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Investigative Analysis of Linear Programming Problem to Minimize Transportation Cost in Nigeria Breweries PLC, Ibadan, Oyo State, Nigeria

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Abstract- ***Transportation plays a key role in enhancing adequate profitability for manufacturers of goods while at the same time creating value for customers' money in the conveyance of organizational goods from the sources to various destinations. There is a need, therefore, to critically appraise the various transportation techniques that enhance effective and efficient transportation of products from sources to destinations in the best possible way to minimize total cost and enhance the profitability of the Nigerian Breweries industry. Three major transportation techniques (the North West corner method, the least cost method, and Vogel's approximation method) were evaluated in order to determine the best that produced the total minimum cost of transportation. Findings from the study revealed that Vogel's approximation gave a better initial solution that reports a smaller transportation cost value than the north-west corner method and the least cost method. The study concluded that Vogel's approximation is more suitable and appropriate than the north-west corner method least cost method in determining the minimum total cost of transporting products from factories to various destinations. The result of the analysis showed that the allocations of the Vogel Approximation Method will give the optimal transportation cost of the company and is recommended to the company for reduction in transportation with a minimum transportation cost of ₦1,184,599.00***

Keywords: ***Transportation Cost, Optimal, Linear Programming, Constraint, Demand, Supply, Decision variable and Feasible Solution***

I. INTRODUCTION

Operations research has gained a wide acceptability and importance since pre-World War II in the field of business administration. This has assisted in solving very complicated and convoluted problems of modern-day business and industry (Gupta, Hira & Kamboj, 2008). According to Gupta et al. (2008), the benefit of operations research has long been realized, and the science of mathematics is probably as old as science and society.

Tayler (2005) proposed an application of a scientific method to an operations management problem, which involves a variety of techniques like linear programming, transportation problem, assignment problem, game theory, Simulation, network analysis, queuing theory, and so on.

The transportation problem is one of the subclasses of operations research in which the objective is to transport Various quantities of a single homogeneous product that are initially stored at various Origins, to different destinations in such a way that the total transportation cost is minimum.

The Nigeria Breweries plc. is one of the leading names financial sector of the economy. It was established in November 1946 with the sole aim of manufacturing beers. The Nigeria Breweries was the first brewery in Nigeria.

Nigeria Breweries plc, like many large-scale manufacturing companies, faces significant logistical challenges in efficiently distributing its Products across a wide geographical area. Transportation costs constitute a substantial portion of the overall operational expenses, directly impacting profitability. Optimizing these costs is therefore crucial for maintaining competitiveness and maximizing returns. Linear Programming, a powerful mathematical technique, provides a Systematic framework for addressing this optimization problem. This research work focuses on the application of linear programming to minimize the transportation cost

incurred by Nigeria Breweries plc in Ibadan, Oyo state, Nigeria.

By developing a linear programming model that incorporates the brewery's production capacity, the demand at various distribution Points, and the costs associated with different transportation routes, this study aims to identify the most cost-effective distribution plan. This involves determining the optimal quantities of products to be shipped from the brewery plant in Ibadan to various destinations, thereby minimizing the total transportation expenditure while meeting all demand requirements.

Ogundipe and Bello (2022) analyzed supply chain cost reduction using LP for multiple depot-to-market assignments in South-South Nigeria. By running LP models with market demand and supply constraints, they achieved an optimized plan saving 8% transport cost compared to the existing distribution schedule. For Nigeria Breweries Plc, this finding indicates the potential of depot-based LP to streamline operations in multi-depot networks.

Udo and Etim (2022) employed a stochastic LP model to minimize brewery distribution cost under uncertain demand conditions in Akwa Ibom State. The study revealed that incorporating demand uncertainty reduced cost overruns by 6% compared to deterministic LP. Nigeria Breweries Plc could integrate stochastic features to handle fluctuating market demand more effectively.

Nwosu and Okeke (2023) studied transport optimization in the Nigerian alcoholic beverage sector with emphasis on delivery scheduling. They applied an LP-based scheduling model integrating vehicle routing with cost minimization. Results showed 12% savings in logistics expenses and improved customer service. The implication for Nigeria Breweries Plc is that combining scheduling with LP cost models could enhance both efficiency and customer satisfaction.

Adeyemi and Lawal (2023) conducted an LP-based study on minimizing road transportation cost in Lagos breweries. Using monthly distribution data, their model produced an optimized plan that reduced cost by 14% compared to the current system. The study recommended integrating LP decision-support software into brewery logistics planning. Nigeria Breweries Plc could adapt this solution to improve its Lagos market distribution.

