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APPLICATION OF LINEAR PROGRAMMING IN PROFIT MAXIMISATION USING CLIFFORD UNIVERSITY CAFETERIA AS A CASE STUDY

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ABSTRACT

This paper applied the concept of Simplex method algorithm as an aspect of Linear Programming to allocate different types of food produced: (White rice, Jollof rice, Porridge yam, Porridge beans, Jollof pasta, White pasta, *Ukazi* soup and *Egusi* soup) at Clifford University Cafeteria for the purpose of profit maximisation. The analysis was carried out and the results showed that 2.6 units of Jollof rice, 3.9 units of *Egusi* soup and 0 units of others, should be produced more in order to generate a profit of Five hundred and forty-eight thousand, Seven hundred and fifty Naira (₦548,750. 00).From the solutions, it was observed that Jollof rice and *Egusi* soup contributed more to the profit objectively. Hence, more of Jollof rice and *Egusi* soup are to be produced and served in order to maximise the profit.

Keywords: Linear programming, Optimisation, Clifford University Cafeteria, Profit maximisation, Simplex method.

1.0 INTRODUCTION:

Most often one come across many target based situations in one's everyday life. For instance, a student who has to complete his project within 15days, a restaurant that have to achieve a production and sales target within a month and another person who has to buy an electronic gadget within a budget of ₦100,000. Now the objectives of these cases are:

1. For the student: to achieve a maximum score in the project.
2. For the restaurant: to achieve a maximum possible production in order to enhance the sale in a month to optimise profit.
3. For the person buying a gadget: to minimise the cost as much as possible to fall within his budget.

From the cases above, we could see that the objective of the situation was either to maximise profit or to minimise the cost.

The Clifford University Cafeteria requires optimal managerial decisions about production levels and sales of food produced in order to maximise their profit making. To achieve this, a number of management theories have been put forth to address real-world issues, such as industry-specific issues and environmental issues faced by the industries that called for the creation of a number of mathematical methodologies. One of the most widely used mathematical approaches for finding the best solution with limited resources is the linear programming.

Linear programming is a powerful mathematical optimisation technique used to solve a wide range of real-world decision-making problems. It provides a systematic approach for finding the

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best outcome, often referred to as the optimal solution, among a set of possible choices while adhering to linear constraints. Linear programming has applications across various domains, including economics, engineering, logistics, finance, and even in everyday decision-making situations.

This method relies on linear relationships and mathematical programming to allocate limited resources efficiently, maximise profits, minimise costs, or achieve other specific objectives. By formulating complex problems into a mathematical framework, linear programming enables one to make informed decisions and optimise outcomes in a structured and quantifiable manner (Mahto, 2012).

The words "optimisation" and "optimal" share a common root that denotes what is best or most favourable. Making something better or looking for the most favourable answer are both examples of optimising something. Though "best" can vary. Football players may seek to increase their running yards while minimising their injury risks. As a result, optimising challenges can be classified as either maximising or minimising.

The goal of optimisation is to improve things. This can be done by assisting a business in making decisions that will maximise profits, assisting a factory in producing goods with minimal environmental impact, or assisting a zoologist in improving an animal's nutrition. Whenever one discussesoptimisation, it frequently utilise words like "better" and "improved." (Griffin, 2014 and Niclas*et al*, 2005).

Profit is the primary driver of people entering the business world, thus business can only develop and thrive when profit is made. Government and its stakeholders in the business world should make sure that profit is being maximised in order to promote economic progress and the creation of jobs. Failure to do so would have disastrous retrenchment and economic underdevelopment effects on the economy and society. In Nigeria, many things have been done to assure profit maximisation in the labour market, from layoff of employees — people-hating strategy—to enforcing strict adherence to the mathematical notion of profit maximisation. The linear programming method is one of the mathematically demonstrated ways to achieve profit maximisation.

To this end, Clifford University Cafeteria seems to be facing some challenges as regards what to be cooked and and when to cook what will be both satisfactory and profitable to both the cafeteria and those who patronize them.

2. LITERATURE REVIEW

There are still various problems with the Restaurants or Cafeteria or Fast Foods in their maximisation of profit. The most common challenge they face is the inability to know the exact food to sell at a certain price considering the cost of production in order to get an optimal profit. Oladejo*et al* (2019), researched on Optimization Principle And It's Application InOptimising Landmark University Bakery Production Using Linear Programming.

They analysed the five different types of bread which Landmark University Bakery produce in their firm which they make use of secondary data collected from the records of the Landmark University Bakery. They converted it into a linear programming problem and used A Mathematical Programming Language (AMPL) software to solve it in order to get the optimum profit.

