FNAS Journal of Mathematical Modeling and Numerical Simulation
Print ISSN: 3027-1282
www.fnasjournals.com
Volume 2; Issue 1; September 2024; Page No. 108-114.

Optimizing Agricultural Stock Portfolios in Ughelli Town Using Linear Programming

[*]Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H.,
Department of Mathematics, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria

***Corresponding author email:** godspowerovbije@gmail.com

Abstract
The decision-making process for an investor crucially hinges on selecting a portfolio that offers maximum benefits, given the associated risk levels of investment stocks.This research aims to evaluate optimal management of agricultural portfolio to enhance profit margins while mitigating risks. Ten (10) agricultural stocks were analyzed as variables using a linear programming model, with the utilization of Tora package based on Big M and Two-Phase methods to derive an optimal solution. Findings indicated that out of the 10 stocks considered, only Rice and Cocoa should be selected for investment to yield maximum returns. Sensitivity analysis revealed that a decrease or increase in the available resources would subsequently lead to a decrease or increase in the optimal profit. This research provides insights into optimal management of portfolio, and offers a practical framework for investors in theagricultural sector.

Keywords: Linear Programming, Portfolio Management, Agricultural Stocks, Optimal Portfolio, Returns on Investment.

Introduction

Agricultural stocks have become an attractive investment opportunity in recent years due to their tendency for high investment returns and benefits associated with diversification. However, investing in agricultural stocks also comes with unique risks. Recently, the agriculture sector has become susceptible to various investment risks, which include market volatility, climate change, geopolitical factors, and regulatory changes. As a result, effective risk assessment and portfolio management strategies have become crucial for stakeholders in the agricultural industry to mitigate potential losses and maximize returns. Previous research works have highlighted the significance of incorporating risk assessment methodologies in portfolio management, emphasizing the need for dynamic strategies that adapt to changing market conditions. These studies have shown that traditional portfolio management approaches may not adequately address the unique challenges faced by agricultural investments, thus underscoring the importance of innovative optimization techniques. A portfolio can be regarded as an investment that can be managed by experts in finances, and it may include assets or stocks. Portfolio is a popular investment technique and has seen a boom within the urban society and has seen a steady rise in usage during the last few years. A typical portfolio is designed to suit an investor's risk tolerance, time frame, and investment objectives (Oladejo et al., 2020). Maximizing the returns and reducing the risks involved are the major aims of many investors. Several surveys of investors' behaviour showed that organization, individual preferences are also being affected by risk (Nagy & Obenberger, 1994). Building an optimal portfolio is a major challenge in investment and finance, and has the tendency to affect holders and managers of portfolios, who are responsible for decision-making in allocating limited resources across different investment categories. The choice of the portfolio that will provide the highest benefit to the investor has become a very critical and complex decision-making problem and has become a subject of much research and discussion in the field of finance. As a result, various portfolio management strategies have been developed to identify the optimal portfolio

The linear programming approach plays a vital role in optimizing the choice of an asset to yield optimal returns. Moreover, the integration of linear programming methods, such as the Big M and Two-Phase methods, offers a systematic approach to solving complex portfolio optimization problems with multiple constraints. Various research has applied Linear Programming techniques in optimizing portfolio and decision-making processes, the Simplex Method is used in solving linear programming models that involve an all-slack constraint. However, The Big M and the Two-Phase Methods can be adopted in optimizing a portfolio that includes the surplus and equality constraints.

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.

Nyor et al. (2014) focused on optimizing bus allocation for intra and interstate routes of the transport authority in a manner that will yield optimum profit in Minna, Nigeria. The simplex method was used as a method of solution by the use of linear programming problem solver, TORA and the result showed maximization of profit by an additional amount of NGN 131,168. Junaiddin et al. (2023) in their work titled "The Application of Linear Programming into Production Schedule at Electrical Panel Company" aimed to maximize production schedule to obtain maximum profit for an electric manufacturing company in Sulawesi, India. They made use of the Simplex method to solve the formulated Linear Programming model and obtained a result that surpassed the company's target by 152 switchboard panels.

