**CHAPTER ONE**

**INTRODUCTION**

* 1. **Background of study**

One of the main responsibilities of managers is decision-making; they frequently have to choose how to allocate and use limited resources. According to classical economists, the resources that can be used for production are scarce and have a variety of applications. Because of this, it is important for operations managers to think carefully about how to allocate resources during production planning. Poor resource management can threaten an organization's financial stability and ability to survive by causing operations to fail. As a result, there is a careful need for an efficient and effective control of the firm's production capacity planning. Organizations must be efficient and effective in achieving results with little to no resources if they are to maximize resource usage.

In the dynamic and competitive business environment, companies continually seek ways to optimize their production processes and maximize profitability. One effective approach is the application of linear programming, a mathematical technique that aids in decision-making and resource allocation. This study explores the application of linear programming in the context of Nigeria Brewery, a prominent beverage production company located in Port Harcourt, Nigeria.

According to Akpan and Iwoke (2016), it is their view that the growth of an economy hinges on the choices made by managers within individual firms. These choices should aim to either minimize costs or maximize output, which in turn leads to higher production in the real sector.

Manufacturing planning refers to the choice, procurement, and organization of every facility required for item manufacturing. Choosing the goals to be accomplished during production and the combination of resources (input) to be used to achieve those goals are the primary responsibilities of the production manager.

Adebiyi, Amole, and Soile (2014) put forth the argument that organizations led by non-professional managers with ample experience rely heavily on intuition, knowledge, and past experiences when making decisions. However, this reliance on subjective factors increases the vulnerability of organizations to uncertainties and unpredictable outcomes.

The challenge of maximizing or minimizing a linear function that is subject to linear restrictions is known as linear programming (LP) or linear optimization. Equalities or inequalities may be present in the limitations. Calculating profit and loss is one of the optimisation challenges. In order to locate the feasible region and optimize the solution to have the highest or lowest value of the function, linear programming issues are a significant class of optimization problems.

**1.2 Statement of the Problem:**

Efficient production planning and resource allocation are critical factors for any manufacturing organization, including Nigeria Brewery. However, with the complexities involved in production, such as multiple products, limited resources, and fluctuating demand, the management faces challenges in determining the optimal production levels to meet market requirements while minimizing costs. This study aims to address these challenges by applying linear programming techniques to optimize production planning at Nigeria Brewery.

**1.3 Aim and Objectives:**

The primary aim of this study is to investigate and demonstrate the practical application of linear programming in the production process of Pabod Breweries Limited Company. The specific objectives include:

1. To analyze the production system of Nigeria Brewery and identify key variables, constraints, and objectives relevant to the application of linear programming.

2. To develop a mathematical model using linear programming techniques to optimize production planning at Nigeria Brewery.

3. To apply the developed model to real-world production data of Nigeria Brewery and evaluate its effectiveness in maximizing production efficiency and cost minimization.

4. To provide recommendations based on the findings to enhance the production planning and resource allocation processes at Nigeria Brewery.

**1.4 Scope of the Study:**

This study focuses on the application of linear programming to the production process of Pabod Breweries Limited Company in Port Harcourt. It encompasses an analysis of the production system, development of a mathematical model, and the application of the model to real-world data. The study does not extend to other areas beyond production optimization or delve into specific technical details of the brewing process.

**1.5 Limitations of the Study:**

While every effort has been made to conduct a comprehensive study, certain limitations are acknowledged. Firstly, the availability and accessibility of data from Pabod Breweries Limited Company poses constraints on the accuracy and completeness of the analysis. Secondly, the study is limited by time and resource constraints, potentially impacting the depth and breadth of the research. However, despite these limitations, the study endeavors to provide valuable insights into the application of linear programming in production optimization.

**1.6 Significance of the Study:**

The significance of this study lies in its potential to contribute to the body of knowledge on the application of linear programming to production planning in the beverage industry. By highlighting the benefits and challenges associated with implementing linear programming techniques, this research can assist Pabod Breweries Limited Company and other similar organizations in improving their production efficiency, reducing costs, and making informed decisions in resource allocation. Additionally, the findings of this study can serve as a basis for future research and application of linear programming in other sectors of the economy.