The concept of Simplex algorithm was effectively and practically used in Okekeand Akpan (2019) work. The allocation of raw materials to competingvariables(small bucket and huge bucket) in the paint business with the goal of maximising company profit with a feature of linear programming. The analysis was carried out using the 2007 edition of MS Excel Solver, and the outcome revealed that 10 units of small buckets of paint and 0 units of large buckets of paint needed to be separately created in order to achieve a profit of N7000.00. The investigation revealed that the tiny bucket of paint merely objectively contributes to the profit. Therefore, additional tiny buckets of paint must be made and sold in order to maximise business profit while also meeting customer demand.

Igbinehi*et al* (2015) applied linear programming model to maximise profit in a local soap production company, the company produces three different types of soap, 5g white soap, 10g white soap and 10g coloured soap. From the data analysis, they observed that the company spends more on coloured soap and they get more profit from white soap than the coloured soap. At the end of the analysis, the company was advised to produce more of white soap (5g and 10g) than the coloured soap in order to obtain an optimal profit.

Igwe*et al* (2011) reported that linear programming is a relevant technique in efficiency in production planning, particularly in achieving increased agricultural productivity. They observed this when carrying out investigation on maximisation of gross return from semi-commercial agriculture in Ohafia zone in Abia state. The general deterministic model is a gross margin maximisation model designed to find out the optimum solutions, the decision variables for the model are numbers of hectares the farmer devoted to the production to the production of crop and combination of crop or livestock capacity produced by the farmer.

Waheed*et al* (2012) demonstrated the application of linear programming in profit maximisation in a product-mix company, in selecting the best means for selling her medicated soap product which are; 1 tablet per pack, 3 tablets per pack, 12 tablets per pack and 120 tablets per pack, which are subject to some constraints. The data analysis was carried out with R-statistical packages, from the analysis, it showed that the company would obtain optimal monthly profit level of about ₦271.296 , if she concentrates mainly on the unit sales (one tablet per pack) of her medicated soap product ignoring other types of sales packages.
In the same vein, Balogun*et al* (2012), used the simplex algorithm concept in their work; use of linear programming for optimal production in Coca-Cola Company, here they applied linear programming in obtaining production process for the company. They formulated a linear programming model for the production process, they identified the decision variables to be the following Coke, Fanta orange, Schweppes, Fanta tonic, etc which sum up to nine decision variablesand the constraint were identified to be concentration of the drinks, Sugar content,water volume and carbon(iv)oxide. From the analysis of the data, they advised the company to produce 50cl Fanta orange and 50cl Coke with specified quantity 462547 and 416593 in order to obtain a maximise profit of ₦263,497,283, so as to maximise their profit in order not to run in high cost.

Akpan and Iwok(2016) used linear programming to allocate raw materials in bakery industry to competing variables which include; big loaf, giant loaf and small loaf for the purpose of profit maximisation. From the analysis, it showed that 962 units 0f small loaf, 38 units of big loaf and 0 unit of giant loaf should be produced in order to generate a profit of ₦20385. Also, they observed that the small loaf, followed by big loaf contribute objectively to the profit. Hence, more of small loaves and big loaves are to be produced and sold to maximise the profit.

3. METHOD

3.1 Mathematical Formulation

This study investigates the overall quantity and tickets sold for the eight various food produced by Clifford University Cafeteria and the allocation of resources (cost of production) to the various products through the records kept by the staff of the Clifford University Cafeteria as shown in Table 1.

Linear programming is presented as a general standard form to display all properties required of a linear programming problem. This consists of a linear objective function (Ƶ) such that real numbers $C_1, C_2, C_3, \ldots, C_n$ then the function Ƶ of real variables $X_1, X_2, \ldots, X_n$ can be defined in equation (1)

$$Ƶ = C_1X_1 + C_2X_2 + \ldots + C_nX_n \qquad (1)$$

Other properties include a linear constraint (which is one that is either a linear equation or linear inequality) and a non-negativity constraint.

