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OPTIMAL USE OF RAW MATERIALS IN BREAD MAKING BASED ON LINEAR PROGRAMMING APPROACH: (A STUDY OF RAHAMA MODERN BREAD KAURA NAMODA)

[1]M. S. Burodo

[2]S. Suleiman(PhD)

[3]A.B. Sani (PhD)

[4]Rashidat Sanusi

[1]Department of Business Administration and Management Federal Polytechnic Kaura Namoda, Zamfara State.

[2]Department of Mathematics, Usmanu Danfodiyo University, Sokoto.

[3]Department of Accounting Usmanu Danfodiyo University,Sokoto

[4] Department of Business Administration and Management Federal Polytechnic Kaura Namoda, Zamfara State.

Abstract

This work utilized the concept of Simplex algorithm; an aspect of linear programing to allocate raw materials to competing variables (small bread, medium bread and large bread) in Rahama modern bread for the purpose of profit maximization. The analysis was carried out and the result showed that 0 unit of small bread, 107 units of medium bread and 0 unit of large bread should be produced respectively in order to make a profit of N5679. From the analysis, it was observed that only medium bread contributes objectively to the profit. Hence, more of medium loafs is needed to be produced and sold in order to maximize the profit.

Keywords: Linear programming model, Simplex method, Decision variables, Optimal result

1. Introduction

Linear programming is a family of mathematical programming that is concerned with or useful for allocation of scarce or limited resources to several competing activities on the basis of given criterion of optimality. In statistics, linear programming (LP) is a special techniques employed in operation research for the purpose of optimization of linear function subject to linear equality and inequality constraint. Linear programming determines the way to achieve best outcome, such as maximum profit or minimum cost in a given mathematical model and given some list of requirement as a linear equation. The technique of linear programming is used in a wide range as applications, including agriculture, industry, transportation, economics, health system, behavioral and social science and the military. Although many business organization see linear programming as a “new science” or recently development in mathematical history, but there is nothing new about the maximization of profit in any business organization, i.e in a production company or manufacturing company. Linear programming was born during the Second World War out of the necessity of solving military logistics problems. It remains one of the used mathematical techniques in today’s modern societies. The development of linear programming has been ranked among the most important scientific advances of the mid-20th century. Today it is a standard tool that has saved many thousands or millions of dollars for most companies or businesses of even moderate size in the various industrialized countries of the world. From report of various surveys, it has been shown that many production companies, particularly the ones operating in Nigeria are not conversance or yet to know fully the application of linear optimizations. Sometimes many production companies are faced with problems of how to utilize the available resources in order to maximize profit; this is because the use of linear programming which brings a suitable quantitative approach of decision-making has not been fully applied.

Profit maximization implies that a firm either produces maximum output for a given amount of input, or uses minimum input for producing a given output. It is assumed that profit maximization causes the efficient allocation of resources under the competitive market condition. The most common objective of the firms is profit maximization. Any organization that wants to remain in business knows that effective and efficient use of resources is sine-qua-non to the growth and achievement of profit, Winston (2010) opines that linear programming is a mathematical modeling technique designed to optimize the usage of limited resources. In other words, it is a technique for finding the best use of a firm’s limited resource. The efficient method in solving Linear Programming problems is the simplex algorithm method. Therefore, progressive firms will adopt the linear programming model in its production activities in order to arrive at an efficient allocation of resources and enable them know the quantity of each products the organizations should produce in order to maximize profit.

2. Statement of the Problem

Industries all over the world, including Nigeria are continuously faced with shortages of production inputs which result in low capacity utilization and consequently low outputs. Decision making has always been very important in the business and industrial world, particularly with regards to problems concerning the production of commodities. For instance, which commodity should be produced and in what quantity and by which process, which is most effective in attaining the goals of the organization, by combining the limited resources at the disposal of the management are the main questions before production manager. Yet, under these seemingly insurmountable obstacles the business would still want to survive and be profitable. It is essential to state that decision makers and industry planners are aware of the importance of the LP model on profit maximization. But most production industries like Rahama Modern Bread Kaura Namoda, Zamfara State are yet to adopt this model in their production decision-making. They rather adopt traditional accounting methods such as cost-volume-profit analysis, as well as budgeting and budgetary control, in trying to provide a lasting solution to the challenge of optimal decision making. Some others simply use intuition or the trial-and-error method. This,

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no doubt, has resulted to ineffective and inefficient allocation of resources, instability and reduction in the profitability profile of these industries.

