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AN OPTIMIZATION SCHEME USING LINEAR PROGRAMMING IN A PRODUCTION LINE OF RITE FOODS LIMITED OSOSA

Erinle-Ibrahim, L. M., Adewole, A. I., Loyinmi, A. C. and Sodeinde, O. K.

Mathematics Department, College of Science and Information Technology, Tai Solarin University of Education, Ijagun, Ijebu-Ode, Ogun State Nigeria

Corresponding Author's Email: erinle-ibrahimlm@tasued.edu.ng, latifat78@yahoo.com

ABSTRACT
The research on the analysis of resource allocation for the maximization of profits using simplex The research of linear optimization in the production line of Rite food limited, Ososa, Odogbolu Local Government Area, Ogun State, Nigeria. In the study, it is observed that the company's profits would be maximized if it produced more of Bigi Cola and Bigi Tropical soft drinks among those used for the analysis

Keywords: Industrial, Algorithm, Programming, Production

INTRODUCTION

Operations Research is a science designed to provide quantitative tools to decision-making processes. It comprises a set of mathematical optimization and simulation methods and models, such as Linear Programming, Non-linear Programming, Theory of Queues, Dynamic Programming, Theory of Decisions, etc. Today, implementing optimized solutions by linear programming has reduced costs significantly in many middle to large scale companies in several industrialized countries. Linear programming has demonstrated to be an alternative solution to plan replacing the traditional solutions based on trial and error (Cardoen, et al. 2010).
Lenka, 2013) opined that global economic crisis makes the business environment unfavourable for industries to survive or to manage their resources optimally. For instance, few decades ago we have witnessed the transition from an industrial nation-based resource oriented economy to a global, networked knowledge intensive economy. Manufacturing in Nigeria cannot be left out of this global connectivity in terms of technology, ideas, techniques and procedure for achieving effectiveness and efficiency. Profit maximization and cost minimization are the sole aims of all enterprises. There is no doubt that there are limited resources at the disposal of every organization. As result of this, managers are faced with decision to choose the best means of managing the scarce resources using linear programming in order to maximize profit. (Sohi et al. 2013) added that, linear programming plays an important role in improving management decision and has proven to be capable of solving problem such as production planning, allocation of resources, inventory control and advertisement. In like manner, we wish to apply the aforesaid method in the decision making process of Right Food Nigeria Limited, Ogun State, Nigeria. Thus, we will employ the linear programming model, simplex method in particular in making our analysis of maximizing profit by minimizing cost.
Rite Foods Limited is a Nigerian Foods and Beverage manufacturing company which started production in 2007. They have taken a grand leap in the FMCG industry by building a World Class, beverage and sausage roll factory. Their world-class factory is currently, considered as one of the leading production facilities Nigeria. Some of their popular products are Rite and Bigi Sausage Rolls Bigi Cola, Bigi Orange, Bigi Apple, Big Lime and Lemon, Bigi Tropical, Big premium Water and Fearless Energy Drink.
Company managers are often faced with decisions relating to the use of limited resources. These resources may include manpower materials and finance. The problem is on how to decide on which resources would be allocated to obtain the best result, which may relate to profit or cost or both. A host of problems fall under Linear Programming

and as such can be modeled accordingly and their solutions sought for (Sivarethinamohan, 2008)."

Thus the study seeks to observe an optimization scheme using linear programming technique in a production line of Rite foods limited Ososa, Ogun state, Nigeria.

According to Miller (2007), linear programming is a generalization of linear algebra use in modelling so many real life problems. These problems range 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.

Akpan and Iwok (2016) in their study of application of linear programming for optimal use of raw materials in bakery reported that Goretta bakery limited should produce the three sizes of bread (big loaf, giant loaf and small loaf) in order to satisfy her customers and more of small of and big loaf in order to attain maximum profit. Linear programming is a mathematical model used to improve management decision and capable of production planning, resource allocation, inventory control and advertising. Method considers objective function as which is optimization element and decision variable as constraint.

In Pakistan, Izaz et al. (2011) estimated an optimal production levels for the different products manufactured at ICI Pakistan Ltd 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 significant profit by operating on the proposed production forecasts.

