ISSN: 5078 - 5388
Volume 10, Number 1, 2025
Management, Accounting and Economics Journal

GRAPHICAL METHODS OF LINEAR PROGRAMMING AND OPTIMAL ALLOCATION OF RESOURCES IN ANIMAL FEED COMPANIES IN PORT HARCOURT

David Onwuchekwa, Ph.D & Elohor Dede
Department of Management, Faculty of Management Sciences,
Ignatuis Ajuru University of Education, Port Harcourt

Email:truedave4real@yahoo.com

ABSTRACT

This study examines the relationship between graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt. The study adopted a correlational survey research design as it seeks to determine the relationship existing between two variables. The population of the study consisted of 20 animal feed firms in Port Harcourt as retrieved from Encyclopedia of Agriculture and Food Systems 2014. 3 managers were selected from each firm multiplied by 20 firms gives us a total of 60 respondents. The instrument used in data collection was a structured questionnaire titled graphical methods of linear programming and optimal allocation of resources. The result of the Cronbach's Alpha reliability test indicates .888 which is above .70 which implies that the items are reliable. Person product moment correlation was used to test hypotheses on SPSS version 25. The study revealed that there is a significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt, there is a significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt, there is a significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt, there is a significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt. The study concluded that graphical methods of linear programming have a positive relationship with optimal allocation of resources in animal feed companies in Port Harcourt. The study recommended that Animal feed companies in Port Harcourt should make use of graphical methods of linear programming to optimize their resource allocation efficiently.

Background of the Study

Linear programming is a mathematical method used to determine the best possible outcome in a given mathematical model for a particular set of requirements represented by linear relationships. Graphical methods of linear programming involve visualizing the constraints and objective function on a graph to find the optimal solution. This method is particularly useful for understanding and solving optimization problems with two decision variables (Winston, 2004).

Taha (2016) the graphical method for maximization in linear programming involves plotting the constraints as inequalities on a graph and identifying the feasible region where all constraints are satisfied. The objective function is then plotted as a line with its slope representing the objective coefficient ratios. The optimal solution, which maximizes the objective function, is found at the corner point within the feasible region that gives the highest value. Conversely, the graphical method for minimization in linear programming follows a similar process but aims to minimize the objective function rather than maximize it. The optimal solution for minimization is found at the corner point within the feasible region that gives the lowest value of the objective function.

Optimal allocation of resources using linear programming involves determining how to distribute limited resources among competing activities or projects to achieve an optimal outcome. By formulating constraints based on resource availability and requirements, as well as defining an objective function that represents the goal to be optimized, linear programming can help identify the most efficient allocation strategy. Overall, graphical methods of linear programming provide a visual representation of complex optimization problems, making it easier to understand and solve

them efficiently. By graphically depicting constraints and objectives, decision-makers can make informed choices regarding resource allocation and maximize or minimize outcomes based on specific criteria (Mankiw, et al.,2017).

Graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt is a study that focuses on the application of mathematical techniques to optimize resource allocation in the production process of animal feed companies located in Port Harcourt, Nigeria. Linear programming is a mathematical method used to determine the best possible outcome given a set of constraints. In the context of animal feed companies, this technique can be applied to maximize production efficiency, minimize costs, and ensure optimal allocation of resources such as raw materials, labor, and machinery (Taha, 2016).

The study aims to address key challenges faced by animal feed companies in Port Harcourt, such as fluctuating input costs, limited availability of resources, and increasing competition in the market. By utilizing graphical methods of linear programming, researchers can develop models that help decision-makers in these companies make informed choices regarding resource allocation and production planning. This approach can lead to improved profitability, sustainability, and competitiveness for animal feed companies operating in Port Harcourt. Overall, the study on graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt provides valuable insights into how mathematical optimization techniques can be applied to real-world business problems in the agricultural sector.

Statement of the Problem

The study on graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt may face several challenges that could impact the research process and outcomes. The optimal allocation of resources in animal feed companies involves multiple variables such as ingredient costs, nutritional requirements, production capacities, and market prices. Managing these complex variables within a graphical method framework can be challenging and may require sophisticated modeling techniques to ensure accurate results (Okoli, 2016).

