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A TRANSSHIPMENT MINIMIZATION MODEL FOR BUA MANUFACTURING INDUSTRY

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ABSTRACT

Establishing an optimal distribution plan for BUA Cement manufacturing industries has remained a challenge due to the frequent fluctuations of cost of transporting cement. This research revealed a Transportation Optimization Model for cement distribution using Transportation Distance Matrix instead of Transportation Cost Matrix. The study optimized the transportation distance of cement with special interest from two plants namely; Cement Company of Northern Nigeria (Kalambaina, Sokoto) and BUA (Okpella, Edo State) while Sokoto, Kebbi, Zamfara, Kano, Kaduna and Katsina States in Nigeria and as well as Niger Republic were identified as distribution centers. The result of the findings using the Vogel Approximation Method, minimized the total transportation distance and by implication the total transportation costs.

Keywords: *Transsshipment, Minimization Model, Distance Matrix, Supply and Demand*

INTRODUCTION

Since the goal of every business is to make profit, it is therefore imperative for every business to find an optimal way of distributing its product that would minimize cost and subsequently maximize profit. In business, a successful logistics automatically translates to increased efficiencies, higher production rates, reduced cost, better stock control and efficient use of warehouse space(Reference). The transportation models or problems are primarily concerned with the optimal (most accurate) way in which product produced at different factories or plants can be transported to a number of warehouses Aliyu *et al.,* (2019). According to Bowersox (2007) logistics is engaged in a wide range of important activities for the transfer of goods, services and related information. Modern industries rely on the movement of goods from areas of production to locations of demand. Ogwo and Agwu, (2016), stressed the importance of the transportation sector to industrial viability when they asserted that product distribution from point of production to target market must fall within the right time, appropriate quality, expected quantity and right customers. According to Agadaga and Akpan (2019), typical transportation problem deals with the distribution of goods from several points of supply to a number of points of demand. This problem usually arises when a cost-effective pattern is needed to ship/ transport items from origins that have limited supply to destinations that have demand for the goods.

BUA Group possesses a strong capacity in cement manufacturing with 3 major subsidiaries and plants in Northern and Southern Nigeria as well as a 2 million metric tons per annum floating terminal serving niche markets. The Group also holds a stake in Damnaz Cement Company Ltd which is the Majority Shareholder in Cement Company of Northern Nigeria (CCNN). The Group's plants have the capacity to provide various grades of cement as required in the local Nigeria markets and meet the highest standard of cement manufacturing. The BUA cement company is located at Kalambaina (Sokoto state) and Okpela (Edo state) with major distribution centers scattered across Nigeria and beyond. (BUAgroup, 2021). Over the years, there have been challenges of determining an optimal distribution plan from sources (plants) to the various destinations (distribution centers). This paper determines the minimal total transportation distance subject to demand and supply constraints by transshipment minimization model. The study chooses to minimize the total transportation distance instead of the total transportation cost due to variation in transportation cost of transporting a bag of cement from each source to the destinations.

Aliyu *et al.,* (2019) employed a transportation model to find the minimum cost of transporting manufactured bags of cement. The data was modeled using linear programming: The transportation algorithm and used R programming and Tora software in running the models. From the result of the analysis, it was shown that all three methods of initial basic feasible solution (North-West corner method. Least Cost Method and Vogel Approximation Method) gave varying answers. The conclusion is that the Vogel Approximation Method gave a more optimal solution compared to the other two methods. It is worthy to note that this work seeks to improve on the aforementioned research with the introduction of a transportation distance matrix.

Abduljabbar (2013), formulated a transportation optimization model for oil products. The result of his work is the best refinery –to- depots assignments that minimized total transportation distance as well as the total transportation cost. It is important to mention that the use of transportation distance has informed the adoption of the distance matrix in this work.

MATERIALS AND METHODS

For the sake of this work, data sourced from BUA group were utilized. The data showed that the total capacity of supply was 87,700 bags while the quantity demanded from the seven distribution centers were captured as 107,700 bags. As earlier mentioned in this work that obtaining data on cost of transporting cement from each source to each destination has become a challenge, the option left to the researcher was only to make use of transportation distance matrix since cost of transportation can be ascertained to be proportional to the distance covered. This follows the thinking of Abduljabbar (2013). In the light of the above, data on the distance from each source to each destination were sourced from the Nigerian Kilometer map/ distance calculator (Distance Calculator, 2021). The transportation distance matrix was obtained as the actual distance in kilometers of transporting cement from plant (source) to each destination (distribution centers). This is shown in Table 2.

Model Formulation

Using the transportation distance (D_{ij}), the total demand and total supply constraints $\sum b_j$ and $\sum a_i$ respectively, capacity of the truck (V) as well as the number of vehicle trips (X_{ij}) from source i to destination j, we adopt the transportation model of Abduljabaar (2013) in formulating the transportation problem of the BUA cement distribution as a Linear Programming Problem. This is given below;

Minimize:

$$\mathbf{Z} = \sum_{i=1}^{3}\sum_{j=1}^{10} dij\, X_{ij} \qquad (1)$$

Subject to

$$V\sum_{J=1}^{10} X_{ij} = a_i, i = 1,2,3 \qquad (2)$$

(Supply Constraints)

$$V\sum_{i=j}^{3} X_{ij} = b_j, j = 1,2,3,4,\dots,7 \qquad (3)$$

(Demand Constraints)
(Abduljabbar, 2013)