The flowchart of the Linear programming is as shown in Figure 1

From Table 1, the total production budget = ₦300,000 and the total amount generated from the sales of ticket = N684,300 while the total profit realised = ₦684,300 – ₦300,000 = **₦384,300.**

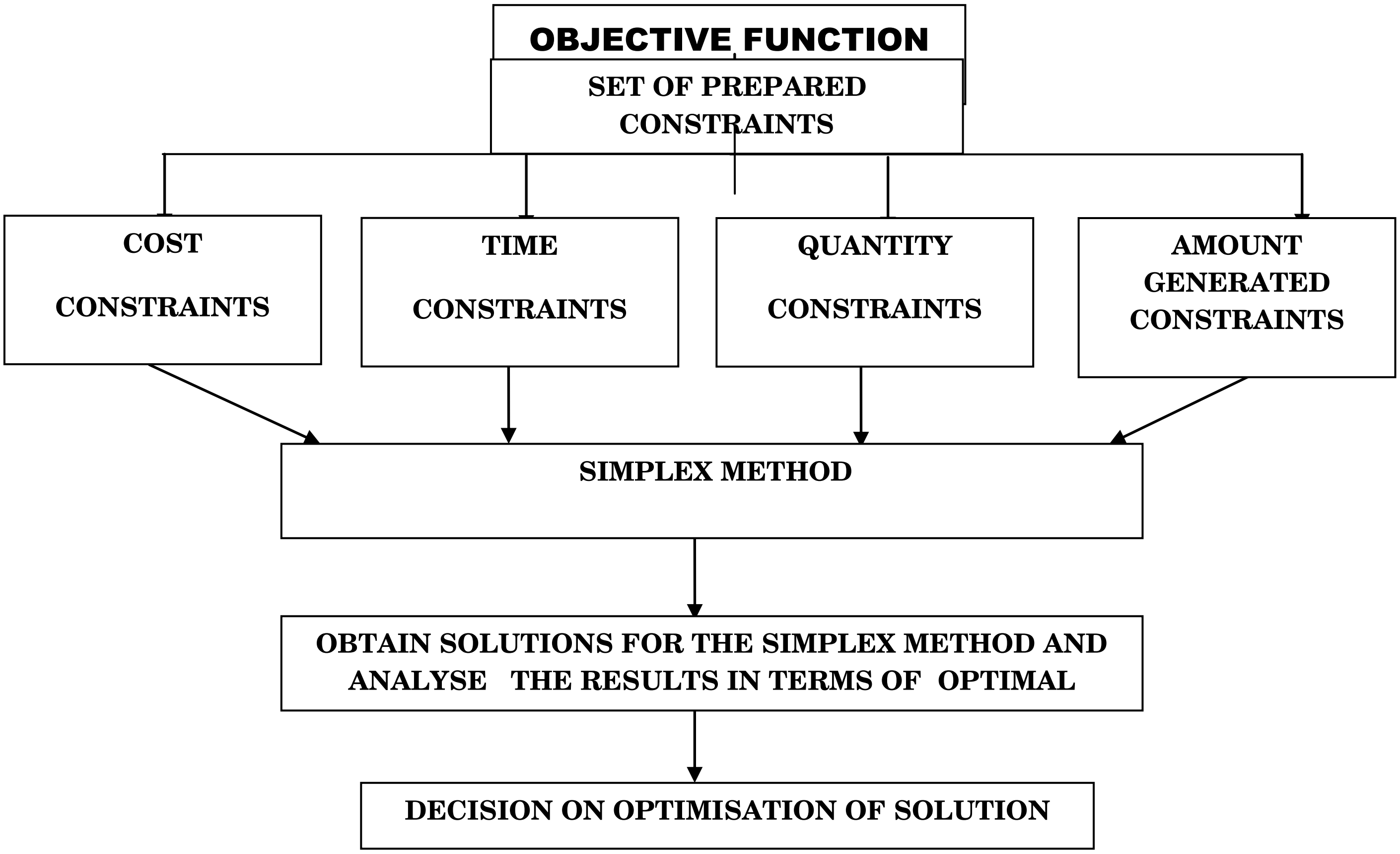

Figure 1: Flowchart development for the linear programming model

3.1 Formation of A Linear Programming Problem (LPP) Model

a. Objective Function

The objective function of the model is to maximise profit generated from the sales of ticket by the Clifford University Cafeteria, which will be mathematically represented.

