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OPTIMIZATION OF TOTAL TRANSPORTATION COST

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ABSTRACT

In this research work, the study used transportation problem techniques to determine minimum cost of transportation of Gimbiya Furniture Factory using online software, Modified Distribution Method (MODI). The observation made was that if Gimbiya furniture factory, Birnin Kebbi could apply this model to their transportation schedule, it will help to minimize transportation cost at the factory to ₦1,125,000.00 as obtained from North west corner method, since it was the least among the two methods, North west corner method and Least corner method. This transportation model will be useful for making strategic decision by the logistic managers of Gimbiya furniture factory, in making optimum allocation of the production from the company in Kebbi to various customers (key distributions) at a minimum transportation cost.

KEYWORDS: North West corner, Least corner, Transportation problem, minimum transportation.

INTRODUCTION

Every business environment is faced with challenges of transporting the products from the sources (e.g. factory) to their destinations (e.g. Customers), since the aim of any business is to maximize profit. The transportation problem is one of the fundamental problems of network flow problem which is usually used to minimize the transportation cost for industries to transport goods, which deals with shipping commodities from sources to destinations.

Transportation model plays a vital role to ensure the efficient movement and in – time availability of raw materials and finished goods from sources to destinations. It is a linear programming stemmed from a network structure consisting of a finite number of nodes and arcs attached to them. The objective of transportation problem is to determine the shipping schedule that minimizes the total shipping cost while satisfying the demand and supply limit. If we are able to minimize the transportation time, transportation cost comes down naturally. In literature a good numbers of researches are available regarding minimization of transportation cost. (Uddin 2012).

Solving transportation problems where products are to be supplied from one side (Sources) to another (demands) with a goal to minimize the overall transportation cost represents on activity of great importance. Most of the works done in the field deals with the problem as two sided model (sources such as factories and demands such as warehouses) with no connections between sources or demand. However, real world transportation problems, may come in other model where sources are connected in a network like graph in which each sources may supply other sources in a specific cost. The work in this paper suggest an algorithm and a graph model with mathematical solution for finding the minimum feasible solution for such widely used transportation problems. (aljanabi and Jasim 2015).

The transportation model can also be used in making location decisions. The model helps in locating a new facility, a manufacturing plant or an office when two or more number of locations are under consideration. The total transportation cost. Distribution cost or shipping cost and production costs are to be minimized by applying the model (Jalsanka 2009).

Uddin (2012) extends the earlier application of finding initial basic feasible solution (IBFS) of transportation problem in cost minimization to transportation time minimization, using an algorithmic approach. In this research, a transportation time algorithm is applied to determine the minimum transportation time. The algorithm determiners the IBFS of transportation problem minimize time. Here in, the distribution indicators (D I) is calculated by the difference of the greatest time unit and the nearest to the greatest time unit. Then the teast entry of the transportation table (TT) along the highest DI is taken as the basic cell. The result with an elaborate illustration demonstrates that the method presented here is effective in minimizing the transportation time. Onianwa et al., (2012) performed a research on a plat form for solving transportation

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problem using an interactive system for optional solution. The concept of transportation system and the method of solving transportation problems were discussed using software. In this study they developed a model for the transportation system in Ambrose Alli University (AAU), Ekpoma though private but provide an optimal transportation division. In developing the software, I used Microsoft visual Basic the optimal solution arrived at showed that the management can operate at a minimum cost if they utilize the routes as presented in the study: main campus to Alliquare conviying an average of 90 passengers per day, main campuls to market square with an average of 150 passengers, basic medical science to all square with an average of 15 passengers, basic medical science to Opoji junction with an average of 85 passengers. Consequently, the cost of transportation in these routes are, ₦30, ₦20, ₦20, and ₦30 respectively per journey. An online application was also developed using North – West Corner (NWC) rule to automate the analysis of system.

