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Linear Programming for Profit Maximization of Agricultural Stock

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Abstract

This paper discusses a few common issues that are specific to agricultural investing, such as the challenge of choosing which stocks to buy in order to maximize returns. The linear programming model was applied to ten (10) agricultural stocks, and the simplex approach was used as the numerical technique to calculate the best possible outcome. The TORA programmer was used to verify the best option, and the findings indicated that not every item should be invested in order to maximize profit.

Keywords: agricultural stock, linear programming (LP), mathematical programming, profit maximization, sensitivity analysis, simplex method.

1. INTRODUCTION

One of the problems that humanity faces is producing enough revenue to maintain a sustainable quality of life. Due to its ability to generate money, its employment potential, and the barriers it places on the expansion of other industries, farming is vital to the Nigerian economy (Nwibo and Mbam, 2013). It is not overstatement to say that the growth

and development of any country is largely dependent on the growth of agriculture, since even industrial enterprises depend on agricultural endeavours to produce the raw materials that are then converted into capital goods through the application of human resources. Agriculture is, therefore, defined as intentional work that uses natural resources to meet human needs. Among its many advantages are national cash earnings, food, clothes, fibres, housing, a variety of raw materials for industrialization, investment and job possibilities, and capital development. For farmers' communities and countries, agriculture is an essential business. However, Nigerian agriculture is subsistence-level, with many farmers working on dispersed, small, and fragmented land plots with hand tools and traditional farming techniques like planting on mounds, land rotation, superficial hand tillage, mixed cropping with several carefully planned crop associations, mixed farming, etc (Odoemenem, et al. 2013). Maintaining a household's income raises the likelihood of making investments in the future. Income raises collateral in a loan market, credit rating, and repayment capacity indirectly (Osondu et al. 2015).
A subset of mathematical programming, linear programming (LP) is a quantitative analytical method for choosing how to accomplish a goal. It is used to find the problem's most ideal solution within a set of limitations. It consists of linear inequalities as the goal function and certain restrictions expressed as either linear equations or inequalities. Depending on certain restrictions expressed in the linear relationship, this approach is used to maximize or minimize the objective function of the supplied mathematical model, which consists of the collection of linear inequalities. According to Danzig and Thapa (1997), LP deals with the maximization or minimization of a linear objective function in a number of variables while adhering to restrictions on linear equality and inequality. LP assists in effectively allocating resources to maximize profits, minimize losses, or make the best use of production capacity (Srinath, 2018).
The goal of Nyor et al. (2019) was to maximize the demands of the Federal University of Technology Minna, Nigeria, which has two campuses, in terms of both student and agency transportation. Software for solving linear programmes was used to tackle the problem using the simplex approach. 10%, 6%, 17%, and 3% student percentage increases were shown in the linear programming formulation result for the corresponding example under consideration. The goal of Ruby et al. (2022) was to surreptitiously ascertain how the merchant saw that particular consumer group in order to adjust the product mix. The emphasis is on small businesses in little communities that lack the resources to successfully coordinate choices about the product mix. Ten representatives and five supervisors participated in in-person interviews to gather the data, which was done in accordance with the manufacturing department's existing papers and datasheet, which was slightly modified to create the final product. The information covered a single season, from April to March. Profits from pre- and post-linear programming were examined using data analysis. Using a linear programming process, they determine the advantage of each period and the present asset consumption level of one of the garment manufacturing companies. Real resource consumption was computed in order to assess profit after using linear programming to determine costs and waste. After LP, resource utilization increased by 54% as compared to product-wise utilization. Similar to this, while using linear programming, the profit more than doubled due to low costing and waste and high revenue. The paper concentrated on utilising Excel (Solver) LINGO to discover the product mix using the straightforward fundamentals of linear programming.

2.**Methodology**

For the purpose of this research, personal (direct interview) with the middle men in Paiko market, Paiko Minna was made in June 2023 as the source of data. The data used in these work has not been in used but were obtained for the purpose of this study. The analysis of data was earned out using optimization software for the models used such as LP with TORA.

2.1 Mathematical Formulation of Linear Programming Problems the steps in formulating linear programming problem are as follows;

Step 1: Identify the decision variables.
Step 2: Express the objective function in terms of decision variables.
Step-3: Write down the constraints with the help of which the objective function is to be optimized.
Step-4: Write down the non- negative constraints.