Let "Ƶ" be the objective function. The objective function is to maximise profit

Let the unit of white rice produced = x_1

Let the unit of jollof rice produced = x_2

Let the unit of porridge yam produced = x_3

Let the unit of porridge beans produced = x_4

Let the unit of jollof pasta produced = x_5

Let the unit of white pasta produced = x_6

Let the unit of *ukazi* soup produced = x_7

Let the unit of *egusi* soup produced = x_8

To optimise profit, the objective function (Ƶ)

$Ƶ = 46{,}400x_1+72{,}000\ x_2+22{,}600\ x_3+46{,}000\ x_4+70{,}000\ x_5+29{,}000\ x_6+37{,}700\ x_7+60{,}600\ x_8$

To optimise from the amount generated, we have the objective function (Ƶ)

$Ƶ = 71{,}400x_1+152{,}000\ x_2+42{,}600\ x_3+81{,}000\ x_4+130{,}000\ x_5+49{,}000\ x_6+62{,}700\ x_7+95{,}600\ x_8$

b. Constraints

Subjected to:

Cost of Production Constraint

$21{,}000x_1+80{,}000\ x_2+20{,}000\ x_3+35{,}000\ x_4+60{,}000\ x_5+20{,}000\ x_6+25{,}700\ x_7+35{,}600\ x_8 \leq 300{,}000$

Time of Production Constraint

$2x_1+3x_2+3x_3+2x_4+2\ x_5+2\ x_6+1\ x_7+2x_8 \leq 17$

Quantity Produced Constraint

$^1/_2 x_1+2x_2+3x_3+20x_4+3\ x_5+1\ x_6+ {}^1/_2 x_7+3x_8 \leq 43$

Amount Generated Constraint

$71{,}400x_1+152{,}000\ x_2+42{,}600\ x_3+81{,}000\ x_4+130{,}000\ x_5+49{,}000\ x_6+62{,}700\ x_7+95{,}600\ x_8 \geq 684{,}000$

4. RESULTS AND DISCUSSION

The linear programming model (LPM) has been formulated to maximize profit generated by the University's Cafeteria from the cost of production and the amount generated. Linear programming models were developed for eight different variables x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8 and solved with Simplex method as shown in Table 2.

Table 1: Details of food menu and profit generated

S/N	FOOD ITEM	TIME OF PRODUCTION	COST OF PRODUCTION (₦)	NO OF MEAL TICKETS SOLD		TOTAL AMOUNT GENERATED (₦)	PROFIT REALISED
				₦400	₦500		
1.	White rice	2	25,000	81	78	71,400	46,400
2.	Jollof rice	3	80,000	148	186	152,000	72,000
3.	Porridge beans	3	20,000	64	34	42,600	22,600
4.	Porridge yam	2	35,000	110	74	81,000	46,000
5.	Jollof pasta	2	60,000	131	156	130,000	70,000
6.	White pasta	2	20,000	55	54	49,000	29,000
7.	*Ukazi* soup	1	25,000	48	87	62,700	37,700
8.	*Egusi* soup	2	35,000	84	124	95,600	60,600
		Total	**300,000**	**721**	**793**	**684,300**	**384,300**

Table 2: Values of the objective function and the constraints

Basic	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	S_1	S_2	S_3	S_4	Solution
S_1	25000	80000	20000	35000	60000	20000	25000	35000	1	0	0	0	300000
S_2	2	3	3	2	2	2	1	2	0	1	0	0	17
S_3	71000	152000	42600	81000	130000	49000	62700	95600	0	0	1	0	684000
S_4	0.5	2	3	20	3	1	0.5	3	0	0	0	1	43
Maz	-71000	-152000	-42000	-81000	-130000	-49000	-62700	-95600	0	0	0	0	0

Table 3: Constraints with Echelon-Row Reduction on Simplex Method

Basic	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	S_1	S_2	S_3	S_4	Solution
X_1	3.13E-01	1	0.25	0.4375	0.75	0.25	0.3125	0.4375	0.0000125	0	0	0	3.75
S_2	1.06E+00	0	2.25	0.6875	-0.25	1.25	0.0625	0.6875	-0.0000375	1	0	0	5.75
S_3	2.35E+04	0	4600	14500	16000	11000	15200	29100	-1.9	0	1	0	114000
S_4	-1.25E-01	0	2.5	19.125	1.5	0.5	-0.125	2.125	-0.000025	0	0	1	35.5
Maz	-2.35E+04	0	-4000	-14500	-16000	-11000	-15200	-29100	1.9	0	0	0	570000

Table 4: The Optimum Result

Basic	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	S_1	S_2	S_3	S_4	Solution
X_1	-4.08E-02	1	0.180842	0.219502	0.50945	0.084622	0.083978	0	4.10653E-05	0	-1.50344E-05	0	2.036082
S_2	5.07E-01	0	2.141323	0.344931	-0.62801	0.99012	-0.29661	0	7.38832E-06	1	-2.36254E-05	0	3.056701
X_3	8.08E-01	0	0.158076	0.498282	0.549828	0.378007	0.522337	1	-6.52921E-05	0	3.43643E-05	0	3.917526

