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APPLICATION OF LINEAR PROGRAMMING TO MINIMIZE TRANSPORTATION COST IN NIGERIA BREWERIES PLC, IBADAN, OYO STATE, NIGERIA

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ABSTRACT: *This research paper work analyzed the transportation cost of Nigeria Breweries Plc, Ibadan in Oyo State in relation to the units of its products demanded at the various deports and the capacity of the factories. Five origins which are Ibadan, Osogbo, Ikeja, Oyo and Ondo as well as twelve destinations (warehouses): Gbagi, Dugbe, Oje, Ikorodu, Mowe, Ife, Ilesa, Iseyin, Ogbomosho, Owode, Akure and Ore were examined. The data also include the requirements at each destination and capacity at each source. The costs represent the average transportation cost from June to December 2019. Initial feasible solution was obtained for the secondary data collected by using North-West corner Method, and Vogel Approximation Method. The result of the analysis showed that the allocations of 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 ₦1,168,431.*

KEYWORDS: Linear Programming, Vogel Approximation, North-west Corner, Destination, Minimum Cost, Optimum, Constraint, Transportation.

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INTRODUCTION

Business and industries are practically faced with both economic optimization such as cost minimization of non-economic items that are vital to the existence of their firms. The transportation models or problems are primarily concerned with the optimal (best possible) way in witch a product produce at different factories or plants (called supply origins) can be transported to a number of warehouses or customers (call demand destination). The objective in transportation problem is to fully satisfy the destination requirements within the operating production capacity constraint at the minimum possible cost.

Whenever there are a physical movement of goods from the point of manufacturer to the final consumers though a variety of channels of distribution (wholesalers, retailers, distributors etc.) there is a need to minimize the cost of the transportation so as to increase profit on sales. The transportation problem is special class of linear programming problem, which deals with shipping commodities from source to destinations. The objective of the transportation problem is to determine the schedule that minimize the total shipping cost while satisfy and demand limits the transportation problem has an application in industry, communication network, planning, scheduling transportation and allotment etc.

Transportation problem involves movement of specified quantity of an item from 'm' sources to 'n' destination/location at minimum cost. After considering a variety of transport or shipping routes and a verity of cost for these routes, we would like to determine the number of units that would be shipped and the total transportation cost minimized.

Transportation problem is one of the fundamental problems of network flow problem which is usually use to minimize the transportation cost for industries with number of sources and number of destination while satisfying the supply limit and demand requirement. In the recent past, Transportation problem with a different single objective to minimize the duration of transportation has been studied by many researchers such as Sharma and Swarup [2007], Sonia et al [2008], Seshan and Tikekar [2010] and Prakash and Papmanthou [2012].

Let the supply available in the factories be ${}^{a}1\ {}^{a}2 \ldots, a^{m}$: and the demand at the warehouses be ${}^{b}1, {}^{b}2, \ldots, {}^{b}n$: the unit cost of shipping from warehouse i to market j is $\#C_{ij.}$ We wish to find optimal shipping or distribution route that minimizes total cost of transportation from all the factories to the warehouses/market. It is assumed that the total supply and total demand are equal. This is situation is guaranteed by creating either a fictitious destination with total supply or fictitious sources with a supply equal to the shortage if total demand exceeds total supply.

The materials and concepts involved in the study. Transportation problem is a particular class of linear programming, which is associated with day-to-day activities in our real life and mainly deals with logistics. It helps in solving problems on distribution and transportation of resources from one place to another. The goods are transported from set of sources (e.g., factory) to set of destination (e.g., warehouse) to meet the specific requirements. There is a type of linear programming problem that may be solved using a simplified version of the simplex technique called transportation method.

Because of its major application in solving problems involving several product sources and several destinations of products, this type of problem is frequently called the transportation problem. It gets its name from its application to problems involving transporting products

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from several sources to several destinations although the formation can be used to represent more general assignment and scheduling problems as well as transportation and distribution problems. The two common objectives of such problems are either (1) minimize the cost of shipping *m* units to *n* destinations.

Transportation theory is the name given to study of optimal transportation and allocation of resources. The model is useful for making strategic decisions involve in selecting optimum transportation routes so as to allocate the production the [production of various plants to several warehouses or distribution centers. The transportation model can also be used in making location a new facility, a manufacturing plant or an office when two or more number of location is under consideration. They total transportation cost or shipping cost and production costs to be minimized by applying the model.