METHODOLOGY

The data used for the purposed of this research work on transportation problem was collected from Gimbiya furniture factory, Kebbi State. Data required for this study includes: demand of the products by the customers, capacity of the products supply by the company, the truck transportation cost. The study is based only on the B/Kebbi and Zuru Branches and the customers geographically within the region, data used for this research work is on monthly basis. The data used for this analysis is a secondary data collected from Gimbiya furniture factory.

THE TRANSPORTATION PROBLEM

The transportation problem is a type of linear programming problem that may be solved using a simplified version of simplex technique called transportation method. Because of its major application in solving problems involving several products involving transporting products from several sources to several destinations.

The TP seeks to find the best way to fulfill the demand of say N demand points using the capacities of say M supply points. The objective in a TP is to fully satisfy destination requirements within the operating production capacity constraints at the minimum possible cost.

In any situation that there is physical movement of goods from point of manufacture or production to the final consumers through varies of channels of distribution (wholesalers, retailers, distributors e.t.c), there is also a need to minimize the cost of transportation so as to increase profit on sales.

TP arise in all such as providing assistance to top managers in ascertaining how many units of a particular products should be transported from each supply origin to each demand destinations so that the total prevailing demand for the company's product is satisfied, while at the same time the total transportation costs are minimized. Bresster and king (1978) noted that widely separated region may not engage in trading because the costs in absence of trade, therefore, great distances and expensive transportation restrict trade whiles technological developments that reduces transfer cost can increase trade. Identification of surplus to which deficit region of ten becomes a complicated task. Consideration of transportation cost couses the pattern of distribution of the commodity to become an essential factor in determing the total transportation cost. Sasieni et al., (1959) noted that problems of allocation arise whenever there are a number of activities to perform, but limitations on either the amount of resources or the way they can be spent prevent me from performing each separate activity in the must effective way conceivable. In such situations I wish to allot the available resources to the activities in a way that will optimize the total effectiveness Brany (2013).

Transportation model is used in the following:

To decide the transportation of new materials from various centers to different manufacturing plants. In the case of multi – plant company this is highly useful. To decide the transportation of finished goods from different manufacturing plants to the different distribution centers. For a multi – market company this is useful. These two are the uses of TM. The objective is minimizing transportation cost. Brany (2013).

MATHEMATICAL FORMULATION

The transportation problem applies to situation where a single commodity is to be transported from various sources of supply (origins) to various demands (destinations). Thus, the costs are assumed to be linear. Let there be m sources of supply S_1, S_2, - - -, S_m having a_i (i = 1,2…m) units of supplies respectively to be transported among n destinations d_1, d_2 …… with b_j, (j = 1,2…n) units of requirements respectively.
Let C_{ij} be the cost for shipping one unit of the commodity from source i, to destination j for each route.

THE DECISION VARIABLES

The decision variables are:
X_{ij} =number of units transportation from supply center i to destination j where i= 1, - - -, M and j = 1, - - - - -., n.
This is a set of mxn variables.
3.5.2 – the Object Function
The objective function shows the relationship between the costs and each of the variable. The problem is to identify the minimum cost shipping schedule. Consider the shipment from supply center I to destinations center for any I and j, the transportation cost per unit cij and the total cost function is linear, the total cost of this shipment is given by cij xij. Summing overall I and j now yields the overall transportation cost for all supply center – demand center combinations.
That is, our objective function is:

$$\text{Minimize } Z=\sum_{i=1}^{M}\sum_{j=1}^{n} C_{ij} X_{ij}$$

THE OBJECTIVE FUNCTION

The objective function shows the relationship between the costs and each of the variables. The problem is to identify the minimum cost shipping schedule. Consider the shipment from the supply centre 'i' to destination centre 'j' for any I and j, the transportation cost per unit C_{ij} and the size of the shipment is X_{ij}. Since we assume that the total cost function is linear, the total cost of this shipment is given by C_{ij} X_{ij}.