Transportation Tableau

Each cell represents a shipping route. Supply availability (a_i) at each source is shown in the far right column and the destination requirements (b_j) are shown in the bottom row. The transportation distance (D_{ij}) is shown in the upper right corner of each cell, the number of vehicle trips(X_{ij}) is shown below the D_{ij}'s in each cell. We represent the distance from two supply source (1 and 2) to seven demand destination j (1, 2, 3, 4, 5, 6, and 7) as D_{ij} . While X_{ij} is the number of vehicle trips from source i to destination j. The amount of supply at source i is a_i and the amount of demand at destination j is b_j .The objective of the model is to determine the unknowns X_{ij} that will minimize the total transportation distance in delivering cement while satisfying all the supply and demand constraints

Destination → Source ↓	D_1	D_2	...D_J...	D_7	Source Supply
S_1	D_{11} X_{11}	D_{12} X_{12}	...D_{1j}... X_{1j}	... D_{17} X_{17}	a_1
S_2	D_{21} X_{21}	D_{22} X_{22}	...D_{2j}... X_{2j}	... D_{27} X_{27}	a_2
S_3 (Dummy)	D_{31} X_{31}	D_{32} X_{32}	...D_{3j} X_{3j}	D_{37} X_{37}	a_3
Destination	b_1	b_2	b_3 ...	... b_7	

Table 1: The Transportation Tableau

Vogel Approximation Method (VAM)

VAM is an enhance form of the least-cost method that usually, but not often, yields better initial results. VAM is established on the notion of reducing opportunity (or penalty) costs. The opportunity cost for a specified supply row or demand column is defined as the difference between the lowest cost and the next lowest cost alternative. The technique is an iterative process for calculating a basic feasible solution of a transportation problem. According to Taha, 1992, this method is favored over the two methods discussed earlier, because the standing body of literature recognized that the initial basic feasible solution gotten by this method is either optimal or close to the optimal solution. Thus, it was adopted for this work. The Tora Optimization Software was used in the implementation of the Vogel Approximation method.

RESULTS AND DISCUSSION

The transportation distance matrix was obtained as the actual distance in kilometers of transporting cement from plant (source) to each destination (distribution centers). This is shown in Table 2.

DESTINATION SOURCE	SOKOTO	KEBBI	ZAMFARA	KANO	KADUNA	KATSINA	NIGER REPUBLIC	SUPPLY
KALAMBAINA	6	125	148	381	370	261	435	40000
OKPELLA	890	762	766	663	430	745	1164	47700
DUMMY	0	0	0	0	0	0	0	20000
DEMAND	21600	15600	15600	19500	16800	10500	8100	

Table 2: Actual distance in kilometers of transporting cement from plant (source) to each destination (distribution centers).

DESTINATION SOURCE	SOKOTO	KEBBI	ZAMFARA	KANO	KADUNA	KATSINA	NIGER REPUBLIC	SUPPLY
KALAMBAINA	6 **21600**	125 **15600**	148 **2800**	381	370	261	435	40000
OKPELLA	890	762	766 **900**	663 **19500**	430 **16800**	745 **10500**	1164	47700
DUMMY	0	0	0 **11900**	0	0	0	0 **8100**	20000
DEMAND	21600	15600	15600	19500	16800	10500	8100	

Table 3: Optimal Iteration Tableau using the Vogel Approximation Method

Note: *Figures in bold are the optimal numbers of bags of cement*

FROM SOURCE	TO DESTINATION	NUMBER OF BAGS X_{ij}	DISTANCE IN KILOMETER D_{ij}	$X_{ij} * D_{ij}$ (KM)
S1: KALAMBAINA	D1: SOKOTO	21600	6	129600
S1: KALAMBAINA	D2: KEBBI	15600	125	1950000
S1: KALAMBAINA	D3: ZAMFARA	2800	148	414400
S2: OKPELLA	D3: ZAMFARA	900	766	689400
S2: OKPELLA	D4: KANO	19500	663	12928500
S2: OKPELLA	D5: KADUNA	16800	430	7224000
S2: OKPELLA	D6: KATSINA	10500	745	7822500
S3: DUMMY	D3: ZAMFARA	11900	0	0
S3: DUMMY	D7:NIGER REPUBLIC	8100	0	0
TOTAL				31158400

Table 4. The optimal distribution plan for BUA Cement

The transportation distance matrix in Table 2 shows the actual distance of cement transportation from each plant to each destination. It also captures the demand and supply constraints of cement for the plants and destinations respectively. The longest distance (1164km) of cement transportation is from Okpella to Niger Republic while the shortest distance (6km) is from Kalambaina to sokoto. Since the demand does not equal to the supply, there was a need to balance the problem. Hence the creation of a dummy supply point at source 3. The distance matrix contains the actual kilometers by road from each plant to the various destinations. This matrix is used to replace the usual cost matrix employed in transportation problem of this nature. This as earlier stated was done to eliminate the challenges of estimating the cost of transporting a bag of cement due to numerous factors that can cause fluctuation in determining the cost of transporting cement. The researcher considered this replacement adequate since the total cost of transportation is proportional to the distance covered

From the study, the cement company is advised to adopt the optimal cement distribution plan as follows: From the Kalambaina factory 21600, 15600 and 2800 bags of cement should be made to Sokoto, Kebbi and Zamfara distribution centers respectively. From Okpella production plant, 900, 19500, 16800 and 10500 bags should be shipped to Zamfara, Kano, Kaduna and Katsina distribution centers respectively. The dummy variable allocates 11900 and 8100 bags of cement to Zamfara and Niger Republic respectively. See Table 3 for details. This result minimizes the total transportation distance and by implication the total transportation costs

CONCLUSION

The problem of minimizing the total transportation cost of Cement has been modeled as a transportation problem. An optimal distribution plan that will minimize the total transportation distance has been determined in the face of plant (capacity) and destination (demand) constraints. Also, the challenge posed by lack of data on transportation costs from sources to destinations has been overcome by the use of the transportation distance matrix.

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