The transportation problem itself was first formulated by Hitchcock (1941), while Dantzing (1951) gave the standard linear programming formulation for transportation problem has become the classical common subject in almost every textbook on operation research and mathematical programming. The transportation problem can be described using linear programming mathematical model and usually it appears in a transportations tableau. Linear programming has been used successfully in solution of problems concerned with the assignment of personnel, distribution and transportation, engineering, banking, education, petroleum, etc

The classical transportation problem is the name of a mathematical model, which has a special mathematic structure. The mathematical formulation of a large number of problem conforms (or can be made to conform) to this special structure. So the name is frequently used to refer to a particular form of mathematical model rather than the physical situation in which the problem most natural originates. The transportation problem is a special kind of the network optimization problem. The transportation models play an important role in logistics and supply chains. The objective is to schedule shipment from sources to /destinations so that total transportation cost is minimized. The problem seeks a production and distribution plan that minimizes total transportation cost. The problem can be formulated as the following mathematic program. The function to be formulated as the following mathematical program. The function to be minimized (or maximized) is called objective function. When the linear system model and the objective function are both linear equation, we have a linear programming problem.

Furthermore, linear programming algorithms are used in subroutines for solving more difficult optimization problem. A widely considered quintessential LP algorithm is the simplex algorithm developed by Dantzing (1947) in response to a mechanize the Air Force planning process. Linear programming has been applied extensively in various areas such as transportation, construction, telecommunication, healthcare and public service to name but few areas.

The simplex algorithm was the forerunner of many computer programs that are used to solve complex optimization problems (Baynto, 2006). The transportation method has been employed to developed many different types of process. From machine shop scheduling Mohaghe (2006) to optimizing operation room schedules in hospitals (Calichman, 2005). The transportation method can be used to reduce the impact of using fossil fuels to transport materials.

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This paper aimed at obtaining the minimum cost of transporting the products of Nigeria Brewery Plc, Ibadan from the factories to the warehouse and depots. The research intended to :

Model the distribution of Nigeria Brewery Plc products as a transportation problem,Minimize the transportation cost, Obtain the minimum possible cost that cost that minimum total shipping cost.

The data for this research is a secondary data,and obtained from Nigerian Brewery Plc, Ibadan, Oyo State. The data contained the unit cost (in Naira) of transporting their products from the five deports (source): Ibadan, Oyo, Ikeja, Osogbo and Ondo to wholesale dealers (destinations) at: Oje, Dugbe, Gbagi, Ikorodu, Mowe, Ife, Ilesa, Iseyin, Ogbomoso, Owode, Akure, and ore. The data also include the requirements at each destination and capacity of each source.

LITERATURE REVIEW

Arsham et al (2013) introduced a new algorithm for solving the transportation problem. The proposed method used only one operation, the Gauss Jordan pivoting method, which was used for the post optimality analysis of transportation problem. This algorithm is faster than simplex, more general than stepping stone and simpler than both in solving general transportation problem. Kikuchi (2010) suggested that, in many problems of transportation engineering and planning, the variables themselves must satisfy a set of rigid relationships dedicated by physical principle. They proposed a simple adjustment method that finds the most appropriate set of crisp numbers. The method assumes that each observed value is an approximate number (or a fuzzy number) and the true value was found in the support of the membership function.

For each of many possible set of value that satisfy the relationships, the lowest membership grade is checked and the set, whose lowest programming approach which is utilized in order to allow for the optimization of multiple conflicting goals while permitting an explicit consideration of the existing decision environment. Zimmermann (2000) applied the fuzzy set theory concept with some suitable membership function to solve multi-objective transportation problems. He presented the application of fuzzy linear programming to approach linear vector maximum problem. It has been found that solutions obtained by fuzzy linear programming are always efficient.

Slowinski (2006) presented a method for solving a multi-criteria linear program where the coefficient of the objective functions and the constraint are fuzzy numbers of the L-R type. He transformed the assuming the aspiration levels for particular criteria to be fuzzy and based on comparison of fuzzy numbers, and then solving the obtained problem by using an interactive technique involving a linear programming procedure in the calculation phase.