THE CONSTRAINTS

Consider supply center i. the total outgoing shipment from this supply center is the sum $x_{i1} + x_{i2} + \ldots + x_{in}$. In summation notion, this is written as $\sum_{j=1}^{n} X_{ij}$. Since the total supply from since the total supply from supply centre i is a_i, the total outgoing shipment cannot exceed a_i. That is I must require

$$\sum_{j=1}^{n} X_{ij} \leq ai, \text{ for } i = 1, 2, ---, m$$

Consider demand center j. The total incoming shipment at this demand center is sum $x_{1j} + x2_j + x_{2j} + X_{mj}$ in summation notation, this written as $\sum_{i=1}^{m} X_{ij}$

since the total supply from supply center j is b_i, the total outgoing shipment cannot exceeds a_i.

That is, i must require

$$\sum_{i=1}^{m} Xij \geq bj. \text{ For } j=1, 2,---,n$$

This results in a set of m + n functional constraints. Of course, as physical shipments, the X_{ij} s should be non negative. That is

$$X_{ij} \geq r_{ij}$$

In summary, I arrive at the following formulations:

Minimize $Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij}$

$$\sum_{j=1}^{n} X_{ij} \leq a_i \text{ , for i =1, 2, - - -, m}$$

$$\sum_{i=i}^{m} X_{ij} \geq b_j \text{ . For j=1, 2, - - -, n}$$

$X_{ij} \geq 0$, for i = 1, 2, - - -, m and j = 1, 2- - -, n

This is a linear program with m x n decision variables, m + n functional constraints and m x n non – negativity constructions.

M = number of source

N = number of destinations

a_i = capacity i-the of source (in sets, liters, e.t.c.)

b_j = demand j – the of destination (in sets, liters, e.t.c)

c_{ij} = cost coefficients of material shipping (unit shipping cost) between i- the source and j – the destinations (in & or as a distance in kilometers, miles, e.t.c).

Amount of material transported between source and destination (in set, liters e.t.c)

A necessary and sufficient condition for the existence of a feasible solution to the transportation problem is that

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Remark. The set of constraints

$$\sum_{i=1}^{m} X_{ij} = b_j \quad \text{and} \quad \sum_{j=1}^{n} X_{ij} = a_i$$

represents m + n equations in non – negative variables. Each variable appears in exactly two constraints, one is associated with the origin and other is associated with the destination.

THE UNBALANCED TRANSPORTATION PROBLEM

When the total supply of all sources in not equal to the demand of all destinations, the problem is an unbalanced transportation problem.

Total supply ≠ Total demand

m n

$$\sum_{i=1}^{m} a_i \neq \sum_{j=1}^{n} b_j$$

There are two cases

Case (1)

If demand is less than supply

$$\sum_{i=1}^{m} a_i > \sum_{j=1}^{n} b_j$$

Case (2)

If demand is greater than supply

$$\sum_{i=1}^{m} a_i < \sum_{j=1}^{n} b_j$$

In real life, supply and demand requirements will rarely be equal. This is because of variation in production from the supplier end, and variations in forecast from the customer end. Supply variations may be because of shortage of raw materials, labour problems, transportation model improper planning schedule ling. Demand variations may be because of change in customer preference, change in price and introduction of new products by competitors.

The unbalanced problems can easily be solved by introducing dummy source and dummy destinations. If the total supply is greater than total demand, a dummy destination (dummy column) with demand equal to the supply surplus is added. If the demand is greater than the total supply, a dummy source (dummy row) with supply equal to the demand surplus is added. The unit transportation cost for the dummy column and dummy row are assigned zero values, because no shipment is actually made in case of dummy source dummy destination.

TRANSPORTATION TABLE

The transportation table where supply availability at each source is shown in the far right column and the destination requirements are shown in the bottom row. Each cell represents one route. The unit shipping cost is shown in upper right corner of the cell, the amount of shipped material is shown in the center of the cell.

For a problem with m sources and n destinations, the tableau will be a table with m rows n columns. Specifically, each source will have a corresponding row; and each destination, a corresponding column. For ease of reference, we shall refer to the cell that is located at the intersection of the I^{th} row and j^{th} column as “cell (i, j)”. parameters of the problem will be entered in to various parts of the table in the format below.