Ekwonwune and Edebatu (2016) made use of the simplex method, a Linear Programming technique to formulate a mathematical model that optimized the portfolio of Golden Guinea Breweries Plc, Nigeria. The methods involved the collection of sample data from the company, analysis carried out and the relevant coefficients were deployed for the coding of the model. The study revealed that using the Linear Programming Model would produce a high return coefficient of NGN 9,190,862,833 in comparison with the result obtained from the actual figures of the company which yielded a profit coefficient of NGN7,172,093,375. Kwapong (2013) employed the use of L.P technique to analyze a portfolio of credit in a Rural Bank in Ghana. The result revealed a positive relationship that exists between the return and risk of the Bank. The research indicated that an increase in the interest rates on bank products led to higher returns and demonstrated lower risk. The work of Oladejo et al. (2020) on portfolio selection utilizing linear programming techniques, incorporating risk score percentages to maximize profit margin, demonstrated a robust approach. The author's inclusion of sensitivity analysis further underlined the model's viability and practical relevance in optimizing portfolio performance. However, the portfolio selection comprises assets from different sectors which signifies too much spread in the portfolio assets. Emphasis on assets from the same sector will create an opportunity for correlation to be closely incorporated using variance and covariance. Also, Akudugu and Boah (2022) showcased a strategic approach to utilizing linear programming for the banking sector, validated through sensitivity and duality analysis. The insights gained emphasized the necessity of formulating a model to assist agricultural sector investors in maximizing returns while mitigating risks effectively.

In the context of Ughelli Town, agricultural stocks are a significant investment opportunity due to the town's proximity to agricultural hubs and its growing economy. However, investors in Ughelli Town face unique challenges such as limited access to market information and high transaction costs. Therefore, this study aims to develop an optimal portfolio management framework using Linear Programming to help investors in Ughelli Town make informed investment decisions.

Materials and Methods

The population of this study consists of marketers and investors of agricultural stocks in Adagbaragba - Ughelli Modern Market, Ughelli, Delta State. According to Ikpoza et al. (2020), Ughelli has a projected population of 476,947 as of 2019 at an annual population growth rate of 2.6%. Agricultural stock marketers in Adagbaragba - Ughelli Modern Market has an estimated population of 500 (Ughelli North L.G. Council Market Committee, 2023). The sample size was determined using the Taro Yamane formula (1967), stated as follows:

$$n = \mathrm{N} \,/\, (1 + N(e)_2)$$

where;

n = The desired sample size

N = The population size under study

e = The level of precision (margin of error) assumed to be 5%

$$n = 500 \,/\, (1 + 500\ (5\%)_2)$$

$$n = 500 \,/\, (1 + 500\ (0.05)_2)$$

$$n = 500 \,/\, (1 + 500\ (0.0025))$$

$$n = 500 \,/\, (1 + 1.25)$$

$$n = 500 \,/\, 2.25$$

$$n = 222.2$$

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.

The sample size derived from Taro Yamane's formula for this study is 222. However, this figure was approximated to 200 as a round number for simplification purposeand due to limitations in resources such as funding. Moreover, the reduction may have a minimal impact on the precision of the results, making it a reasonable approximation.Thus, data were obtained from 200 respondents.

- **Linear Programming**

Linear programming (LP) stands as a mathematical technique for modelling scenarios involving the maximization or minimization of a linear function, while simultaneously considering various constraints. Widely applicable across diverse fields like business planning, industrial engineering, and even the social and physical sciences, this method aids in making quantitative decisions efficiently. Its primary objective lies in achieving the most optimal solution given specific constraints, facilitating resource allocation to maximize processes, minimize losses, or utilize production capacity optimally (Srinath, 1982). The process involves transforming real-life problems into mathematical models, incorporating an objective function, and linear inequalities subject to constraints.

Linear Programming Problems can be expressed in the form (Ekoko, 2016):

$$Max\ or\ Min\ Z = c_1x_1 + c_2x_2 + \cdots + c_nx_n \quad (1)$$

Subject to:

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

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \quad (\leq, =, \geq) \quad b_2$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \quad (\leq, =, \geq) \quad b_n \quad (2)$$

and $x_1, x_2, \ldots, x_n \geq 0$ (3)

where eqn. (1) is the objective function, eqn. (2) contains the constraints while eqn. (3) are the non-negative conditions.