The animal feed industry is subject to various external factors such as changes in raw material prices, regulatory requirements, and consumer preferences. These dynamic elements can introduce uncertainty into the linear programming models used for resource allocation, making it challenging to develop robust optimization strategies. While graphical methods can provide visual insights into linear programming problems, they may have limitations in handling large-scale optimization problems common in industrial settings. Researchers may need to supplement graphical approaches with computational tools or software to address complex resource allocation challenges effectively (Adepoju, 2016).

Even if an optimal resource allocation strategy is identified through graphical methods, implementing these recommendations within animal feed companies in Port Harcourt may pose practical challenges. Factors such as organizational resistance, cost implications, and operational constraints could hinder the adoption of optimized resource allocation strategies derived from the study. Overall, addressing these challenges requires a comprehensive understanding of both the theoretical foundations of linear programming and the practical realities of the animal feed industry in Port Harcourt. Researchers must carefully navigate these obstacles to ensure that their study on graphical methods of linear programming and optimal resource allocation provides valuable insights for improving operational efficiency in animal feed companies.

Conceptual Framework

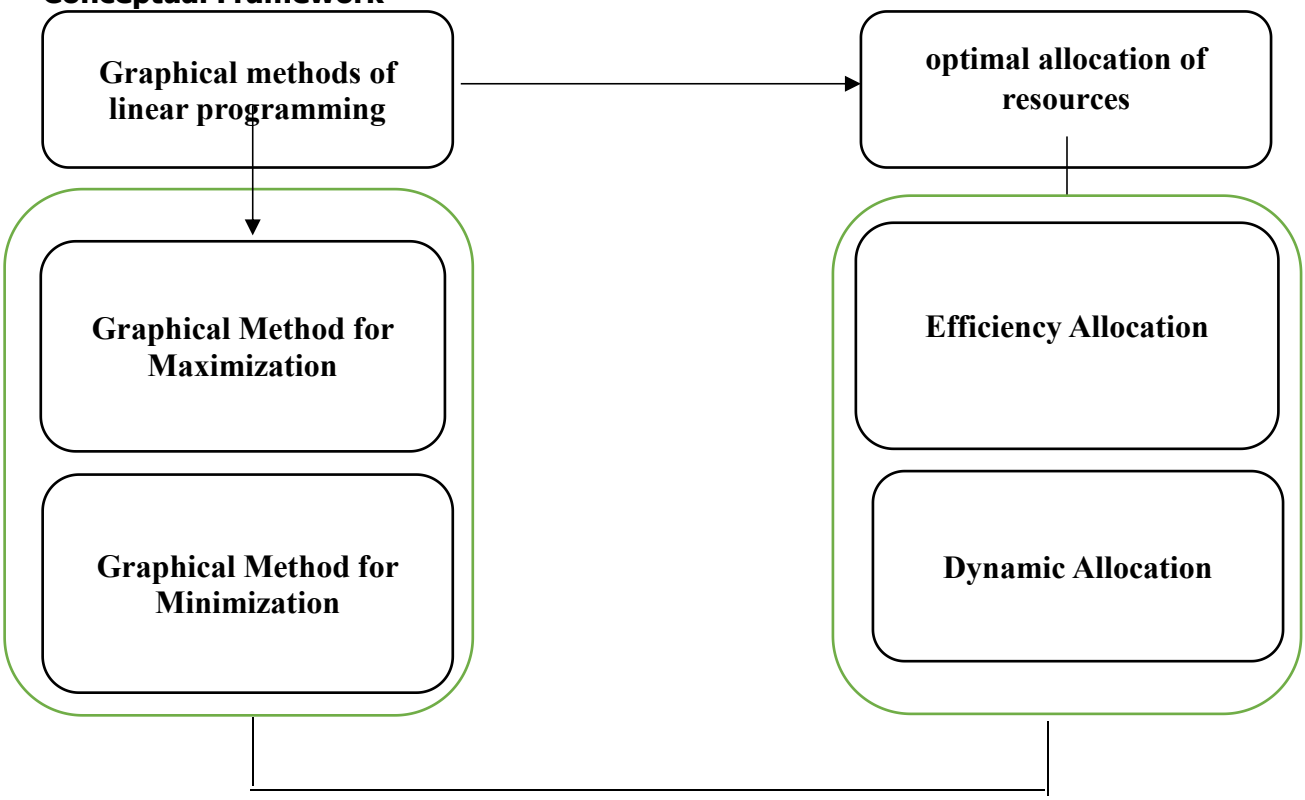

Figure 1: Conceptual framework on Graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt
Source: Adapted from Winston, (2004), Taha, (2016) and Mankiw, et al., (2017).