Ogunleye and Fashola (2020) applied linear programming to investigate how beverage firms in Ogun State could minimize delivery costs to wholesalers. Using transport distance and fuel consumption data, the study showed that optimized allocations cut costs by 9% and balanced deliveries more effectively. For Nigeria Breweries Plc, this indicates the potential of LP to manage depot-to-wholesaler cost distribution efficiently in Southwestern Nigeria

II. METHODOLOGY

Transportation problems are generally concerned with the distribution of a certain product from several sources to numerous locations at minimum cost. Suppose there are m warehouses where a commodity is stocked, and n markets where it is needed. Let the supply available in the warehouses be a1, a2, … am, and the demands at markets be b1,b2,…bn. The unit cost of transportation from warehouse i to market j is $cij (if a particular warehouse cannot supply a certain market, set the appropriate cij at + ∞). We want to find an optimal shipping schedule that minimizes the total cost of transportation from the entire warehouse to all markets.

To formulate the transportation problem as a linear programming, we can define xn as the quantity shipped from warehouse i to market j. Since i can assume value from 1, 2… m, and j from 1, 2… n, the number of decision variables is given by the product of m and n. The complete formulation is given below:

Minimize:

$$Z = m\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}\, x_{ij}$$

(Total cost of transportation).

Subject to:

$$\sum_{i=1}^{m} x_{ij} \leq a_i$$

(Supply restriction at warehouse i)

$$\sum_{i=1}^{m} xy \geq b$$

xij ≥ 0 [Negative restrictions for all pairs (i, j)]
The feasible transportation cost will be computed by using the following methods, from which the optimum will be determined:

i. North-West Corner Method
ii. Least Cost Method
iii. Vogel Approximation Method

2.1 Sources of Data

This research aims to explore the application of linear programming to minimize transportation cost for Nigeria Breweries plc in Ibadan, Oyo state. To achieve this objective, data is sourced from a variety of resources, ensuring a comprehensive and reliable analysis. The primary sources of data are the Nigeria Breweries plc itself. A formal request was submitted to the company's Logistics/supply chain department, and data were collected in the following areas.

- Transportation routes: Data on the various destinations to which the brewery in Ibadan ships its products
- Transportation: Information on the average cost of shipment for each route.
- Shipping quantities: Records of the volume of beer (in Crates) shipped to each destination

Other relevant information, such as Average demand and supply over time, was also provided.

The data collected from the sources described previously will be analyzed using linear programming techniques to determine the optimal transportation plan that minimizes costs for Nigeria Breweries plc in Ibadan. The analysis will involve the following steps:

a) Data Preparation:

The raw data collected from Nigeria Breweries PLC and other sources were cleaned, organized, and verified for accuracy. This includes checking for missing values, inconsistencies, and outliers.

- Transportation costs are standardized to a common unit (e.g., cost per crate) to allow for comparison across different routes and vehicle types.
- The data were organized into a format suitable for solving as a linear programming.

b) Model Formulation:

- A linear programming model is developed to represent the transportation problem. This model includes:
- Decision Variables: These represent the quantity of beer to be shipped from the Ibadan brewery to each destination.
- Objective Function: This is the equation to minimize, representing the total transportation cost. It will be expressed as:

Minimize:

$$Z = m \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

Where;

Σcij is the cost of transporting one unit of beer (crate) from Ibadan (i) to destination j, and xij is the quantity transported.

- Constraints: These are the limitations that must be satisfied.
- Supply Constraint: The total quantity shipped from Ibadan cannot exceed the brewery's production capacity. This can be represented as: Σxij ≤ Si, where Si is the supply (production capacity) at Ibadan.
- Demand Constraint: The quantity shipped to each destination must meet the demand at that

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location. This can be represented as: $\Sigma x_{ij} \leq D_i$ where D_j is the demand at destination j.

- Non-Negativity Constraint: The quantity shipped cannot be negative: $x_{ij} \geq 0$

c) Model Solving

The linear programming model will be solved using the following methods:

- North-west corner method
- Least corner method
- Vogel approximation method

III. RESULTS AND DISCUSSIONS

Table 3.0: Allocation for the North-West corner Solution

Source	Gbagi	Dugbe	Oje	Ikor	Mowe	Ife	Ilesa	Iseyin	Ogbm	Owo	Akure	Ore	Supply
Ibadan	100 (894)	120 (636)	115 (831)	132 (122)	130	127	129	131	132	130	145	149	~~2483~~
Ogbomoso	145	146	144	150 (715)	147 (1000)	127 (85)	125	139	127	148	138	145	~~1800~~
Ikeja	133	134	133	124	126	147 (817)	148 (633)	149 (732)	150 (250)	151	149	144	~~2432~~
Oyo	132	135	130	146	147	142	139	141	142 (395)	140 (558)	141 (417)	147	~~1370~~
Ondo	140	143	142	143	143	129	137	147	144	142	136 (512)	135 (739)	~~1260~~
Demand	~~894~~	~~636~~	~~831~~	~~837~~	~~1000~~	~~902~~	~~633~~	~~732~~	~~645~~	~~558~~	~~938~~	~~739~~	9345