Ibitoye et al. (2015) empirically examined the impact of linear programming in entrepreneur decision making process as an optimization technique for maximizing profit with the available resources. Their work drew examples from a fast food firm that encountered some challenges in the production of meat pie, chicken pie and doughnut due to an increment in the price of raw materials. Their results showed that there should be discontinuity in the production of chicken pie and doughnut and that they should concentrate in the production of meat pie.

Balogun, et al. (2012) used linear programming technique to derive the maximum profit from the production of soft drink for Ilorin plant. Linear programming of the operations of the company was formulated and optimum results derived using software that employed simplex method. Their results showed that two particular items should be produced even while satisfying the demands of the other-not-so profitable items in the surrounding of the plants. They reported that, the problem of the production sectors is the problem of management, that many companies are faced with decision relating to the use of limited resources such as manpower, raw materials, capital etc. In their work titled "Use of linear programming for optimal production" in Coca-Cola Company, they were able to applied linear programming in obtaining the optimal production process for Coca-Cola Company. In the course of formulating a linear programming model for the production process, they identified the decision variables to be the following Coke, Fanta, Schweppes, Fanta tonic, Krest soda etc. which some up to nine decision variables and the constraint were identified to be concentration of the drinks, sugar content, water volume and carbon (iv) oxide. The resulting model was solve using the simplex algorithm, after the data analysis they came to a conclusion that out of the nine product the company was producing only two contribute most to their profit maximization, that is Fanta orange 50cl and Coke 50cl with a specified quantity of 462,547 and 415,593 in order to obtain a maximum profit of N263,497,283. They advise the company to concentrate on the production of the two products in order not to run into high cost.

Veli Ulucamli (2010) reported that a mixed integer linear programming plays an important role in aggregate production planning i. e., macro production planning) which addresses the problem of deciding how many employees the firm should retain and for manufacturing company, the quantity and mix of products to be produced. He argued that the decision variables for an integer programming are required to be an integer in order in order to satisfy both the objective function and the constraints

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. The decision of most production managers are based on the total input used in the production and output proceed. This method of decision making is always biased, that brings about a reduction in the accuracy of forecasting for such as price fluctuation and shortage of raw materials or available resources. The problem of decision making based on the use of limited resources a major factor that brought the application of linear programming model which is now one of the most powerful tools which all decision makers (managers) must apply before achieving effective decision. The problem then is on how to utilize limited resources to the best advantage, to maximize profit and at the same time select the products to be produced out of the number of products considered for production that will maximize profit. Thus the study seeks to observe an optimization scheme using linear programming technique in the production line of Rite foods limited Ososa, Ogun state, Nigeria.

The general objective is to observe an optimization scheme using linear programming in a production line for Rite foods limited Ososa Ogun State.

While the specific objective is to:

i. Know how limited raw materials are maximize
ii. Know how the products contribute to profit.

MATERIAL AND METHODS

Linear programming is a mathematical technique for finding optimal solutions to problems that can be expressed using linear equations and inequalities. If a real-world problem can be represented accurately by the mathematical equations of a linear program, the method can be used to find the best solution to the problem. Of course, few complex real-world problems can be expressed perfectly in terms of a set of linear functions. Nevertheless, linear programs provide reasonably realistic representations of many real-world problems especially if a little creativity is applied in the mathematical formulation of the problem.

The subject of modeling was briefly discussed in the context of regulation. The regulation problems very simple mathematical representations of reality. As we progress, the models will become more mathematical and more complex. The real world is always more complex than a model. Thus, as we try to represent the real world more accurately, the models we build will inevitably become more complex. Recall the maxim discussed earlier that a model should only be as complex as necessary in order to adequately represent the real word situation represent. Therefore, the added complexity introduced by using linear programming should be accompanied by some significant gains in our ability to represent the problem and, hence, in the quality of the solutions that can be obtained. It is necessary to ask the following questions as you learn more about linear programming What is the benefit of technique and do the outweigh the additional cost? The jury is still out on the question of the usefulness of linear programming in forest planning. Nevertheless, linear programming has been widely applied in forest management planning. Initial applications of the technique to forest management planning problems started in the mid1960s. The sophistication of these analyses grew until, the mid-1970s, when the technique was being applied in real-world forest planning. The passage of the Forest and Rangeland Renewable Resource Planning Act in 1974 created a huge demand for analytical forest planning methods, and linear programming was subsequently applied on almost every national forest in the country. The forest products industry has also adopted linear programming in their planning. Today, most large forest landowners use linear programming, or more advanced techniques similar to linear programming, in their forest management planning.