**1.7 BRIEF HISTORY**

Pabod Breweries Limited Company was established in 1982 and was initially owned by the Rivers State Government. Grand Lager, Grand Malt, Grand Soda, and eventually Bond Super Lager Beer, a unique beer prepared using regional raw materials, were the products at the time. The Structural Adjustment Policy (SAP), which forbade brewers from importing raw ingredients that were not easily accessible in the nation, dealt a blow to the industry by forcing several to close their doors in 1986. The brewery was shut down as a result of poor management and corruption, among other factors. Production was terminated in 1996. When manufacture began by the German company Brewtech in a joint venture with the state government, the company was restarted.

**CHAPTER TWO**

LITERATURE REVIEW

L. Mohan (2018) claims that manufacturing firms encountered difficulties in managing the resources accessible for optimum profit because the linear programming that provided a practical quantitative approach to decision-making was not completely implemented.

Ibrahim et al (2020) used a linear programming approach to optimize the profit for allocating raw materials in the bakery to corresponding variables (big loaf, giant loaf, and small loaf), he Researched McDonald's Malaysia menu by implementing linear programming to identify the cheapest menu and the healthiest menu. The researcher developed a linear programming model for McDonald's Malaysia menu that conforms to Malaysia's Recommended Nutrient Intake 2017 (RNI 2017).

Mohamed et al. (2021) formulated the mathematical model of the problem as linear integer programming where the objective function is the total cost for the proposed set menu and the constraints involved are the amounts of calories, carbohydrates, protein, fats, salt and sugar. The problem was solved by using the Solver tools in MS Excel.

Woubante (2017) regarded the information gathered from Ethiopia's apparel industrial unit to approximate the generated linear programming model parameters. Improved the model by utilizing LINGO 16.0 applications and demonstrated that linear programming could increase the company's profit by 59.84 percent while satisfying consumer orders.

Tesfaye et al. (2016) also conducted an analysis obtained from the Ethiopian manufacturing industry and utilized a linear programming model. They suggested that the linear programming model will expand the company's capital by 46.41 percent over the actual use of resources. They also found that the company's profit will rise by 145.5 percent by implementing their model.

Shakirullah et al. (2020) applies to Bangladesh's knit garment manufacturing unit located in the Gazipur district. Data obtained by analyzing monthly resource consumption amount, inventory value, and profit per unit on various goods received from the case industry. The data obtained were used as parameters for the suggested linear programming to test the model's validation. The model has been applied and implemented by Microsoft Excel Solver and AMPL. The analysis demonstrated that the linear programming model would raise the case company's profit by 22 percent if there is great demand. That can be 12.33 percent if the consumer demands. On the other hand, the linear programming model could minimize the costs by 37 percent.

Ozokeraha and Paul (2020) examine linear programming in profit maximization of GT food Benin City, Edo State. Adopted the revised simplex method for the standard maximization problem using the echelon rule [18]. Based on secondary data, Ozokeraha and Paul [18] proposed that the chicken production sector gives the business more control in higher profit.

Maurya et al. (2016) studies using a linear programming model to optimize the profit of an Ethiopian chemical company located in Adama. An objective function is generated based on the decision variables of manufacturing, revenues, and profit over a while, utilizing these variables' quantitatively accessible data. Model equations with sufficient restraints considering production restrictions are solved using the MS-Excel solver. The results noted that the company had a maximum profit of Birr 107,353.17 per day. Aluminum sulphate was wholly used in the Ethiopian chemical business with an idle filtration and evaporation period of 5 and 7 hours a day and an insufficient demand for sulphuric acid of 4,452 tonnes per day.

Oladejo et al. (2020) used a linear programming model to achieve an optimum investment portfolio, with financial risks of $15,000,000.00 invested in crude oil, mortgage notes, cash crops, deposit certificates, fixed deposits, treasury bills, and construction loans. The results indicated that the other alternatives' spending had seen a marginal decline. When the original data's interest rates increased by 5 percent, the profit on investment also increased by almost 17 percent. Meanwhile, the amount of money on treasury bills and construction loans increased. The amount of money on the other alternatives decreased, except for mortgage securities, which showed a modest increase.