Bit at al (2003) considered a k- objective transportation problem fuzzified by fuzzy numbers and used I- cut to obtain a transportation problem in the fuzzy sense expressed in linear programming form. He also membership grade is the highest, is chosen as the best set of values for this problem. This process is performed using the fuzzy linear programming method. The multi-objective transportation problem refers to a special class of linear

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programming problem in which the constraints are of equality type and all objectives are conflicting with each other all the proposed methods to solve multi-objective linear programming problem generate a set of non dominated, interactive algorithms, fuzzy programming approaches, the step 24 method, the utility function method have been developed by many researchers for the multi-objectives. Virtually, all models developed to solve the transportation problems ignore the multiple conflicting objectives linear programming problem.

Lee et al (2007) applied goal programming to find a solution is multi-objective transportation problem. Goal programming has been widely applied to solve different problems which involve multiple objectives involve in the problem. The priority structures of these various environmental constraints, unique organizational values of the firm, and bureaucratic decision structures. However, in reality these are important factors which greatly influence the decision process of the transportation problems. They studied the goal programming approach which is utilized in order to allow for the optimization of the multiple conflicting goals while permitting an explicit consideration of the existing decision environment.

Bit at al (2003) considered a k- objective transportation problem fuzzified by fuzzy numbers and used I - cut to obtain a transportation problem in the fuzzy sense expressed in linear programming form. He also introduced an additive fuzzy programming model for the multi-objective transportation problem. The method aggregates the membership functions of the objectives to construct the relevant decision function. Weights and priorities for non-equivalent also incorporated in the method. This model gives a non-dominated solution which is nearer to the best compromise solution.

Das et al (2009) focused on the solution procedure of the multi-objective functions, and the source and destination parameters are expressed as interval values by the decision maker. They transform the problem into a classical multi-objective transportation problem so as to minimize as the interval objective function. They define the order relations that represent the decision maker's preference between interval profits. They converted the constraints with interval source and destination parameters into deterministic one. Finally, they solved equivalent transformed problem by fuzzy programming technique.

Sakawa et al (2001) dealt with actual problems on production and work force assignment in housing material manufacturer and a sub contact firm. He formulated two kinds of two- level programming problems: one is a profit maximization problem of both the housing material manufacturer and the subcontract firm, and the other is a profitability maximization problem of them. Applying the interactive fuzzy programming for two-level linear and linear and fractional programming problems, he obtained the satisfactory solution and stability of multi-objective transportation problem with fuzzy coefficient and/or fuzzy supply quantities and/or fuzzy demand quantities.

Wahed et al (2006) proposed an interactive fuzzy goal programming approach to determine the preferred compromise solution for the multi-objective transportation problem. The proposed approach considered the approach focuses on minimizing the worst upper bound of each objective function. The solution which is close to the best lower bound of each objective function. The procedure controls the search direction via updating both the membership values and the aspiration levels.

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Zangiabadi et al (2007) presented a goal programming approach to determine an optimal compromise solution for the multi objective transportation problem by assuming that each objective function has a fuzzy goal. A special type of non-linear (hyperbolic) membership function is assigned to each objective function to describe each fuzzy goal. The approach focuses on minimizing the negative deviation varies from one to obtain a compromise solution of the multi-objective transportation problem.

Surapati et al (2008) presented a priority based fuzzy coefficients. Initially, they define the membership functions for the fuzzy goals, by assigning the highest degree (unity) of a membership function as the aspiration level and introducing deviational variables to each of them. In the solution process, negative deviational variables are minimized to obtain the most satisfying solution.

The basic transportation problem was originally developed by Hitchcock (1941). Efficient methods of solution are derived from the simplex algorithm and where developed in 1947. The transportation problem can be converted as a standard linear programming problem, which can be solved by the simplex method. However, because of its very special mathematical structure, it was recognized early that the simplex method applied to the transportation problem can be made quite efficient in terms of how to evaluate the necessary simplex-method information (variable to enter the basis, variable to leave the basis and optimality conditions).

Charnes et al (1954) developed the stepping stone method which provides alternative way of determining the simplex-method information.

Dantzig (1963) used the simplex method in the transportation problem as the primal simplex transportation method. Can be obtained by using the North West corner rule, Row minima, Column minima, Matrix minima, or the Vogel's approximation method. Modified distribution methods is useful for finding the optimal solution for the transportation problem. The linear interactive and Discrete optimization (LINDO), General interactive optimizer (GINO) and TORA packages as well as many 23 others commercial and academic packages are useful to find the solution of the transportation problems reviewed above are not carried out in Nigeria hence the need for this study.