Production planning is the integration of critical activities on the basis of demand or sales objectives, availability of resources and budgeted fund flow. It involves planning at various levels of production from resource determination, procurement, time planning and scheduling, coordination of tasks performed and tracking (Cichos and Aurich 2016) One major issue of concern in the food processing industry is the planning of procurement, storage of perishable items and if planning is optimum it will lead to substantial reduction in cost of production due to reduction in wastage (Matopoulos *et al*, 2012).

Planning plays a vital role, strategic or long term planning, tactical or medium term planning, operational or short term planning are necessary for efficient production and cost optimization (Guimar et al, 2004). Sometimes linear programming and iterative methods like the simplex method can be employed for mathematical modeling and arithmetic calculations by computing the objective function Cj, reduction objective function Pj, and then

computing values for key, non-key non rows and repeating steps to get the desired answer resulting in optimum production at desired cost (Sinebe *et al*, 2014).

In this paper we assume the following

a. That conditions of certainty exist; that is, the numbers in the objective and constraints are known with certainty and do not change during the period being studied.

b. That proportionality exists in the objective and constraints. This means that if production of 1 unit of a product uses 3hrs of a particular scarce resource, then making 10 units of that product uses 30hrs of the resource.

c. Technical assumption deals with additives, meaning that the total of all activities equals the sum of the individual activities.

d. That solutions need not be in whole numbers (integers) instead, they are divisible and may take any fractional value.

e. That all answers or variables are nonnegative. Negative values of physical quantities are impossible; we simply cannot produce a negative number of textile products.

In general, if $C = (c_1, c_2, ...c_n)$ is a tuple of real numbers, then the function *f* of real variables $X = (x_1, x_2, ...x_n)$ defined by $f(X) = (c_1x_1 + c_2x_2 + ... + c_nx_n)$ is known as a linear function. If *g* is a linear function and $b = (b_1, b_2, ...b_n)$ is a tuple of real numbers, then $g(x) = b$ is called a linear equation, whereas $G(x)(<, =, >)b$ is called a linear inequality. A linear constraint is one that is either a linear equation or a linear inequality. A linear programming problem (LPP) is one which optimizes (maximizes or minimizes) a linear function subject to a finite collection of linear constraints. Formally, any LPP having *n* decision variables can be written in the following form:

Optimize $Z = \sum_{j=1}^{n} C_i X_i$ subject to

$$Z = \sum_{j=1}^{n} a_{ij} x_i (<, =, >) b_i, \qquad i = 1, 2, ...m, \qquad x_i \geq 0,\ j = 1, 2, ...n$$

Common terminology for the aforementioned linear programming model can now be summarized as follows. The function, being optimized (maximized or minimized), is referred to as the objective function. The restrictions normally are referred to as constraints. The first *m* constraints (those with a function of all the variables, on the left-hand side) are called functional constraints (or structural constraints). Similarly, the

$X_j \geq 0,\ j = 1, 2, ..., n$ restrictions are called non-negativity constraints (or non-negativity conditions) and the aim is to find the values of the variables X_j. Any vector X_j, satisfying the constraint of the LPP is called a feasible solution of the problem (Fogiel, 1996, Chinneck, 2000). In this paper, we use the following terminology for the solution. A feasible solution is a solution for which all the constraints are satisfied. An infeasible solution is a solution for which at least one constraint is violated. The problem is to find the values of the decision variables X_j that maximize the objective function *Z* subject to the *m* constraints and the non-negativity restriction on the X_j variablesThe resulting set of decision variables that maximize the objective function is called the optimal solution.

Data collection

The data were collected from the company management, Rite Food Company, Ososa, Ogun State, Nigeria. Secondary data based on the types produced by the organization were used. Some assumptions were made for unavailable data. The roduction process adopts a repetitive approach irrespective of the workmanship involved. The process of the observation was being carried out for a week so as to know if there will be any deviation in the mode of operation.