- **The Linear Programming Problem**

Okes Agro Ventures Ltd., an investment company in Ughelli seeking to invest in multiple agricultural stock opportunities is currently grappling with the challenge of optimizing the allocation of funds across various investment options. The company is constrained not to go beyond allocating Ten Million Naira in the entire ten (10) agricultural stock options namely; Maize, Guinea Corn, Soya Beans, White Beans, Rice, Palm Oil, Vegetable Oil, Dried Pepper, Stock Fish, and Cocoa. The investment company wishes to invest at least 25% of the total investment into Cocoa and Maize; at least 30% of the total investment to Rice and Vegetable Oil; at least 50% of the total investment into Maize, Rice and Vegetable Oil; and investment into Soya Beans and Dried Pepper must not exceed 15% of the total investment. However, due to varying risk levels associated with each stock, the firm must carefully consider these factors in order to align with their investment policies and ultimately maximize profit with an expectation of at least 10% on returns on investment. The expected return rate of each commodity is stated as 12%, 11%, 10%, 13%, 20%, 12%, 15%, 15%, 16% and 14% respectively.

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.

Table 1: Table Showing Selected Agricultural Stock and Their Return Rate.

S/N	Stock	Return Rates (%)
1.	Maize	12
2.	Guinea Corn	11
3.	Soya Beans	10
4.	White Beans	13
5.	Rice	20
6.	Palm Oil	12
7.	Vegetable Oil	15
8.	Dried Pepper	15
9.	Stock Fish	16
10.	Cocoa	14

Decision Variables of the Model

Let x_i be the amount of money to invest in stock i, then the decision variables of the model are:

x_1 = Amount of money to be invested in Maize
x_2 = Amount of money to be invested in Guinea Corn
x_3 = Amount of money to be invested in Soya Beans
x_4 = Amount of money to be invested in White Beans
x_5 = Amount of money to be invested in Rice
x_6 = Amount of money to be invested in Palm Oil
x_7 = Amount of money to be invested in Vegetable Oil
x_8 = Amount of money to be invested in Dried Pepper
x_9 = Amount of money to be invested in Stock Fish
x_{10} = Amount of money to be invested in Cocoa

Objective Function of the Model

Profit Return = (*Return Rate / 100)* x *Amount Invested*

$Max\ Z = 0.12x_1+0.11x_2+0.1x_3+0.13x_4+0.2x_5+0.12x_6+0.15x_7+0.15x_8+0.16x_9+0.14x_{10},$
where Z is the Total Profit to be accrued from the various investment.

Constraints of the Model

- A maximum of NGN 10 million to be invested implies that:Let M be defined as equivalent of Million.
  $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \leq 10M.$
- To invest at least 25% of total investment into Cocoa and Maize implies that:
  $x_1 + x_{10} \geq 25\%$ of $10M$
  $x_1 + x_{10} \geq 2.5M$
- To invest at least 30% of total investment into Rice and Vegetable Oil implies that:
  $x_5 + x_7 \geq 30\%$ of $10M$
  $x_5 + x_7 \geq 3M$
- To invest at least 50% of total investment into Maize, Rice and Vegetable Oil implies that:
  $x_1 + x_5 + x_7 \geq 50\%$ of $10M$
  $x_1 + x_5 + x_7 \geq 5M$

- Investment on Soya Beans and Dried Pepper must not exceed 15% of the total investment implies that:
  $x_3 + x_8 \le 15\%$ of $10M$
  $x_3 + x_8 \le 1.5M$

The Developed Agricultural Portfolio Model

$$Max\ Z = 0.12x_1 + 0.11x_2 + 0.1x_3 + 0.13x_4 + 0.2x_5 + 0.12x_6 + 0.15x_7 + 0.15x_8 + 0.16x_9 + 0.14x_{10}$$

subject to:

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \le 10M$$
$$x_1 + x_{10} \ge 2.5M$$
$$x_5 + x_7 \ge 3M$$
$$x_1 + x_5 + x_7 \ge 5M$$
$$x_3 + x_8 \le 1.5M$$
$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10} \ge 0$$

Results

The Linear Programming Model is solved using the Tora Optimization Software based on Big M and Two-Phase Methods. The optimal solution from Big M and Two-Phase Methods produced similar results, which shows the efficiency of the model. From the results obtained as shown in the Table below, Okes Agro Ventures Ltd should invest NGN 7.5 million in Rice and NGN 2.5 million in Cocoa, in order to receive an optimal profit return of NGN 1.85 million. The model effectively yielded a return on investment of NGN 1.85 million which is above the targeted return of NGN 1 million (18.5% profit return which is 8.5%more than the company's target of 10%). Also, for a smart investment, Okes Agro Ventures Ltd. should not invest in other agricultural stock listed apart from Rice and Cocoa. It is expected that this would help maximize portfolio return.