Aims & Objectives

The aim of this study is to determine the relationship between graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt. Specifically, the study seeks to:

1) Determine the relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.
2) Determine the relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.
3) Determine the relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.
4) Determine the relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Research Questions

The following research questions were raised to guide the study

1) What is the relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt?
2) What is the relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt?
3) What is the relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt?
4) What is the relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt?

Hypothesis

The following null hypotheses were formulated and tested at a significant level of 0.05.

HO_1: There is no significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

HO_2: There is no significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

HO_3: There is no significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

HO_4: There is no significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

REVIEW OF RELATED LITERATURE

This section reviews various extant literatures related to the study under investigations under the headings of conceptual review, theoretical review and empirical review.

Conceptual Review

Concept of Graphical Methods of Linear Programming

Linear programming is a mathematical method used to determine the best possible outcome in a given mathematical model for a set of linear relationships. In the context of animal feed companies, linear programming can be used to optimize resources such as ingredients, labor, and production capacity to maximize profits or minimize costs. Graphical methods are one approach to solving linear programming problems, particularly useful for visualizing and understanding the constraints and feasible solutions (Mankiw, et al.,2017).

Dimensions of Graphical Methods of Linear Programming

Graphical Method for Maximization

Taha, (2016) In the graphical method for maximization, the objective is to find the maximum value of a linear function subject to certain constraints. This method involves plotting the constraints on a graph and identifying the feasible region where all constraints are satisfied simultaneously. The objective function is then plotted as a line with a slope determined by its coefficients. The optimal solution is found at the corner point within the feasible region that gives the maximum value of the objective function.

Graphical Method for Maximization

Similarly, in the graphical method for minimization, the objective is to find the minimum value of a linear function subject to constraints. The process involves plotting constraints and identifying the feasible region, but in this case, the objective function line is minimized rather than maximized. The optimal solution is again found at a corner point within the feasible region that gives the minimum value of the objective function. In animal feed companies, graphical methods of linear programming can be applied to optimize feed formulations based on ingredient costs and nutritional requirements, maximize production efficiency given resource limitations, or minimize transportation costs while meeting demand constraints (Winston, 2004).

Concept of Optimal Allocation of Resources

Bazaraa, et al., (2013) Optimal allocation of resources is a critical aspect of the operations of animal feed companies. Efficient allocation of resources involves the strategic distribution of available resources such as capital, labor, raw materials, and technology to maximize productivity and profitability. In the context of animal feed companies, optimal allocation of resources is essential for ensuring the production of high-quality feeds that meet the nutritional requirements of various animals while minimizing costs and waste. Another important consideration in resource allocation for animal feed companies is investment in technology and innovation (Oyedele, 2018).

By adopting advanced manufacturing processes, automation systems, and quality control measures, companies can enhance production efficiency, product consistency, and overall competitiveness in the market. Investing in research and development activities also enables companies to develop new feed formulations that cater to evolving consumer preferences and regulatory standards (Taha, 2016).

Boyd and Vandenberghe (2004) Furthermore, human resource management plays a crucial role in optimizing resource allocation within animal feed companies. Recruiting skilled employees, providing ongoing training programs, fostering a culture of continuous improvement, and incentivizing performance are all essential strategies for maximizing workforce productivity and engagement. Effective communication channels between different departments within the company also facilitate coordination and collaboration in resource planning and utilization. In conclusion, optimal allocation of resources is vital for the success and sustainability of animal feed companies. By implementing efficient resource management practices, embracing innovation, adapting to changing market dynamics, and nurturing a skilled workforce, these companies can enhance their operational efficiency, product quality, customer satisfaction, and overall profitability (Taha, 2016).