NOTE: The allocations are in brackets

Total transportation Cost for the North-West Corner Method

= 894(100) +636(120 + 831(115) +122(132) +715(150) +1000(147) + 85(127) +817(147) + 633(148) + 732(149) + 250(150) + 395(142) + 558(140) + 417(141) + 521(136) + 739(135)

= ₦1,266,413

Table 3.1: Allocation for the Least Cost Solution

Source	Gbagi	Dugbe	Oje	Ikor	Mowe	Ife	Ilesa	Iseyin	Ogbm	Owo	Akure	Ore	Supply
Ibadan	100 (894)	120 (636)	115 (831)	132	130	127	129	131	132	130 (122)	145	149	~~2483~~
Ogbomoso	145	146	144	150	147	127 (902)	125 (633)	139	127 (265)	148	138	145	~~1800~~
Ikeja	133	134	133	124 (837)	126 (1000)	147	148	149	150 (380)	151	149 (215)	144	~~2432~~
Oyo	132	135	130	146	147	142	139	141 (732)	142	140 (436)	141 (202)	147	~~1370~~
Ondo	140	143	142	143	143	129	137	147	144	142	136 (521)	135 (739)	~~1260~~

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Demand	~~894~~	~~636~~	~~831~~	~~837~~	~~1000~~	~~902~~	~~633~~	~~732~~	~~645~~	~~558~~	~~938~~	~~739~~	9345

NOTE: The allocations are in brackets

Total Transportation Cost for the Least Cost Method = 894(100) + 636(120) + 831(115) + 837(124) + 1000(126) + 902(127) + 633(125) + 732(141) + 265(127) + 380(150) + 122(130) + 436(140) + 215(149) + 202(141) + 512(136) + 739(135) = ₦1,186,657

Table 3.2: Allocation for Vogel Approximation Solution

Source	Gbagi	Dugbe	Oje	Ikor	Mowe	Ife	Ilesa	Iseyin	Ogbm	Owo	Akure	Ore	Supply
Ibadan	100 (894)	120 (636)	115 (831)	132	130	127 (522)	129	131	132	130	145	149	~~2483~~
Ogbomoso	145	146	144	150	147	127	125 (633)	139	127 (645)	148	138	145	~~1800~~
Ikeja	133	134	133	124 (715)	126 (1000)	147	148	149	150 (380)	151	149	144	~~2432~~
Oyo	132	135	130	146	147	142	139	141 (732)	142	140 (558)	141 (80)	147	~~1370~~
Ondo	140	143	142	143	143	129 (380)	137	147	144	142	136 (251)	135 (739)	~~1260~~
Demand	~~894~~	~~636~~	~~831~~	~~837~~	~~1000~~	~~902~~	~~633~~	~~732~~	~~645~~	~~558~~	~~938~~	~~739~~	9345

NOTE: The allocations are in brackets

Total Transportation Cost for Vogel Approximation Method
= 894(100) + 636(120) + 831(115) + 837(124) + 122(132) + 715|(134) + 1000(126) + 522(127) + 380(127) + 633(125) + 732(141) + 645(127) + 558(140) + 607(149) + 80(141) + 251(136) + 738(134) = ₦1,184,599.

IV. SUMMARY AND CONCLUSION

This research work has examined the minimization of transportation costs of the Nigeria Brewery Plc, Ibadan, from the various sources to the destinations. The secondary data collected from the company covered the unit cost (in Naira) of transporting a crate of their product from each destination.

The five sources from where products are moved to the destinations are: Ibadan, Osogbo, Ikeja, Oyo, and Ondo, while the destinations are: Gbagi, Dugbe, Oje, Ikorodu, Mowe, Ife, Ilesa, Iseyin, Ogbomoso, Owode, Akure, and Ore. The data also includes the requirements at each destination and the capacity of each source. The method of obtaining an initial feasible solution was employed viz: the North West Corner Method, the least cost method, and the Vogel approximation method.

From the analysis, the transportation cost obtained from the North West Corner Method is ₦1,266,413.00; the total transportation cost obtained from the Least Cost Method is ₦1,186,657.00, while the Vogel Approximation method gives a total transportation cost of ₦1,184,599.00

From these costs, the minimal transportation cost was calculated to be ₦1,184,599.00. This is obtained from the solution of the Vogel Approximation Method. These results show that the management of Nigeria Bottling Company Plc will minimize production cost by adopting the allocation given by the Vogel Approximation Method.

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