2.2 Formulation of Linear Programming Problem

The general form of linear programming problem (LPP) with decision variables and constraints can be stated as follows:

Decision variables $(x_1, x_2, x_3, \dots, x_n)$.

Objective function: it is the function to optimize and it is written in terms of the decision variable.

Linear program is given by $(Max\ or\ min)\ z = c_1x_1 + c_2x_2 + \dots + c_nx_n$
Subject to Linear Constraints of the form

$$\begin{aligned} a_{11}x_1 + a_{x1,x212}x_2 + \cdots + a_{1n}x_n\ (\le, =, \ge)\ b_1 \\ a_{12}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n\ (\le, =, \ge) b_2 \\ \vdots \qquad\qquad \vdots \\ a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n\ (\le, =, \ge) b_m \\ x_1, x_2, x_3, \dots, x_n \ge 0 \end{aligned} \tag{1}$$

Constraints: they are the conditions under which the objective function is optimized

And, $x_j > 0;\ j = 1,2, \dots, n$ (non negative condition)

And, $x_j > 0;\ j = 1,2, \dots, n$ (non negative condition)

2.3 Problem Description

An investor has a fixed sum of ₦50,000,000 to invest in any of the ten (10) agricultural stocks namely; Maize, Guinea corn, Millet, White Beans, Brown Beans, Soya Beans, Melon, Unpeeled Rice, Groundnut, and Dry Pepper; and at most the sum of ₦5,000,000 for the storage of the stock. This investment is to be made before August and December of the current year and sold between March and July of the following year. Let $x_1, x_2, x_3, \dots x_n$ designate the amount of bag to be allocated to Maize, Guinea corn, Millet, White Beans, Brown Beans, Soya Beans, Melon, Unpeeled Rice, Groundnut, and Dry Pepper respectively. Table 3.1 shows the cost, future expected price and the cost of storing the agricultural stock (August - December 2022: march-July 2023).

2.4 Model Formulation

Let x_i be the share of stock i purchase then the linear programming problem is formulated as

$$Max\ F(x) = 30x_1 + 40x_2 + 45x_3 + 48x_4 + 51x_5 + 31x_6 + 50x_7 + 35x_8 + 80x_9 + 35x_{10}$$

$(expected\ price)$

Subject to

$$21x_1 + 25x_2 + 27x_3 + 40x_4 + 42x_5 + 25x_6 + 35x_7 + 25x_8 + 50x_9 + 25x_{10} \leq 50000$$

$(purchase\ cost)$

$$3.6x_1 + 3.6x_2 + 3.25x_3 + 3.8x_4 + 3.8x_5 + 3.25x_6 + 3.2x_7 + 3.2x_8 + 3.7x_9 + 3.2x_{10} \leq 5000$$ (cost of storage)

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} \geq 0 \quad (2)$$

Table 2.1: Data Collection

s/no	Stock	Purchase cost Per Bag (in thousands naira)	Future expected price (in thousands naira)	Cost of storage (in thousand naira)
1	Maize	21	30	3.6
2	Guinea corn	25	40	3.6
3	Millet	27	45	3.25
4	White beans	40	48	3.8
5	Red beans	42	51	3.8
6	Soya beans	25	31	3.25
7	Melon	35	50	3.2
8	Unpeel rice	25	35	3.2
9	Groundnut	50	80	3.7
10	Dry pepper	25	35	3.2

Source: Personal interview (June 2023).

NB: storage = Chemical + Cost of store + Cost of transportation

3. Results and Discussion

Applying simplex method to equation 3.1, then by standardizing we have

$$Max\ F(x) = 30x_1 + 40x_2 + 45x_3 + 48x_4 + 51x_5 + 31x_6 + 50x_7 + 35x_8 + 80x_9 + 35x_{10} + 0s_1 + 0s_2$$

Subject to

$$21x_1 + 25x_2 + 27x_3 + 40x_4 + 42x_5 + 25x_6 + 35x_7 + 25x_8 + 50x_9 + 25x_{10} + s_1 = 50000$$

$$3.6x_1 + 3.6x_2 + 3.25x_3 + 3.8x_4 + 3.8x_5 + 3.25x_6 + 3.2x_7 + 3.2x_8 + 3.7x_9 + 3.2x_{10} + s_2 = 5000$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, s_1, s_2 \geq 0$$