Table 2: Optimal Solution of the Model Using Tora

Variables	Value	Obj. Coeff.	Obj. Val. Contr.	Max. Return
x_1	0.00	0.12	0.00	
x_2	0.00	0.11	0.00	
x_3	0.00	0.10	0.00	
x_4	0.00	0.13	0.00	
x_5	7.50	0.20	1.50	1.85M
x_6	0.00	0.12	0.00	
x_7	0.00	0.15	0.00	
x_8	0.00	0.15	0.00	
x_9	0.00	0.16	0.00	
$x10$	2.50	0.14	0.35	

- **Sensitivity Analysis**

In this phase, we evaluate the model's stability and resilience by making slight adjustments to the coefficients to assess constraint redundancy. This analysis aims to minimize decision-making errors. By increasing the investment's return rates by 5% and subsequently decreasing them by 5%, we can solve the ensuing linear programming problem and compare the outcomes to those of the original model. Table 3 below shows an increment and reduction of the return rates (coefficients) which would lead to changes in the objective function. This would help us to verify its effect on the optimal solution.

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.

Table 3: Increment and Reduction of Return Rates

Stock	Normal Rate (%)	5% Increment	5% Reduction
Maize	12	12.6	11.4
Guinea Corn	11	11.55	10.45
Soya Beans	10	10.5	9.5
White Beans	13	13.65	12.35
Rice	20	21.0	19.0
Palm Oil	12	12.6	11.4
Vegetable Oil	15	15.75	14.25
Dried Pepper	15	15.75	14.25
Stock Fish	16	16.8	15.2
Cocoa	14	14.7	13.3

The model is thus formulated with consideration of 5% increment as:

$Max\ T = 0.13x_1 + 0.12x_2 + 0.11x_3 + 0.14x_4 + 0.21x_5 + 0.13x_6 + 0.16x_7 + 0.16x_8 + 0.17x_9 + 0.15x_{10}$

subject to:

$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \leq 10M$

$x_1 + x_{10} \geq 2.5M$

$x_5 + x_7 \geq 3M$

$x_1 + x_5 + x_7 \geq 5M$

$x_3 + x_8 \leq 1.5M$

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

Whereas for 5% reduction, the model is formulated as:

$Max\ R = 0.11x_1 + 0.10x_2 + 0.10x_3 + 0.12x_4 + 0.19x_5 + 0.11x_6 + 0.14x_7 + 0.14x_8 + 0.15x_9 + 0.13x_{10}$

subject to:

$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \leq 10M$

$x_1 + x_{10} \geq 2.5M$

$x_5 + x_7 \geq 3M$

$x_1 + x_5 + x_7 \geq 5M$

$x_3 + x_8 \leq 1.5M$

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

Table 4: Sensitivity Analysis Result of the Portfolio

Stock	Normal Return	5% Increment	5% Reduction
Maize	0	0	0
Guinea Corn	0	0	0
Soya Beans	0	0	0
White Beans	0	0	0
Rice	1.50	1.58	1.43
Palm Oil	0	0	0
Vegetable Oil	0	0	0
Dried Pepper	0	0	0
Stock Fish	0	0	0
Cocoa	0.35	0.38	0.33
Maximum Returns	**1.85M**	**1.95M**	**1.75M**

From Table 4, it can be observed that, as the profit coefficients of the model decrease, the optimal profits decrease from NGN 1,850,000 to NGN 1,750,0000. On the other hand, as the profit coefficients increase, the optimal profits increase from NGN 1,850,000 to NGN 1,950,000.

Conclusion

The concept of linear programming has been successfully used in formulating an optimal agricultural portfolio that enhanced profits while mitigating the risks of investors in Ughelli Town. Findings show that:

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.