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Formulation of data

Define the decision variables

X_1 = Bigi Cola

X_2 = Bigi Orange

X_3 = Bigi Apple

X_4 = Bigi Tropical

X_5 = Bigi Bitter lemon

X_6 = Bigi Lemon and lime

Data analysis

The Simplex method, also called Simple technique or Simplex Algorithm, was invented by George Dantzig, an American Mathematician, in 1947. It is the basic workhorse for solving Linear Programming Problems up till today. There have been many refinements to the method, especially to take advantage of computer implementations, but the essentials elements are still the same as they were when the method was introduced (Chinneck, 2000; Gupta and Hira, 2006).

To derive solutions from the LP formulated using the Simplex method, the objective function and the constraints must be standardized.

The characteristics of the standard form are:

All the constraints are expressed in the form of equations except the non-negativity constraints which remain inequalities.

The right-hand-side of each constraint equation is non-negative.

All the decision variables are non-negative.

The Objective function is of maximization or minimization type. Before attempting to obtain the solution of the linear programming problem, it must be expressed in the standard form

Data collected with secondary data from Rite food limited located at Ososa area of Ijebu Ode, Ogun state used to determine an optimization scheme using linear programming in a production line.

Table 1: Quantity of Raw Materials Available in Stock

Raw Materials	**Quantity Available**
Concentrate	1293.6 (Unit)
Sugar	34,180 (Kg)
Water (H_2O)	45920 (Litres)
Citric acid	706.1 (units)
Sodium benzoate	67.15 (Kg)
Potassium sorbate	101.95 (Kg)

Table 2: Quantity of Raw Material Needed to Produce a Pack of Each Flavours

Flavours	**Concentrates**	**Sugar**	**Water**	**Citric acid**	**Sodium benzoate**	**Pottasium sorbate**
Bigi Cola	0.108	4.7621	2.43821	0	0.0054	0.009
Bigi Orange	0.0576	0.4160	3.18398	0.0576	0.00432	0.00722
Bigi Apple	0.17633	3.18622	3.384	0.08150	0.00432	0.00722
Bigi Tropical	0.0576	0.41602	3.18398	0.04536	0.00432	0.00722
Bigi Bitter lemon	0.09266	0.41602	3.024	0.04982	0.00432	0.00722
Bigi Lemon & lime	0.03456	3.9667	3.234	0.0499	0.00432	0.00722

Table 3: Average Cost Price, Average Selling Price and Profit per Pack of Each Flavours

Flavours	**Average Cost Price (₦)**	**Average Selling Price(₦)**	**Profit**
Bigi Cola	530.89	835	304.11
Bigi Orange	450.62	835	384.38
Bigi Apple	530.51	835	304.49
Bigi Tropical	486.40	835	348.60
Bigi Bitter lemon	525.30	835	309.7
Bigi Lemon & lime	405.84	835	429.16

The simplex method adopted minimizes the functions of the n variables depending on the comparison of function values at n + 1 vertices of a general simplex. It was followed by the replacement of the vertex with the highest value by another point. The lowest non zero and non-negative exchange ratio denotes the resources that would leave first**.**

$$z = 304.11x_1 + 384.38x_2 + 304.49x_3 + 348.60x_4 + 309.7x_5 + 429.16x_6$$

Subject to

$$0.108x_1 + 0.0576x_2 + 0.17633x_3 + 0.0576x_4 + 0.09266x_5 + 0.03456x_6 \leq 1293.6$$

$$4.7621x_1 + 0.4160x_2 + 3.81622x_3 + 0.41602x_4 + 0.41602x_5 + 3.9667x_6 \leq 34180$$

$$2.43821x_1 + 3.18398x_2 + 3.384x_3 + 3.18398x_4 + 3.024x_5 + 0.0499x_6 \leq 45920$$

$$0x_1 + 0.0576x_2 + 0.08150x_3 + 0.04536x_4 + 0.04982x_5 + 0.0499x_6 \leq 706.1$$

$$0.0054x_1 + 0.00432x_2 + x_3 + 0.00432x_4 + 0.00432x_5 + 0.00432x_6 \leq 67.15$$

$$0.009x_1 + 0.00722x_2 + x_3 + 0.00722x_4 + 0.00722x_5 + 0.00722x_6 \leq 101.95$$