Where s_1, s_2 are slack variables associated with the respective constraints

Table 3.1 initial table

Basis	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	s_1	s_2	solution	Ratio
z	-30	-40	-45	-48	-51	-31	-50	-35	-80	-35	0	0	0	
s_1	21	25	27	40	42	25	35	25	50	25	1	0	50000	
s_2	3.6	3.6	3.25	3.8	3.8	3.25	3.2	3.2	3.7	3.2	0	1	5000	

Simplex iterations start at the origin $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} = (0,0,0,\dots,0)$ whose associated set of nonbasic variables $(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10})$ and basic variables (s_1, s_2).The starting solution is not optimal because some of the z-row coefficient associated with nonbasic variables are negative. Locate the Entering variable: This is the most negative coefficient in the objective. Locate the Leaving variable: This is the minimum value of the non negative ratio of the right hand side of the equation to the corresponding constraint coefficients under the entering variables. Identify Pivot element: These correspond to the intersection of pivot row and pivot column.

The swapping process in the simplex method is based on the Gauss-Jordan row operation which has two types of computations

i. Pivot row
   a. Replace the leaving variable in the basic column with the entering variable
   b. New pivot row = current row ÷ pivot element

ii. All other rows including z
   New row = current row – (its pivot column coefficient × new pivot row)

These computations are applied to the preceding tables in the same manner until the optimal solution is obtained.

Table 3.2 iteration 1

Basis	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	s_1	s_2	solution	Ratio
z	-30	-40	-45	-48	-51	-31	-50	-35	-80	-35	0	0	0	
s_1	21	25	27	40	42	25	35	25	50	25	1	0	50000	1000
s_2	3.6	3.6	3.25	3.8	3.8	3.25	3.2	3.2	3.7	3.2	0	1	5000	1351.1

The entering variable is x_9 and the leaving variable is s_1 , therefore the pivot element is 50, then we reduce the pivot element to unity and other element in column 10 to zero using row operation. New Row $R_3 = R_3 \div 50$, New Row $R_4 = R_4 - (3.7 \times newR_3)$,

New Row $R_2 = R_2 - (-80 \times newR_3)$

Table 3.3 iteration 2

Basis	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	s_1	s_2	solution	Ratio
z	3.60	0	-1.8	16	16.2	9	6	5	0	5	1.60	0	8000	
x_9	0.42	0.5	0.54	0.80	0.84	0.50	0.70	0.50	1	0.50	0.02	0	1000	1851.85
s_2	2.05	1.75	1.25	0.84	0.69	1.40	0.61	1.35	0	1.35	-0.07	1	1300	1040

The entering variable is x_3 and the leaving variable is s_2 , therefore the pivot element is 1.25, then we reduce the pivot element to unity and other element in column 4 to zero using row operation. New Row $R_3 = R_3 - (0.54 \times newR_4)$, New Row $R_4 = R_4 \div 1.25$,

New Row $R_2 = R_2 - (-1.8 \times newR_4)$

Table 3.4 iteration 3

Basis	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	s_1	s_2	solution
z	6.54	2.52	0	17.21	17.1	11.01	6.88	6.4	0	6.4	1.49	1.44	81869.01
x_9	-0.46	-0.25	0	0.44	0.54	-0.10	0.44	-0.08	1	-0.08	0.05	-0.43	43.30
x_3	1.63	1.40	1	0.67	0.55	1.12	0.4	1.08	0	1.08	-0.06	0.80	1038.34

Based on the optimal condition the z-row coefficient associated with the non basic variable are nonnegative, hence we have obtained the optimal solution. In this case the optimal solution is

$x_1 = 0,\ x_2 = 0,\ x_3 = 1038.34,\ x_4 = 0,\ x_5 = 0,\ x_6 = 0,\ x_7 = 0,\ x_8 = 0,$

$x_9 = 439.30, x_{10} = 0$. Where the variables are the numbers of bag the investor should purchase, and then the maximum profit is ₦81869.01

LINEAR PROGRAMMING OUTPUT SUMMARY

Title: profit maximazation
Final Iteration No.: 3
Objective Value = 81869.01

Variable	Value	Obj Coeff	Obj Val Contrib
x1: maize	0.00	30.00	0.00
x2: guniea corn	0.00	40.00	0.00
x3: millet	1038.34	45.00	46725.24
x4: white beans	0.00	48.00	0.00
x5: brown brown	0.00	51.00	0.00
x6: soyabeans	0.00	31.00	0.00
x7: melon	0.00	50.00	0.00
x8: unpeelrice	0.00	35.00	0.00
x9: groundnut	439.30	80.00	35143.77
x10: dry pepper	0.00	35.00	0.00

