, x_n$ to zero in the constraints we get the basic feasible solution and the objective function becomes $Z = 0$.

Step 2: Optimality Process

Having setup the initial simplex tableau, determine the entering variable (key column) and the

Product type	Cost price/loaf	Selling price/loaf	Profit price/loaf

departing variable (key row). From the $C_i - Z_i$ row we locate the column that contains the largest positive number and this becomes the Pivot Column. In each row divide the value in the R.H.S by the positive entry in the pivot column (ignoring all zero or negative entries) and the smallest one of these ratios gives the pivot row. The number at the intersection of the pivot column and the pivot row is called the pivot. Now, divide the entries of that row in the matrix by the pivot and use row operation to reduce all other entries in the pivot column, apart from the pivot, to zero.

Step 3: The Stopping Criterion

The simplex method will always terminate in a finite number of steps when the necessary condition for optimality is reached. The optimal solution to a maximum linear program problem is reached when all the entries in the net evaluation row, that is $C_i - Z_i$, are all negative or zero.

Data Presentation And Analysis

The information used for this research work was collected from Lucky Bakery in Mahuadanr in April, 2023. The collected data was based on the different types of bread produced by the bakery which are small, medium and large loaves. The bakery makes production from eight 10kg bags of flour on all the seven days of the week from 10:00am to 5:00pm with the exception of Sundays that the bakery opens by 1:30pm and makes production at half capacity.

In Table 1, the various types of loaves produced by the bakery and the unit cost of production, market price and net profit are given. The raw materials used for the production, the raw material mix for each product (in grams), and the available amount of each raw material for weekly production is stated in Table 2.

Table 1: Types of Products Made by the Bakery, the Production cost per unit, market price and Profit

Small loaf (x_1)	15	20	5
Medium loaf (x_2)	30	40	10
Large loaf (x_3)	40	55	15

Table 2: Raw materials used for the production of the different types of bread

Raw material	**Types of bread and their raw materials mix**			**Total quantity per week (grams)**
	x_1	x_2	x_3	
Flour	200	400	500	434000
Yeast	2	4	5	2828
Milk	4	8	10	8680
Water	100	200	250	217000
Preservatives	1	2	2.5	2170
Sugar	10	20	25	21700
Salt	2	4	5	4340

Formulation Of The Linear Programming Problem

Let x_1, x_2 and x_3 be the decision variables which represent the non-negative number of small loaf, medium loaf and large loaf breads to be produced by the factory in a week. c_1, c_2 and c_3 are the respective profits for each unit of the various types of bread produced in the bakery.
$a_{ij}'s$ represent the quantity of each raw material used in the production of the three types of bread. The objective is to maximize the weekly profit Z of the bakery and thus a linear programming model for the maximization of the objective function Z can be stated mathematically as follows:

Maximize the objective function:

$Z = 5x_1 + 10x_2 + 15x_3$ ---------------- (2)

Subject to the constraints:

$200\, x_1 + 400\, x_2 + 500\, x_3 \leq 434000$

$2x_1 + 4x_2 + 5x_3 \leq 2828$

$4\, x_1 + 8x_2 + 10x_3 \leq 8680$

$100x_1 + 200x_2 + 250x_3 \leq 217000$
$x_1 + 2x_2 + 2.5x_3 \leq 2170$
$10x_1 + 20x_2 + 25x_3 \leq 21700$
$2x_1 + 4x_2 + 5x_3 \leq 4340$
with $x_1, x_2, x_3 \geq 0$

By introducing the slack variables $s_1, s_2, s_3, s_4, s_5, s_6, s_7$ to convert inequalities to equations, we have the standard form as follows:

Maximize: $Z = 5x_1 + 10x_2 + 15x_3$
subject to the constraints:
$200x_1 + 400x_2 + 500x_3 + s_1 = 434000$
$2x_1 + 4x_2 + 5x_3 + s_2 = 2828$
$4x_1 + 8x_2 + 10x_3 + s_3 = 8680$
$100x_1 + 200x_2 + 250x_3 + s_4 = 217000$
$x_1 + 2x_2 + 2.5x_3 + s_5 = 2170$
$10x_1 + 20x_2 + 25x_3 + s_6 = 21700$
$2x_1 + 4x_2 + 5x_3 + s_7 = 4340$
with $x_1, x_2, x_3, s_1, s_2, s_3, s_4, s_5, s_6, s_7 \geq 0$
The optimal solution obtained using Solver (Microsoft Excel Tool) as follows:

Table 3: Optimal solution

Variables	Values
Z	4340
x_1	217
x_2	0
x_3	0

Results And Discussion

By applying simplex method on the linear programming model formulated, the optimum solution is as follows:
$x_1 = 217$, $x_2 = 0$ and $x_3 = 0$ with Z = Rs 4340.

This solution shows that x_1 is the only product that contributes significantly to improve the value of the objective function of the linear programming model.
Considering the solution of the linear programming model obtained, it is therefore recommended and beneficial for Lucky Bakery to give much more attention on the production

of small loaf at the moment due to instability of prices and availability of raw materials provided there is demand for the product. By the calculation, we observe the total sales of 217 units would be sold per week. This would yield the Bakery an optimal profit of Rs 4340 per week based on the costs of raw materials to be used.

Conclusion

In this work, we have considered the different types of product, amount of raw materials used and the production cost in Lucky Bakery weekly. The data obtained from the Bakery on three types of bread produced, the optimal solution was obtained after the formulation of the linear programming problem. The solution obtained showed that the management of the Bakery should focus more on the production of the small loaf and produce less on the other products since they contribute less so to gain Rs 4340 weekly.

The study has shown that the linear programming model can be applicable to small scale firms to substitute to the trial and error method in finding optimal solutions to some decision making problems.

Works cited and consulted

Zakariya A, Mashina M.S., Lawal Z. "Application of Linear Programming for Profit Maximization in Shukura Bakery ,Zaria,Kaduna State, Nigeria". *DUJOPAS*, vol.8 No. I a March 2022,pp. 112-116.

Adebiyi, S.O., Amole, B.B., and Soile, I.O. "Linear Optimization Techniques for Product-Mix of Paints Production in Nigeria". *AUDCE*, 10(1), 2014, pp. 181-190.

Amit K.J., Hemlata S., Ramakant B., Jagannadha R., and Siddharth N. "Application of Linear Programming for Profit Maxinization of a Pharma Company", *Journal of Critical reviews*, 7(12), 2020, pp.1118-1123.

Anieting, A.E., Ezugwu, V.O., Ologun, S. "Application of Linear Programming Technique in the Determination Optimum Production Capacity", *.IOSR Journal of Mathematics*, 5(6), 2013, pp. 62-65.

Balogun, O.S., Jolayemi, E.T., Akingbade, T.J., Muazu, H.G. "Use of Linear Programming for Optimal Production in Production Line in Coca-Cola Bottling Company, Illorin", *International Journal of Engineering Research and Application (IJERA)*, 2(5), 2012, pp. 2004-2007.

Ibitoye, O., Atoyebi, K. O., Genevieve, K., and Kadiri.K. "Entrepreneur Decision Making Process and Application of Linear Programming Technique", *European Journal of Business, Economics and Accountancy*, 3(5), 2015, pp. 1-5.

Igbinehi, E.M., Oyede A. O., and Taofeek I.A. "Appilication of Linear Programming in Manufacturing of Local Soap". *IPASJ International Journal of Management (IIJM),* 3(2), 2015, pp. 26-30.

Oladejo N.K., Abolarinwa A., Salawu S. O., and Lukman A. F. "Optimization Principle and Its Application in Optimizing Landmark University Bakery Production Using Linear Production". *International Journal of Civil Engineering and Technology (IJCIET)*, 10(2), 2019, pp. 183-190.

Raimi O.A., and Adebayo O.C. "Application of Linear Programming Technique on Bread Production Optimization in Rufus Giwa Polytechnic Bakery Ondo State, Nigeria". *American Journal of Operation Management and Information Systems,* 2(1), 2017, pp. 32-36