- Results from Big M and Two-Phase Methods were similar which shows that irrespective of the method employed, a feasible solution can be reached efficiently as long as the model is properly formulated and the constraints are well stated.
- Investing NGN 7.5 million in Rice and NGN 2.5 million in Cocoa will maximize a profit return of NGN 1.85 million, which is above the target return of NGN 1 million.
- Sensitivity analysis carried out showed the effect of an increase or decrease in available resources on the portfolio returns as an increase in available resources leads to an increase in optimal profit and a decrease in available resources leads to a reduction of the optimal profit. The implication signifies that investors can easily know the effect of an increase or decrease in an available resource on the optimal profit.

This study on optimal portfolio management of agricultural stocks in Ughelli Town makes significant contributions to the existing body of knowledge by providing insights into the optimization management of agricultural stocks to enhance profit margins while minimizing risks, offering a practical framework for investors in the agricultural sector. Also, it showcases the effectiveness of mathematical optimization techniques in managing agricultural stock portfolios, which can be replicated in other contexts.

Recommendations

Based on the discussion of results and their implications in optimal portfolio management, here are some recommendations that can be adopted to manage agricultural stock portfolio:

- Okes Agro Ventures Ltd. should use the developed model as a guide when allocating funds to invest in agricultural stocks in order to maximize its returns. Also, other investors in Ughelli Town should take a cue from the developed model when creating an optimal agricultural portfolio.
- Investors in Ughelli Town should consider concentrating their investment on Rice and Cocoa to maximize profit margins and mitigate risks associated with agricultural stock investments.

References

Akudugu, S. M., & Boah, D. K. (2022). An optimal loans model for a bank in upper west region of Ghana using linear programming. *Applied Mathematics*, 12(2), 32–39. https://doi.org/10.5923/j.am.20221202.02.

Ekoko, P. (2016). *Operations research for sciences and social sciences*. Mindex Publishing Company Limited.

Ekwonwune, E. N., & Edebatu, D. C. (2016). Application of linear programming algorithm in the optimization of financial portfolio of golden guinea breweries plc, Nigeria. *Open Journal of Modelling and Simulation*, 4(3), 93–101. https://doi.org/10.4236/ojmsi.2016.43008.

Ikpoza, E., Ohwo, O., Nwajei, C., & Tabuanu, C. (2020). Effectiveness of credit utilization among farmers in Ughelli North Local Government area of Delta State, Nigeria. *Journal of Agripreneurship and Sustainable Development*, 3(4), 109–118. http://dx.doi.org/10.59331/jasd.v3i4.165.

Junaiddin, A., Syaifuddin, D. T., Montundu, Y., & Zaid, S. (2023). The application of linear programming into production schedule at electrical panel company. *International Journal of Membrane Science and Technology*, *10*(3), 354-371.

Kwapong, S. D. (2013). *Application of Linear Programming to Optimal Credit Portfolio: The Case of Akuapem Rural Bank Ltd.* PhD thesis, Kwame Nkrumah University of Science and Technology, Ghana.

Nagy, R. A., & Obenberger, R. W. (1994). Factors influencing individual investor behavior. *Financial Analysts Journal*, 50(4), 63–68. https://doi.org/10.2469/ faj.v50.n4.63.

Nyor, N., Omolehin, J., & Rauf, K. (2014). Application of linear programming in modeling the allocation of buses to routes in a transport service authority. *Universal Journal of Applied Mathematics*, 2(3), 125–135. https://doi.org/10. 13189/ujam.2014.020302.

Oladejo, N. K., Abolarinwa, A., & Salawu, S. O. (2020). Linear programming and its application techniques in optimizing portfolio selection of a firm. *Journal of Applied Mathematics*, 2020(1), 1–7. https://doi.org/10.1155/2020/8817909.

Srinath, L. S. (1982). Linear programming: principles and applications. *Macmillan 2nd edition*.

Cite this article as:
Ovbije, O. G., Oyiborhoro, M., & Akworigbe, A. H. (2024). Optimizing agricultural stock portfolios in Ughelli town using linear programming. *FNAS Journal of Mathematical Modeling and Numerical Simulation, 2*(1), 108-114.