Measures of Optimal Allocation of Resources

Efficiency Allocation of Resources

Mankiw, et al., (2017) another important factor in efficiency allocation of resources for animal feed companies is production planning and scheduling. Efficient utilization of manufacturing facilities and equipment is essential to meet demand fluctuations while minimizing idle time and production bottlenecks. Companies must optimize production processes, streamline workflows, and implement lean manufacturing principles to enhance productivity and reduce waste. By aligning production capacity with market demand through effective planning and scheduling, companies can improve operational efficiency and customer satisfaction (Chong, & Zak, 2013).

Dynamic Allocation of Resources

Dynamic allocation of resources refers to the ability of animal feed companies to adapt their resource allocation strategies in response to changing market conditions, technological advancements, regulatory requirements, and other external factors. This dynamic approach allows companies to optimize resource utilization over time and stay competitive in a rapidly evolving industry. One key aspect of optimal allocation of resources in animal feed companies is the efficient management of raw materials. Companies need to carefully monitor and forecast demand for different types of animal feeds to ensure that they maintain adequate inventory levels without excessive stockpiling. By implementing just-in-time inventory management practices and establishing strong relationships with suppliers, companies can minimize storage costs and reduce the risk of stockouts or wastage (Oladele, 2017).

Theoretical Review

Optimization Theory

Optimization theory is a branch of mathematics that deals with finding the best possible solution to a problem from a set of feasible solutions. It involves maximizing or minimizing a function by systematically choosing input values within an acceptable range. The goal is to find the optimal solution that either maximizes or minimizes the objective function, subject to certain constraints.

The foundations of optimization theory were laid down by mathematicians such as Leonhard Euler, Lagrange, and Gauss in the 18th and 19th centuries. However, modern optimization theory has been significantly developed by mathematicians and economists like George Dantzig, John von Neumann, and Harold Kuhn in the mid-20th century.

Assumptions of Optimization Theory

i. Objective Function: There exists an objective function that needs to be optimized.
ii. Decision Variables: The decision variables are controllable and can be adjusted.
iii. Feasible Region: There is a feasible region defined by constraints within which solutions must lie.
iv. Linearity: In linear programming, the relationships between variables are assumed to be linear.
v. Rationality: Decision-makers are rational and aim to maximize their objectives.

Critiques of Optimization Theory:

i. Simplifying Assumptions: Critics argue that the assumptions made in optimization models may oversimplify real-world problems.
ii. Computational Complexity: Solving complex optimization problems can be computationally intensive and time-consuming.
iii. Incorporating Uncertainty: Optimization models often do not account for uncertainty or risk factors in decision-making processes.
iv. Ethical Considerations: Optimization may prioritize efficiency over other ethical considerations such as fairness or social welfare.
v. Limited Applicability: Some critics argue that optimization theory may not always provide practical solutions for highly complex real-world problems.

Relevance to Graphical Methods of Linear Programming and Optimal Allocation of Resources in Animal Feed Companies in Port Harcourt: Optimization theory is highly relevant to graphical methods of linear programming and optimal allocation of resources in animal feed companies in Port Harcourt. By applying optimization techniques, these companies can determine the most efficient way to allocate resources such as raw materials, labor, and production capacity to maximize profits while meeting constraints such as budget limitations and production capacities (Bertsekas, & Nedic, 2003).

Empirical Review

Empirical studies on graphical methods of linear programming and optimal allocation of resources in animal feed companies in Nigeria have been conducted to analyze the efficiency and effectiveness of resource allocation in this sector. One such study is by Oyedele et al. (2018), titled "Application of Linear Programming Techniques for Optimal Feed Formulation in Animal Feed Industry in Nigeria." This study focused on the population of animal feed companies in Nigeria and utilized graphical methods of linear programming for optimal resource allocation. The data analysis method employed was a combination of mathematical modeling and sensitivity analysis. The findings revealed that the application of linear programming techniques led to improved resource allocation, resulting in cost reduction and increased profitability for the companies. The conclusion drawn was that graphical methods of linear programming can be effectively used for optimal feed formulation in the animal feed industry in Nigeria. The study recommended the adoption of these techniques by more companies to enhance their operational efficiency.