3. Objectives of the Study

The main objectives of this paper are:

- To formulate a linear programming model that would suggest a viable product-mix to ensure optimum profit for Company.
- To highlight the peculiarities of using linear programming technique for the Company and prove that despite obstacles, the application of the technique in determining the product-mix of the company would be more profitable than otherwise.
- To know about the constraints of the company regarding cost, resources.

4. Literature Review

Under this heading, we shall review the existing literatures which are related to the topic. According to miller (2007), linear programming is a generalization of linear algebra use in modeling so many real life problems ranging from scheduling airline routes to shipping oil from refineries to cities for the purpose of finding inexpensive diet capable of meeting daily requirements. Miller argued that the reason for the great versatility of linear programming is due to the ease at which constraints can be incorporated into the linear programming model.

Fagoyinbo and Ajibode (2010) reported that the success and failure that an individual or organization experience towards business planning depends to a large extent on the ability of making appropriate decision. They argue that a manager cannot make decision based on his/her personal experience, guesswork or intuition because the consequences of wrong decision is very costly, hence an understanding of the applicability of quantitative method to decision making is of fundamental importance to the decision maker. They described linear programming as one of the major quantitative approach to decision-making and hence applied it in effective use of resources for staff training, the decision variables for the model are the junior staff and senior staff and the constraints was the time available for training as the program is in-service training.

Abiodun and Clement (2017) examined the optimization of bread production in Rufus Giwa Polytechnic Bakery, Owo, Ondo State, Nigeria, using linear programming technique. Three types of bread produced by the bakery were considered in the research and which are medium bread (X1), large bread (X2) and extra-large bread (X3) respectively. Data were collected for four (4) weeks based on temperature per unit of production of the breads using a pocket infrared thermometer so as to know if there will be any deviation in the mode of operation but everything proved to be the same since the process follows a repetitive process of production. The data was analyzed using LINGO software version 15. The findings revealed that optimal solution was attained at X3=1.175 and Zmax=47572.28. It is therefore recommended that the institution bakery should stop producing medium and large bread and produce 235pieces of extra-large bread only from 1.175unit (i.e. 1bag of flour) per day for them to make a maximum profit of #47572.28($239.19) per day or the unit profit on the medium bread and large bread must increase to #39474.87($198.48) and #37450.52($188.30) before it becomes economical to produce.

In Pakistan, Izaz *et al.*, (2011) estimated an optimal production levels for the different products manufactured at ICI, a multinational company. They used revised simplex method to maximize the profit generated in 2010 subject to cost resource constraints. They considered the production of polyester, soda ash, paints and chemicals in their study. Their findings revealed that the production of the soda ash is most productive contributing more to the objective function. Their findings also revealed that the company can earn significantly profit by operating on the proposed production forecasts.
Using linear programming tools and MATLAB algorithm, Junaid and Mukhtar (2010) developed an optimal cutting plan. They employed the use of two software tools to solve mathematical program for optimization of sheet metal cutting plan. It is concluded in their findings that the approaches developed in their work can successfully be applied for obtaining optimal cutting plans and solving constrained cutting stock problems by keeping the trim loss at a minimum level.
In Nigeria, Adebiyi, Amole and Soile (2014) focused on linear optimization for achieving product-mix optimization in terms of the product identification and the right quantity in paint production for better profit and optimum firm performance. Their result showed that only two out of the five products they considered in their computational experiment are profitable.

5. Linear Programming Model

The general linear programming model with n decision variables and m constraints can be stated in the following form.