Table 2.1: The Transportation Tableau

To Destination → From Source ↓	D1	D2	…Dj…..	Dn	Availability
S_1	C_{11} X_{11}	C_{12} X_{22}		C_1n X_{1n}	a_1
S_2	C_{21} X_{21}	C_{22} X_{22}		C_2n X_{2n}	a_2
......Si……				Xmn	……ai……
Sm	C_{m1} X_{m1}	Cm_2 X_{m2}		Cmn Xmn	am
Destination Requirements	b_1	b_1	……bj…..	bn	$\sum ai$ $\sum bi$

That is, each row is labeled with its corresponding source name at the left margin; each column is labeled with its corresponding destination name at the top margin; the supply from each source I is listed at the right margin of the i^{th} row; the demand at destination j^{th} column; the transportation cost C_{ij} is listed in a subcell located at the upper – left corner of cell (i, j); and finally, the value of xij is to be entered at the lower – right corner of cell (i, j).

EMPIRICAL STUDY

The transportation problem formulated for Gimbiya Furniture factory Birnin Kebbi was analyzed using an online software, MODI (Modified Distribution) method and the minimum transportation cost was obtained in 4 iterations as shown below:

INTIAL TABLEAU

	D1	D2	D3	Supply
S1	10000	20000	25000	80
S2	45000	40000	40000	60
Demand	22	17	22	

Iteration 1

	D1	D2	D3	D4	Supply
S1	10000	20000	25000	0	100
S2	45000	40000	40000	0 60	60
Demand	10	20	25	45	

Iteration 2

	D1	D2	D3	D4	Supply
S1	10000	20000	25000	0	100
S2	45000	40000	40000	0 60 45	15
Demand	10	20	25	45	

Iteration 3

	D1	D2	D3	D4	Supply
S1	10000	20000	25000	0	100
S2	45000	40000	40000	0 60 45 15	15
Demand	10	20	25	30	

Iteration 4

	D1	D2	D3	D4	Supply
S1	10000 10	20000 20	25000 25	0 45	100
S2	45000	40000	40000	0 60	60
Demand	10	20	25	105	

Total Minimum Cost

$(10000 \times 10 + 20000 \times 20 + 25000 \times 25 + 0 \times 45 + 0 \times 60)$

1125000

INTERPRETATION OF RESULT

From the result obtained using the modified distribution software, it could be observed that the optimal solution to Gimbiya Furniture Factory Birnin Kebbi is achieved after the fourth iteration. If could be observed from the initial tableau that the problem of Gimbiya Furniture is an unbalanced transportation problem as the total supply exceeds the total demand to solve the problem therefore, a dummy destination is created to handle the excess supply.

At the 4th iteration, an optimal solution was obtained at 10, 20, 25, 45 and 60 yielding the minimum transportation cost of the factory to the 1,125,000 naira. This implies that the minimum amount of money the factory will spend is 1,125,000 naira achieved when the factory transport 10 units of bed from B/K to Jega, 20 units from B/K to Gwandu, 25 units from B/K to the dummy destination created D4 and 60 units from Zuru to the Dummy Destination

CONCLUSION

On the Basic of the results obtained, it can be concluded that the North West Corner Method is better than the Least Cost Method for minimization the cost of transportation for Gimbiya Furniture Factory with the cost of transportation obtained as ₦1,125,000.00.

The computational results provides the minimum total transportation cost and Modified Distribution Method (MODI) was used to check optimality. Using the L P problems by the computer package, the initial basic feasible solution of North West Conner Method and Modified Distribution Method (MODI) provided the valuable information for Gimbiya Furniture Factory, Birnin Kebbi, to make optimal decisions. With the use of mathematical model such as “Transportation Model” the company can easily follow the strategy to its transportation schedule, in order to minimize the cost of transportation of their products.

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