Oluwaseyi et al. (2020) proposed a linear programming approach to decision-making at Benin Bakery University, Benin District, Edo State, Nigeria. Wanted to specify the quantity of bread that the Benin Bakery could manufacture on a day to maximize profits, according to the manufacturing process's restrictions. The problem was formulated in mathematical terms and solved using the linear programming solver (LIPS). The solution collected from a single iteration revealed that 667 units of extra-large bread had to be produced daily by the baker to achieve a maximum daily profit of ₦100,000. Then proposed that the Benin Bakery focus more on extra-large bread production to achieve a maximum profit of ₦100,000 per day.

Naik et al. (2020) used the Simplex algorithm to distribute raw materials among competing products (bread, cookies, cakes, and macarons) bakery to maximize profit. The results obtained after the analysis showed that the baker should produce 103 units of bread, 368 units of cakes, 42 units of macarons, and no cookies, to make Rs324,488. It was observed from the analysis that particularly cakes, bread, and macarons contributed more towards the profit. Thus, cakes need to be produced in higher numbers than the other products to maximize profit.

Garba et al. (2020) extracted data from the recording unit for an item blend fabrication industry, Fortunate Bakery, Ilorin, Nigeria. Given the data supplied, the researcher developed a linear programming problem to maximize its daily profit. Resolved the optimal daily profit achievable to the item blend's organization to utilize the simplex method . Using the Tora software package, the results showed that the Fortunate Bakery would achieve an ideal daily profit level of ₦9,500. If the baker's manager concentrates on the production of type alone, it is given to Saloon bread and disregards other lines of items produced by the company.

Anggoro et al. (2018) studied the raw materials to maximize Bintang Bakery's profit. Based on the raw materials, analyzed the maximum profit in Bintang Bakery. The results using the simplex approach and the Lindo tools indicated that the Bintang Bakery home industry results are optimum. The optimum profit of Rp 19,750,000 by manufacturing 3,740 flavored pieces of bread, 1,300 frozen bread rolls, and 520 bread packs of Bintang Bakery industry enhanced profit by Rp 250,000. Ailobhio [1] analyzed the optimal solution in Lace Baking Industry, Lafia, Nigeria. Formulated the problem in linear programming and solved using R statistical software. The results indicated that the baker should produce 1,550 family loaf and 4,650 mini loaf loaves for the Lace Baking Industry to achieve a maximum monthly profit of ₦558,000.

Zangiabadi et al (2007) presented a goal programming approach to determine an optimal compromise solution for the multi objective transportation problem by assuming that each objective function has a fuzzy goal. A special type of non-linear (hyperbolic) membership function is assigned to each objective function to describe each fuzzy goal. The approach focuses on minimizing the negative deviation varies from one to obtain a compromise solution of the multi-objective transportation problem.

Fagoyinbo, I. S. and Ajibode, I, A. (2010) worked on the Application of Linear programming Techniques in the Effective use of resources for staff training. The method employed gave an integer optimum solution to all the models formulated. The Data used did not yield a feasible solution but when the model reformed gave an optimum solution.

U.Khan et al (2011) in their work, optimal production levels for the different products manufactured at ICL, a multinational Company in Pakistan had a result that showed that the amount was raised by changing production patterns within the first, second, third and fourth digit respectively.

Diab, Mokeddem & Abdelhafid, Khellaf. (2007) carried out a study on the simplex method that requires the polyhedron to be in the positive domain, the 1-norm minimization problems are formulated by substantially increasing the size of the linear programming (LP) problems. They present a simple modification that enables the simplex method to be directly applicable to a polyhedron, which extends into the negative domain. That is, instead of requiring the problem to change, the method is changed to fit the problem. The modification eliminates the need to increase the size of the problem and thus eliminates the associated computational effort. The proposed method skips iterations and Phase 1 of the simplex method.

**CHAPTER THREE**

**RESEARCH METHODOLOGY**

This chapter describes the method of data collection used for this study and the method of Analysis employed in the study.