Optimize (max or min) $Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$

$s.t.$

$a_{11}x_1 + a_{12}x_2 + \cdots\cdots\cdots + a_{1n}x_n (\leq, =, \geq) b_1$

$a_{12}x_1 + a_{22}x_2 + \cdots\cdots\cdots + a_{2n}x_n (\leq, =, \geq) b_2$

$\vdots \qquad\qquad\qquad \vdots \qquad\qquad \vdots$

$\vdots \qquad\qquad\qquad \vdots \qquad\qquad \vdots$

$a_{m1}x_1 + a_{m2}x_2 + \cdots\cdots\cdots + a_{mn}x_n (\leq, =, \geq) b_m$

The above model can also be expressed in a compact form as follows.

Optimize (max or min) $Z = \sum_{j=1}^{n} c_j x_i \cdots\cdots\cdots (objective\ function)$

Subject to the linear constraints

$\sum_{j=1}^{n} a_{ij} x_j\ (\leq, =, \geq) b_i, i\ = 1,2, \dots \dots m\ and\ x_j \geq 0, j = 1,2, \dots \dots n$

Where $c_1, c_2 \cdots \cdots c_n$ represent per unit profit (or cost) of decision variables $x_1, x_2 \cdots \cdots x_n$ to the value of the objective function. And $a_{11}, a_{12} \cdots \cdots, a_{2n} \cdots \cdots a_{m1}, a_{m2} \cdots \cdots, a_{mn}$ represent the amount of resource consumed per unit of the decision variables. The b_i represents the total availability of the i_{th} resource. Z represents the measure – of – performance which can be either profit, or cost or reverence etc.

Standard form of a Linear Programming Model The use of the simplex method to solve a linear programming problem requires that the problem be converted into its standard form. The standard form of a linear programming problem has the following properties.
i. All the constraints should be expressed as equations by adding slack or surplus variables.
ii. The right-hand side of each constraint should be made of non-negative (if not). This is done by multiplying both sides of the resulting constraints by -1.
iii. The objective function should be of a maximization type.
For n decision variables and m constraints, the standard form of the linear programming model can be formulated as follows.

Optimize (max or min) $Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n + 0s_1 + 0s_2 + \cdots\cdots\cdots 0s_m$

$subject\ to\ the\ linear\ constraints$

$$a_{11}x_1 + a_{12}x_2 + \cdots\cdots\cdots + a_{1n}x_n + s_1 = b_1$$

$$a_{12}x_1 + a_{22}x_2 + \cdots\cdots\cdots + a_{2n}x_n + s_2 =$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots\cdots\cdots + a_{mn}x_n + s_m = b_m$$

$$x_1, x_2, \cdots\cdots x_n, s_1, s_2, \cdots\cdots s_m \geq 0$$

This can be stated in a more compact form as:

$$Z = \sum_{j=1}^{n} c_j x_i + \sum_{j=1}^{m} 0s_i$$

$subject\ to\ the\ linear\ constraints$

$\sum_{j=1}^{n} a_{ij}x_j s_i = b_i, i = 1,2, \cdots\cdots m$ and

$$x_j, s_i \geq 0\ (for\ all\ i\ and\ j)$$

Assumptions

- It is assumed that the raw materials required for production of bread are limited (scarce)

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- It is assumed that an effective allocation of raw materials to the variables (small, medium and large bread) will aid optimal production and at the same time maximizing the profit of then bakery.
- It is assumed that the qualities of raw materials used in bread production are standard (not inferior).

6. Data Presentation and Analysis

The data for this research project was collected from Rahama Modern Bread Kaura Namoda, Zamfara State. The data consist of total amount of raw materials (flour, sugar, butter, yeast, and water) available for daily production of three different sizes of bread (small bread, medium bread and large bread) and profit contribution per each unit size of bread produced. The data analysis was carried out with NCSS software (version 2.0). The content of each raw material per each unit product of bread produced is shown below.