Introducing the slack variable

$$0.108x_1 + 0.0576x_2 + 0.17633x_3 + 0.0576x_4 + 0.09266x_5 + 0.03456x_6 + k_1 = 1293.6$$

$$4.7621x_1 + 0.4160x_2 + 3.81622x_3 + 0.41602x_4 + 0.41602x_5 + 3.9667x_6 + k_2 = 34180$$

$$2.43821x_1 + 3.18398x_2 + 3.384x_3 + 3.18398x_4 + 3.024x_5 + 0.0499x_6 + k_3 = 45920$$

$$0x_1 + 0.0576x_2 + 0.08150x_3 + 0.04536x_4 + 0.04982x_5 + 0.0499x_6 + k_4 = 706.1$$

$$0.0054x_1 + 0.00432x_2 + x_3 + 0.00432x_4 + 0.00432x_5 + 0.00432x_6 + k_5 = 67.15$$

$$0.009x_1 + 0.00722x_2 + x_3 + 0.00722x_4 + 0.00722x_5 + 0.00722x_6 + k_6 = 101.95$$

$$z - 304.11x_1 - 384.38x_2 - 304.49x_3 - 348.60x_4 - 309.7x_5 - 429.16x_6 = 0$$

DISCUSSION OF RESULT

The information collected from the case company in addition to the sales and other operating data was analyzed to provide estimates for LPP model parameters.The objective of this work was to apply linear programming for optimal use of raw material in Food production. Rite Food Company, Ososa, Ogun Statewas used as our case study. The decision variables in this research work are; X_1 = Bigi Cola, X_2 = Bigi Orange, X_3 = Bigi Apple, X_4 = Bigi Tropical, X_5 = Bigi Bitter lemon, X_6 = Bigi Lemon and lime by Rite food company. The researcher focused mainly on six raw materials (concentrates, sugar, water, citri acid, sodium benzoate, potassium sorbate)used in the production and the amount of raw material required of each variable. The result shows that 2114 packs of Bigi Cola, 2114 packs of Bigi Tropical, 1759 packs of Bigi Apple, 1684 packs of Bigi Oranges and 120 packs of Bigi Lemon and Lime will yield a maximum profit of #335, 281.88

The task and method employed could help and support the decision making process in the production line of the company. In a competitive world amidst scarce resource, the search for optimized solutions to replace traditional methods may become an issue of survival for many organizations. This study successfully demonstrates the applicability of the linear programming technique to the production line in Rite food Limited.Based on the analysis carried out in this research and the result shown, Rite Food Company, Ososa, Ogun State. The study has given insight into how best production can be effectively planned so that optimal production cost could be realized given the available production capacity and resources. The results revealed that using the linear programming model overall production cost could be optimized to three hundred and thirty five thousand, two hundred and eighty one naira (₦335, 281.88) with production of 2114 packs of Bigi Cola, 2114 packs of Bigi Tropical, 1759 packs of Bigi Apple, 1684 packs of Bigi Oranges and 120 packs of Bigi Lemon and Lime. Hence, it is concluded that production of 2114 packs of Bigi Cola, 2114 packs of Bigi Tropical, 1759 packs of Bigi Apple, 1684 packs of Bigi Oranges and 120 packs of Bigi Lemon and Lime is essential to Rite food Limitedto always thrive in the market.

CONCLUSION

Based on the analysis carried out in the work and the result shown Rite Food Limited should produce the more of the Bigi Cola and Bigi Tropical in order to satisfy her customers. Also, more of Bigi Lemon and Lime should be produced in order to attain maximum profit ecause they contribute mostly to the profit earned by the company.

Also, the literature reviews in this work have - further affirmed that linear programming model is workable. This study recommends that the management of Rite Food Limited give more attention to production of Bigi Cola, Bigi Tropical as the two products give the company optimal production cost and Bigi Lemon and Lime which is small in optimization.

They should also ensure that the resources available are utilized optimally in order to minimize production cost to the barest. However, another developed computer program should be used to identify the production schedule of a company faster and more accurately.

They should also ensure that the resources available are utilized optimally in order to minimize production cost to the barest. Operations research practitioners should consider the use of linear programming model in small-scale production firms as a virgin area to explore their services in a more effective manner, this will yield reduction in business failure in Nigeria.

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