METHODOLOGY

Transportation problem 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 market where it is needed let the supply available in the warehouses be $a_1, a_2, \ldots a_m$ and the demands at markets be $b_1, b_2, \ldots b_n$. the unit cost of transportation from warehouse I to market j is \$cij (if particular warehouse cannot supply a certain market, set the appropriate cij at $+\infty$). We want to find an optimal shipping schedule which minimizes the total cost of transportation from the entire warehouse to all markets.

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To formulate the transportation problem as linear programme, we can define x_n 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 variable is given by the product of m and n the complete formulation is given below:

Minimize z = $\sum_{i=1}^{m} \sum_{m}^{n} c_{ij}\, x_{ij}$ (Total cost of transportation).

Subject to: = $\sum_{i=1}^{m} xij \leq ai$ (supply restriction at warehouse i)

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

$x_{ij} \geq 0$ [Negative restrictions for all pairs (i, j)]

The feasible transportation cost will be computed by using the following methods, from the optimum will determine:

1. North-West Corner Method
2. Least Cost Method
3. Vogel Approximation Method

NORTH WEST CORNER METHOD (NWCM)

Here, we begin with the North West or upper left corner cell of our transportation table. This rule generates a feasible solution with no more than (m+n-1) positive values. The variables which occupy the North-West corner positions in the transportation table are not chosen as basic variables.

LEAST COST METHOD (LCM)

The only difference between this rule and the Northwest-corner rule is the criterion used for selecting the successive basic variables. In the least-cost rule, the variable with the lowest shipping cost be chosen as the basic variable.

VOGEL'S APPROXIMATELY METHOD (VAM)

This method is preferred to the other methods because the initial basic feasible solution obtained is either optimum or very close to the optimum solution. Here the amount of time and energy require to arrive at the optimum solution is greatly reduced. The steps are:

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DATA ANALYSIS

Table.1 Data on the cost matrix (#crate) from each origin to various destinations

Source	Gbagi	Dugbe	Oje	Ikorodu	Mowe	Ife	Ilesa	Iseyin	Ogbomoso	Owode	Akure	Ore	supply
Ibadan	100	120	115	132	130	127	129	131	132	130	145	149	2483
Osogbo	145	146	144	150	147	127	125	139	127	148	138	145	1800
Ikeja	133	134	133	124	126	147	148	149	150	151	149	144	2432
Oyo	132	135	130	146	147	142	139	141	142	140	141	147	1370
Ondo	140	143	142	143	148	129	137	147	144	142	136	135	1260
Demand	894	636	831	837	1000	902	633	732	645	558	938	739	

***Source:** Nigerian Breweries plc, Ibadan (August 2019).*

Table 2 Data on supply from origin (crates)

Source	Supply
Ibadan	2483
Osogbo	1800
Ikeja	1432
Oyo	1370
Ondo	1260

***Source;** Nigerian Breweries plc, Ibadan (August 2019)*

Table 3 Data on demand at each destination (crates)

Source	Gbagi	Dugbe	Oje	Ikorodu	Mowe	Ife	Ilesa	Iseyin	Ogbomoso	Owode	Akure	Ore
Demand	894	636	831	837	1000	902	732	645	558	938	739	

***Source:** Nigerian Breweries plc, Ibadan (August 2019).*

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DATA ANALYSIS

Table 2 Allocation for the North- West Corner Solution

Source	Gbagi	Dugbe	Oje	Ikor odu	Mowe	Ife	Ilesa	Iseyin	Ogbo moso	Owode	Akure	Ore	Supply
Ibadan	100 (894)	(636) 120	(831) 115	(122) 132	130	127	129	131	132	130	145	149	2483
Osogbo	145	146	144	(715) 150	(1000) 147	(85) 127	125	139	127	148	138	145	1800
Ikeja	133	134	133	124	126	(817) 147	(6633) 148	(732) 149	(250) 150	151	149	144	2432
Oyo	132	135	130	146	147	142	139	141	(395) 142	(558) 140	(417) 414	147	1370
Ondo	140	143	142	143	148	129	317	147	144	142	(521) 136	(739) 135	1260
Demand	894	636	831	837	1000	902	633	732	645	558	938	739	

NOTE: The allocations are in brackets

Total transportation Cost for 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)