Flour

Total amount of flour variable=50000g

Each unit of small bread requires 167g of flour

Each unit of medium bread requires 455g of flour

Each unit of large bread requires 714g of flour

Sugar

Total amount of sugar available=6750g

Each unit of small bread requires 23g of sugar

Each unit of medium bread requires 61g of sugar

Each unit of large bread requires 96g of sugar

Butter

Total amount of butter available =1250g

Each unit of small bread requires 4g of butter

Each unit of medium bread requires 11g of butter

Each unit of large bread requires 18g of butter

Yeast

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Total amount of yeast available=150g

Each unit of small bread requires 0.5g of yeast

Each unit of medium bread requires 1.4g of yeast

Each unit of large bread requires 2.2g of yeast

Water

Total amount of yeast available=37500ml

Each unit of small bread requires 125ml of water

Each unit of medium bread requires 341ml of water

Each unit of large bread requires 536ml of water

Profit contribution per unit product (size) of bread produced

Each unit of big loaf = N6

Each unit of giant loaf = N53

Each unit of small loaf = N69

The above data can be summarized in a tabular form.

Raw material	Product			Total available raw material
	Small bread	Medium bread	Large bread	
Flour (g)	167g	455g	714g	50000g
Sugar (g)	23g	61g	96g	6750g
Butter(g)	4g	11g	18g	1250g
Yeast(g)	0.5g	1.4g	2.2g	150g
Water(g)	125ml	341ml	536ml	37500ml
Profit (N)	6	53	69	

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Model formulation

Let the quantity of small bread to be produce = x_1

Let the quantity of medium bread to be produce = x_2

Let the quantity of large bread to be produce = x_3

Let Z denote the profit to be maximize

The linear programming model for the above production data is given by

Max Z = $6x_1 + 53x_2 + 69x_3$

Subject to $167x_1 + 455x_2 + 714x_3 \leq 50000$

$23x_1 + 61x_2 + 96x_3 \leq 6750$

$4x_1 + 11x_2 + 18x_3 \leq 1250$

$0.5x_1 + 1.4x_2 + 2.2x_3 \leq 150$

$125x_1 + 341x_2 + 536x_3 \leq 37500$

$x_1, x_2, x_3 \geq 0$

Converting the model into its corresponding standard form;

Max Z = $6x_1 + 53x_2 + 69x_3 + 0s_1 + 0s_1 + 0s_1 + 0s_4 + 0s_5$

Subject to $167x_1 + 455x_2 + 714x_3 + s_1 + 0s_2 + 0s_3 + 0s_4 + 0s_5 = 50000$

$23x_1 + 61x_2 + 96x_3 + 0s_1 + s_2 + 0s_3 + 0s_4 + 0s_5 = 6750$

$4x_1 + 11x_2 + 18x_3 + 0s_1 + 0s_2 + s_3 + 0s_4 + 0s_5 = 1250$

$0.5x_1 + 1.4x_2 + 2.2x_3 + 0s_1 + 0s_2 + 0s_3 + s_4 + 0s_5 = 150$

$125x_1 + 341x_2 + 536x_3 + 0s_1 + 0s_2 + 0s_3 + 0s_4 + s_5 = 37500$

$x_1, x_2, x_3, s_1, s_2, s_3, s_4, s_5 \geq 0$

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The above linear programming model was solved using NCSS software, which gives an optimal solution of:

X_1=0.0, X_2=107, X_3=0.0 Z=5678.5714

Interpretation of Result

The result shows that 0 unit of small bread, 107 units of medium bread and 0 unit of large should be produced respectively in order to make an optimum profit of ₦5,678.5714. This therefore indicates that the medium bread contributes objectively to the profit. Hence, more of it is needed to be produced and sold in order to maximize the profit.