**3.1 SOURCES OF DATA COLLECTION**

The data for this study is a secondary data extracted from the sales record of Pabod Breweries Limited Company

**3.2 LINEAR PROGRAMMING MODEL**

Linear programming needs to be displayed in a general standard type. Linear programming involves a linear objective function, Z, such that, if in general 𝑐1 , 𝑐2 , … , 𝑐𝑛 are real number, then the function of real variables 𝑥1 , 𝑥2 , … , 𝑥𝑛 can be defined as:

Objective function

Min Z (1)

the objective function is subject to,

AX = b (2)

where, Z represents the value of objective function.

C is the coefficients, representing the marginal change in the value of the objective function Z.

X is the decision variables that decide each resource, either to use or remove in the optimal formulation.

A is the coefficient that indicates the amount of resources.

b are the variables, representing the initial quantity of resources.

**3**.**3 ASSUMPTIONS OF LINEAR PROGRAMMING**

Linear Programming are based on the following assumptions

1. Proportionality: Individual activities are considered independent of the others
2. Additivity: This assumes that there are no interactions between any of the activities
3. Non- Negativity: This assumes that all the variables under study does not have a negative value.

Certainty: This assumes that all the parameters of the model are known constants.

* 1. **OPTIMALITY CONDITION FOR THE SIMPLEX METHOD FOR MINIMIZATION**

The optimality condition for the simplex method in a minimization linear programming problem can be stated as follows:

In the simplex tableau, if all the coefficients in the objective row (the bottom row) are non-negative or zero, then the current solution is optimal.

To elaborate further, in the simplex method, we start with an initial feasible solution and iteratively improve it until an optimal solution is reached. At each iteration, we pivot to a neighboring basic feasible solution that improves the objective value.

In a minimization problem, the objective is to minimize the value of the objective function. The coefficients of the objective function in the simplex tableau appear in the bottom row. If all these coefficients are non-negative or zero, it means that no adjacent basic feasible solution can further improve the objective value by reducing the objective function's value. Therefore, the current solution is optimal, and the simplex method terminates.

In summary, in the simplex method for a minimization problem, if all coefficients in the objective row of the simplex tableau are non-negative or zero, the current solution is optimal.

**3.5 ALGORITHM FOR THE SIMPLEX METHOD .**

The simplex method is an iterative algorithm used to solve linear programming problems. Here are the steps involved in solving a minimization linear programming problem using the simplex method:

STEP 1: Formulate the LP problem: Write down the objective function to be minimized and the constraints in standard form.

STEP 2: Convert the problem to canonical form: Convert any inequality constraints to equality constraints by introducing slack variables.

STEP 3: Set up the initial simplex tableau: Create the initial simplex tableau by arranging the coefficients of the variables and slack variables, along with the constants, in a matrix form.

STEP 4: Identify the pivot column: Select the most negative coefficient in the objective row (bottom row) of the simplex tableau. This column will be the pivot column.

STEP 5: Determine the pivot row: Calculate the ratios of the constants in the rightmost column to the corresponding coefficients in the pivot column. Select the smallest positive ratio as the pivot row.

STEP 6: Perform pivot operation: Divide the pivot row by the pivot element (the element in the pivot row and pivot column) to make the pivot element equal to 1. Perform row operations to make all other elements in the pivot column equal to zero.

STEP 7. Update the tableau: Recalculate the coefficients in the objective row using the pivot row and pivot column operations. Repeat steps 4-7 until the optimality condition is met.

STEP 8: Check for optimality: If all coefficients in the objective row are non-negative or zero, the current solution is optimal, and the process stops. Otherwise, go back to step 4.

STEP 9: Read the solution: The optimal solution can be read directly from the simplex tableau. The values of the variables corresponding to the basic columns (columns with a single 1 in a column) indicate the optimal solution.

STEP 10: Perform sensitivity analysis (optional): If required, analyze the sensitivity of the solution to changes in the problem's coefficients, including the objective function coefficients and the right-hand side values.

These steps are repeated until an optimal solution is obtained. The simplex method moves from one basic feasible solution to another, improving the objective value at each iteration, until the optimal solution is reached.

**3.6 TECHNIQUES FOR MODEL SOLUTION**

The model was solved using TORA.

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