Another relevant study is by Adepoju et al. (2016), titled "Optimal Resource Allocation Using Linear Programming: A Case Study of an Animal Feed Milling Company in Nigeria." This research also focused on animal feed companies in Nigeria, analyzing resource allocation through linear programming methods. The study population consisted of an animal feed milling company, and the data analysis method involved mathematical optimization techniques. The findings indicated that optimal resource allocation through linear programming led to increased productivity and reduced costs for the company. The conclusion emphasized the importance of efficient resource management for enhancing competitiveness in the animal feed industry. Recommendations included the widespread adoption of linear programming tools for better decision-making processes.

METHODOLOGY

The study adopted a correlational survey research design as it seeks to determine the relationship existing between two variables. The population of the study consisted of 20 animal feed firms in Port Harcourt as retrieved from Encyclopedia of Agriculture and Food Systems 2014. 3 managers were selected from each firm multiplied by 20 firms gives us a total of 60 respondents.

The instrument used in data collection was a structured questionnaire titled graphical methods of linear programming and optimal allocation of resources. The most commonly used indicators of internal consistency is Cronbach's alpha coefficient. Questionnaire item statements with Cronbach's alpha reliability coefficient below the 0.70 threshold were eliminated. the test-re-test method was used. 10 copies of the questionnaire instrument were issue and some later same copies were issue through electronic media. the results were used in computation using Cronbach's alpha test of reliability.

Table 1: Reliability Statistics

Cronbach's Alpha	N of Items
.888	4

Source: Researcher Computation via SPSS Version 25

The result of the Cronbach's Alpha reliability test indicates .888 which is above .70 which implies that the items are reliable. Person product moment correlation was used to test hypotheses on SPSS version 25.

Data Analysis

HO_1: There is no significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

Table 2: Correlations on Graphical Method for Maximization and Efficiency Allocation

		Graphical Method for Maximization	Efficiency Allocation of resources
Graphical Method for Maximization	Pearson Correlation	1	.857**
	Sig. (2-tailed)		.000
	N	60	60
Efficiency Allocation of resources	Pearson Correlation	.857**	1
	Sig. (2-tailed)	.000	
	N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlations on Graphical Method for Maximization and Efficiency Allocation revealed that there is a significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt with a (P. .857 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

HO_2: There is no significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Table 3: Correlations on Graphical Method for Maximization and Dynamic Allocation of resources

		Graphical Method for Maximization	Dynamic Allocation of resources
Graphical Method for Maximization	Pearson Correlation	1	.714**
	Sig. (2-tailed)		.000
	N	60	60
Dynamic Allocation of resources	Pearson Correlation	.714**	1
	Sig. (2-tailed)	.000	
	N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations on Graphical Method for Maximization and Dynamic Allocation of resources revealed that there is a significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt with a (P. .714 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

HO_3: There is no significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

Table 4: Correlations on Graphical Method for Minimization and Efficiency Allocation of resources

		Graphical Method for Minimization	Efficiency Allocation of resources
Graphical Method for Minimization	Pearson Correlation	1	.802**
	Sig. (2-tailed)		.000
	N	60	60
Efficiency Allocation of resources	Pearson Correlation	.802**	1
	Sig. (2-tailed)	.000	
	N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4: Correlations on Graphical Method for Minimization and Efficiency Allocation of resources revealed that there is a significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt with a (P. .802 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

HO_4: There is no significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Table 5: Correlations on Graphical Method for Minimization and Dynamic Allocation of resources

		Graphical Method for Minimization	Dynamic Allocation of resources
Graphical Method for Minimization	Pearson Correlation	1	.805**
	Sig. (2-tailed)		.000
	N	60	60
Dynamic Allocation of resources	Pearson Correlation	.805**	1
	Sig. (2-tailed)	.000	
	N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5: Correlations on Graphical Method for Minimization and Dynamic Allocation of resources revealed that there is a significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt with a (P. .805 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Discussion of Findings

Table 2: Correlations on Graphical Method for Maximization and Efficiency Allocation revealed that there is a significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt with a (P. .857 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Maximization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

Table 3: Correlations on Graphical Method for Maximization and Dynamic Allocation of resources revealed that there is a significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt with a (P. .714 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Maximization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Table 4: Correlations on Graphical Method for Minimization and Efficiency Allocation of resources revealed that there is a significant relationship between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt with a (P. .802 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship

between Graphical Method for Minimization and Efficiency Allocation of resources in animal feed companies in Port Harcourt.