Constraint	RHS	Slack-/Surplus+
1 (<)	50000.00	0.00
2 (<)	5000.00	0.00

Sensitivity Analysis

Variable	Current Obj Coeff	Min Obj Coeff	Max Obj Coeff	Reduced Cost
x1: maize	30.00	-infinity	36.54	6.54
x2: guniea corn	40.00	-infinity	42.52	2.52
x3: millet	45.00	43.20	70.27	0.00
x4: white beans	48.00	-infinity	65.21	17.21
x5: brown brown	51.00	-infinity	68.19	17.19
x6: soyabeans	31.00	-infinity	42.01	11.01
x7: melon	50.00	-infinity	56.88	6.88
x8: unpeelrice	35.00	-infinity	41.94	6.94
x9: groundnut	80.00	64.26	83.33	0.00
x10: dry pepper	35.00	-infinity	41.94	6.94

Constraint	Current RHS	Min RHS	Max RHS	Dual Price
1 (<)	50000.00	41538.46	67567.57	1.49
2 (<)	5000.00	3700.00	6018.52	1.44

Figure 3.1.1 summary of model 1

The model was solved by analyzing the data using TORA software.

$F(x) = 30(0) + 40(0) + 45(1038.34) + 48(0) + 51(0) + 31(0) + 50(0) + 35(0) + 80(439.30) + 35(0) = 81869.01$

Optimal Decision: The results require that the investor should invest on only Millet of 1038.34 bags and Groundnuts of 439.30 bags in order to maximized profit and also it is noticed that if the investor embarks on this plan the following results would follow:

a. The money invested shall be fully exhausted /utilized.

b. The cost of storing the stock shall be fully used.

4.1 Sensitivity Analysis for model

The goal of sensitivity analysis is to determine how much the input data may be modified while still maintaining a relatively constant output from the linear programming model. The investor need to look closely at the sensitivity analysis of the stock from fig 3.1.1

In order to attain the same result the cost of a bag of Maize, Guinea Corn, White Bean, Brown Beans, Soya Beans, Melon, Unpeeled Rice, and Dry Pepper is at the minimum of any amount and the maximum should be at ₦36540, ₦42520, ₦65210, ₦68100, ₦42010, ₦56880, ₦41400 and ₦41400 respectively. While minimum cost of Millet is at ₦43200 and maximum at ₦70270 also that minimum cost of Groundnut is at ₦64260 and maximum at ₦83330.

The investor can invest the minimum of ₦41,538,460 and maximum of ₦67,567,570 instead of ₦50,000,000 and the minimum cost of storing are ₦3,700,000 and maximum of ₦6,018,520 instead of ₦5,000,000 and the profit made will remain unchanged.

5. **Conclusion**

In this paper, the concept of linear programming to model 10 agricultural stocks which the data were collected through direct interview in paiko market was used. Based on the analysis carry out on the model, the results require that the investor should invest on only Millet of 1038.34 bags and Groundnuts of 439.30 bags in order to maximized profit. Sensitivity Analysis is useful for investors who must work in a dynamic environment with imprecise estimates of the coefficients because it shows how changes in values of decision variable affect the optimal solution within certain ranges in the objective function coefficients and the right hand value.

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Statistical Analysis of Computer Management Information System in First Bank Minna Niger State

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Abstract

Business managers in Nigeria see the installation of information systems as a way to battle competition by increasing productivity, profitability, and, most importantly, organizational performance. The extent to which Nigerian banks use information systems has not yet been determined. This study investigated the link between information systems and bank organizational performance, utilizing the First Bank PLC Minna branch as a case study. This study looked into the role of information systems (IS) in bank organizational performance by administering a structured questionnaire to 20 randomly chosen staff members from the First Bank Minna branch in Niger State, Nigeria, and analyzing the results using descriptive (percentage and frequency) statistical analysis. The research found that First Bank workers understand the significance of information systems to businesses and ensure that the available information systems within their branches are well used by their staff and customers, however there is still a gap when compared to developed countries. The researchers recommended that