S_4	-1.84E+00	0	2.164089	18.06615	0.331615	-0.30326	-1.23497	0	0.000113746	0	-7.30241E-05	1	27.17526
Maz	0.00E+00	0	600	0	0	0	0	0	0	0	1	0	684000

Table 5: Profits to be generated from Jollof Rice and *Egusi* soup

Food Produced	**No. of units produced**	**Amount used in production**	**Amount generated**	**Profit**
Jollof rice	2.6	210,950	522,270	311,320
Egusi soup	3.9	89,000	326,430	237,430
TOTAL	**6.5**	**₦299,950**	**₦848,700**	**₦548,750**

From Table 2,

$$\frac{300000}{80000} = 3.75$$
$$\frac{17}{3} = 5.66$$
$$\frac{684000}{152000} = 4.5$$
$$\frac{43}{2} = 21.5$$

New R_1 = $^1/_{80,000}$ (Current R_1) = (0.313, 1, 0.25, 0.4375, 0.75, 0.25, 0.3125, 0.4375, 1.25E-5, 0, 0, 0, 3.75)

New R_2 = (current R_2) – 3(new R_1) = (1.06, 0, 2.25, 0.6875, -0.25, 1.25, 0.0625, 0.6875, -3.75E-5, 1, 0, 0, 5.75)

New R_3 = (current R_3) – 152,000(new R_1) = (23,500, 0, 4600, 14500, 16000, 11000, 15200, 29100, -1.9, 0, 1, 0, 114000)

New R_4 = (current R_4) – 2(new R_1) = (0.125, 0, 2.5, 19.125, 1.5, 0.5, -0.125, 2.125, -2.5E-5, 0, 0, 1, 35.5)

New R_5 = (current R_5) + (new R_1) = (23500, 0, -4000, -14500, -16000, -11000, 15200, -29100, 1.9, 0, 0, 0, 570000)

Table 3 shows the constraints with Echelon-Row Reduction on simplex method while Table 4 shows the optimum result.

From Table 3,

$$\frac{114000}{29100} = 3.92$$

$$\frac{3.75}{0.4375} = 8.57$$

$$\frac{5.75}{0.6875} = 8.36$$

$$\frac{35.5}{2.125} = 16.71$$

New R_1 = (current R_1) – 0.4375(new R_3) = (-4.08, 1, 0.8084, 02.195, 0.50945, 0.0846, 0.08398, 0, 4.106E-5, 0, -1.503E-5, 0, 2.03608)

New R_2 = (current R_2) – 0.6875(new R_3) = (0.507, 0, 2.14, 0.344, -0.628, 0.9901, -0.29661, 0, 7.388, 1, -2.3625, 0, 3.0657)

New R_3 = $^1/_{29,100}$ (Current R_3) = (0.808, 0, 0.158, 0.49828, 0.5498, 0.378, 0.52234, 1, -6.659E-5, 0, 3.436E-5, 0, 3.91753)

New R_4 = (current R_4) – 2.125(new R_3) = (-1.84, 0, 2.16409, 18.0662, -0.33162, -1.23497, 0, 0.0001137, 0, -7.3024, 1, 27.1753)

New R_5 = (current R_5) + 29100(new R_3) = (0, 0, 600, 0, 0, 0, 0, 0, 0, 0, 1, 0, 684000)

Based on the data collected, the optimum result derived from the model using Simplex method indicates that two types of food should be produced more, that is; jollof rice and *egusi* soup. Meanwhile, their production quantities should be 2.6 units and 3.9 units respectively. This will yield a maximum profit of ₦548,750.00 (Table 5). Meanwhile, other types of food should be produced in a lesser quantity.

CONCLUSION

The objective of this paper was to apply linear programming in profit maximisation in food production using Clifford University Cafeteria as a case study. Where the decision variables in this work are eight types of food; (white rice, jollof rice, porridge yam, porridge beans, jollof pasta, white pasta, *ukazi* soup and *egusi* soup) produced by the Cafeteria, with constraints;(Cost of Production, Time of Production, Quantity Produced and Amount Generated). The result shows that 2.6 units of jollof rice, 3.9 units of *egusi* soup and 0 unit of the remaining six(6) should be produce respectively. This will yield a maximum profit of ₦548,750.00

Based on the analysis done for this study and the results obtained, it has been determined that Clifford University Cafeteria, Ihie Campus, should produce more jollof rice and egusi soup in order to maximise their profit.

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