Table 5: Correlations on Graphical Method for Minimization and Dynamic Allocation of resources revealed that there is a significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt with a (P. .805 = sig. .000) thus leading to accepting the alternate hypothesis: There is a significant relationship between Graphical Method for Minimization and Dynamic Allocation of resources in animal feed companies in Port Harcourt.

Similarly, one such study is by Oyedele et al. (2018), titled "Application of Linear Programming Techniques for Optimal Feed Formulation in Animal Feed Industry in Nigeria." The findings revealed that the application of linear programming techniques led to improved resource allocation, resulting in cost reduction and increased profitability for the companies. The conclusion drawn was that graphical methods of linear programming can be effectively used for optimal feed formulation in the animal feed industry in Nigeria. The study recommended the adoption of these techniques by more companies to enhance their operational efficiency.

Another relevant study is by Adepoju et al. (2016), titled "Optimal Resource Allocation Using Linear Programming: A Case Study of an Animal Feed Milling Company in Nigeria." This research also focused on animal feed companies in Nigeria, analyzing resource allocation through linear programming methods. The findings indicated that optimal resource allocation through linear programming led to increased productivity and reduced costs for the company. The conclusion emphasized the importance of efficient resource management for enhancing competitiveness in the animal feed industry. Recommendations included the widespread adoption of linear programming tools for better decision-making processes.

CONCLUSION

The study concluded that graphical methods of linear programming have a positive relationship with optimal allocation of resources in animal feed companies in Port Harcourt. The graphical method of linear programming is a valuable tool for optimizing resource allocation in animal feed companies in Port Harcourt. By visually representing constraints and objectives on a graph, decision-makers can easily identify the optimal allocation of resources to maximize profits or minimize costs. For maximization problems, the graphical method involves plotting constraints as inequalities on a graph and finding the feasible region where all constraints intersect. The objective function is then plotted, and the optimal solution is found at the vertex within the feasible region that maximizes the objective function. Conversely, for minimization problems, the process is similar, but the optimal solution is found at the vertex that minimizes the objective function.

RECOMMENDATIONS

1) Animal feed companies in Port Harcourt should make use of graphical methods of linear programming to optimize their resource allocation efficiently.
2) Regularly analyze and update data to ensure that the model accurately reflects current constraints and objectives.
3) Provide training to employees on how to interpret and utilize graphical solutions for decision-making processes.
4) Conduct sensitivity analysis to assess how changes in parameters affect the optimal solution.

REFERENCES

Adepoju, T. F. (2016). Optimal Resource Allocation Using Linear Programming: A Case Study of an Animal Feed Milling Company in Nigeria. *International Journal of Agricultural Economics, 4*(3), 89-102.

Bazaraa, M. S., Jarvis, J. J., & Sherali, H.D. (2013). *Linear Programming and Network Flows*. Cengage Learning

Bertsekas, D.P., & Nedic, A. (2003). *Convex Analysis and Optimization*. Pearson Education

Boyd, S., & Vandenberghe, L. (2004). *Convex Optimization*. Cengage Learning

Chong, E.K.P., & Zak, S.H. (2013). *An Introduction to Optimization*. Cengage Learning

Dantzig, G.B., & Thapa, M.N. (2003). Linear Programming 2: Theory and Extensions (Print).

Mankiw, N.G., Taylor, M.P., & Ashwin, A.P. (2017). *Economics*. Cengage Learning (Print).

Okoli, C.(2016). Resource Allocation Efficiency among Livestock Farmers in Nigeria: A Data Envelopment Analysis Approach. African Journal of Agricultural Research, 11,(25), 2205-2215.

Oladele, O.I.(2017). Linear Programming Model for Optimal Resource Allocation among Poultry Farmers in Southwest Nigeria. *Journal of Agricultural Extension and Rural Development, 9*(7), 172-180.

Oyedele, L.O.(2018). Application of Linear Programming Techniques for Optimal Feed Formulation in Animal Feed Industry in Nigeria. Journal of Agricultural Science, 15(2), 123-136.

Taha, H. A. (2016). *Operations Research: An Introduction*. Pearson Education India.

Winston, W. L. (2004). *Operations Research: Applications and Algorithms*. Cengage Learning.