=₦1,202,629

Table .3: Allocation for Least Cost Solution

Source	Gbagi	Dugbe	Oje	Ikor odu	Mowe	Ife	Ilesa	Iseyin	Ogbo moso	Owode	Akur e	Ore	Supply
Ibadan	100 (894)	(626) 120	(831) 115	132	130	127	129	131	132	(122) 130	145	149	2483
Osogbo	145	146	144	150	(1000) 147	(902) 127	(633) 125	139	(265) 127	148	138	145	1800
Ikeja	133	134	133	(837) 124	126	147	148	149	(380) 150	151	(215) 149	144	2432
Oyo	132	135	130	146	147	142	139	(732) 141	142	(436) 140	(202) 141	147	1370
Ondo	140	143	142	143	148	129	137	147	144	142	(521) 136	(739) 135	1260
Demand	894	636	831	837	1000	902	633	732	645	558	938	739	

NOTE: The allocations are in brackets

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Total Transportation Cost for Least Cost Method=

894(100) + 636(120) + 831(115) + 837(124) + 902(127) + 633(125) + 732(141) + 265(127) + 380(150) + 122(130) + 436(140) + 215(149) + 202(141) + 739(135)

₦1,186,657

Table.4: Allocation for Vogel Approximation Solution

Source	Gbagi	Dugbe	Oje	Ikor odu	Mowe	Ife	Ilesa	Iseyin	Ogbo moso	Owode	Akure	Ore	Supply
Ibadan	100 (894)	(626) 120	(831) 115	132	130	(122) 127	129	131	132	(122) 130	145	149	2483
Osogbo	145	146	144	150	(1000) 147	(518) 127	(633) 125	139	(265) 127	148	138	145	1800
Ikeja	133	134	133	(837) 124	126	147	148	149	(380) 150	151	(215) 149	144	2432
Oyo	132	135	130	146	147	142	139	(732) 141	142	(436) 140	(202) 141	147	1370
Ondo	140	143	142	143	148	(262) 129	137	147	144	142	(521) 136	(739) 135	1260
Demand	894	636	831	837	1000	902	633	732	645	558	938	739	

NOTE: The allocations are in brackets

Total Transportation Cost for Vogel Approximation Method=

894(100) + 636(120) + 831(115) + 837(124) + 1000(126) + 122(127) + 518(127) + 262(129) + 633(125) + 732(141) + 645(127) + 558(140) + 938(136) + 585(144) + 60(135) + 938(136) + 585(144) + 60(135) + 739(135)

₦1,168,431

CONCLUSION

This research work had 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 from the company covered the unit cost (in Naira) of transporting a crate of their product from each destination as at August, 2019.

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

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From the analysis, the transportation cost obtained from North West Corner Method is #1,202,629.00; the total transportation cost obtained from Least Cost Method is #1,186,657.00 while the Vogel Approximation method gives a total transportation cost #1,168,431.00

From these costs, the minimal transportation cost was calculated to be #1,168,431.00. This is the obtained from the solution of Vogel Approximation Method. This results shows that the management of Nigeria Bottling Company Plc will minimize production cost by adopting the allocation given by the Vogel Approximation Method.

RECOMMENDATIONS

Based on the result of findings from the data analysis, I hereby recommended the following in order to reduce the production cost which in turn will lead to profit maximization:

Provided the transportation costs given in this data still remain valid, the management of Nigeria Breweries plc should henceforth:

- Allocate 894 units from Ibadan to Gbagi;
- Allocate 636 units from Ibadan to Dugbe
- Allocate 831 units from Idadan to Oje;
- Allocate 122 units from Ibadan to Ife;
- Allocate 518 units from Osogbo to Ife;
- Allocate 633 units from Osogbo to Ilesa;
- Allocate 645 units from Osogbo to Ogbomoso;
- Allocate 837 units from Ikeja to Ikorodu;
- Allocate 1000 units from IKeja to Mowe;
- Allocate 585 units from Ikeja to Ore;
- Allocate 732 units from Oyo to Owode;
- Allocate 80 units from Oyo to Ore;
- Allocate 262 unit from Ondo to Ife;
- Allocate 732 units from Oyo to Iseyin;
- Allocate 938 units from Ondo to Akure;
- Allocate 60 units from Ondo to Ore;

In order to obtain the minimize transportation cost of ₦1,168,431.

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