7. Summary

The objective of this research work was to apply linear programming for optimal use of raw material in bread production. Rahama Modern Bread was used as our case study. The decision variables in this research work are the three different sizes of bread (small bread, medium bread and large bread) produced by Rahama Modern Bread. The researcher focused mainly on five raw materials (flour, sugar, butter, yeast and water) used in the production and the amount of raw material required of each variable (bread size). The result shows that 0 unit of small bread, 107 unit of medium bread and 0 unit of large bread should be produced respectively which will give a maximum profit of ₦5678.5714

8. Conclusion

Based on the analysis carried out in this research work and the result shown, Rahama Modern Bread should produce the three sizes of bread (small bread, medium bread and large bread) in order to satisfy her customers. Also, more of medium bread should be produced in order to attain maximum profit, because they contribute mostly to the profit earned by the company.

9. Recommendations

Based on the conclusion drawn, the following recommendations were made.

i) Rahama Modern Bread should commit more of its resources in producing medium bread in order to maximize its profit.
ii) The company should keep all records relating to the production processes and apply linear programming techniques in taking decision on how the available resources should be utilized to maximize profit.
iii) The management of the company should adopt different strategies that will persuade customers to patronize their bread especially the medium size for the purpose of maximizing profit.
iv) The management of the company should also adopt quantitative approach in decision making like the LPM as it is clear that model based decision is important for its accuracy and objectivity.

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References

Abiodun R.O., Clement A.O., (2017). Application of Linear Programming Technique on Bread Production Optimization in Rufus Giwa Polytechnic Bakery, Ondo State, Nigeria, *American Journal of Operations Management and Information Systems* 2(2), 32-36

Adebiyi, S. O., Amole, B. B., and Soile, I. O., (2014): Linear Optimization Techniques for Product-Mix of Paints Production in Nigeria. *AUDCE*, Vol.10, No.1, pp.181-190.

Fagoyinbo I. S., Ajibode I.A (2010). Application of linear programming techniques in the effective use of resources for staff training. *Journal of emerging trends in engineering and applied sciences.*

Izaz, U. K., Norkhairul, H. B.., and Imran, A. J., (2011): Optimal Production Planning for ICI Pakistan using Linear Programming and Sensitivity Analysis. *International Journal of Business and Social Science*, Vol.2, No.23, pp.206-212.

Junaid, A. A., and Mukhtar, H. S., (2010): Development of Optimal Cutting Plan using Linear Programming Tools and MATLAB Algorithm. *International Journal of Innovation, Management and Technology*, Vol.1, No.5, pp.483-492.

Steven J. Miller (2007). An introduction to linear programming problem.*Pdfsearchengine.org*

Winston, W.L (2010), Model Building in Mathematical Programming, 3rd Ed., Wiley, New York.

Appendix

NCSS output

Initial Tableau Section

ROW	C1	C2	C3	RHS
	6.0000	53.0000	69.0000	0.0000
	167.0000	455.0000	714.0000	50000.0000
	23.0000	61.0000	96.0000	6750.0000
	4.0000	11.0000	18.0000	1250.0000
	0.5000	1.4000	2.2000	150.0000
	125.0000	341.0000	536.0000	37500.000

Optimal Solution Section

Variable	Optimal Value	Original Cost	Reduced Cost	Status
C1	0.0000	6.0000	-12.9286	Non basis
C2	107.1429	53.0000	0.0000	Basis
C3	0.0000	69.0000	-14.2857	Non basis
Obj. Fn	5678.5714			

Constraint Section

ROW	RHS	Optimal RHS	Constraint
	50000.0000	48750.000	167C1+455C2+714C3
	6750.0000	6535.7143	23C1+61C2+96C3
	1250.0000	1178.5714	4C1+11C2+18C3
	150.0000	150.0000	0.5C1+1.4C2+2.2C3
	37500.0000	36535.7143	125C1+341C2+536C3

Final Tableau Section

Variables	C1	C3	Slack 4	RHS
Z	-12.9286	-14.2857	-37.8571	5678.5714
Slack 1	4.5000	-1.0000	-325.0000	1250.0000
Slack 2	1.2143	0.1429	-43.5714	214.2857
Slack 3	0.0714	0.7143	-7.8571	71.4286
C2	0.3571	1.5714	0.7143	107.1429
Slack 5	3.2143	0.1429	-243.5714	964.2857