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Transportation Modeling of Farm Product Distribution: A Case Study of Maizube Farm, Minna, Nigeria

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Abstract—The major objective of this study is to determine an optimal way of transporting specified quantities products manufactured at Maizube Farms complex that minimizes the total transportation cost between the factory, the depots and various customer locations. While the analysis of data was done using the TORA software, the solution was based on the Vogel's Approximation Method (VAM). The result of the analysis shows that the minimized transportation cost of a unit (a carton) of the products carton is N712,800.00, compared to the current cost N849,600.00; representing a 16.10% savings (or N136,800.00). The Management of Maizube Farms Limited is advised to adopt the routes used in this study in order to reduce the overhead (distribution) cost and boost its profit.

Index Terms— Cost, linear programming, logistics, maximization, minimization, supply chain, transport model.

1 Introduction

There are indications that an efficient supply chain not only enhance the competiveness of organizations, but also provides a very good opportunity to reduce the cost of goods sold [1]. Different views have been expressed about what a supply chain is. While Towill *et al.* [2] describe it in terms of flow (distribution) of materials and information; others see it as comprising of dynamically managed networks of procurement and distribution [3], with a view to satisfying the needs of various the stakeholders [4].

According to [5], the integrating philosophy used in managing the total flow of a distribution channel from supplier to the ultimate customer is known as supply chain management (SCM). SCM is a principle that requires a coordinated management of the flow of goods from suppliers to consumers, in a way that satisfies customer service objectives while minimising inventory and related costs [6]. It is in this regard that SCM is seen as offering firms significant opportunities to create strategic advantage and achieve mutually beneficial performance outcome(s) ([7], [8], [9]). Although there are different elements of supply chain management through which this can be achieved, this paper shall, however, concentrate on the distribution (transportation) aspect of supply chain management.

The attainment of mutually beneficial performance outcomes in supply chains as noted earlier is achievable through the optimisation of management as well as operational processes of firms within the chain. Reed *et al.* [10] opine that contemporary supply chain optimisation models are rooted in classic operations research models with the aim of improving these models to include the new areas of interest in production planning, purchasing and logistics. It is in this respect that operations research techniques are increasingly being applied in the optimisation of transportation options and choices with a view to reducing the total cost (in including environmental impact(s) of product(s) or services offered.

The implication of transportation options and choices on cost of product and services has been highlighted variously. While [10] highlight the influence of transportation cost on the final cost of the finished product, [11] note that mode of transportation contributes more to the logistical cost incurred in a supply chain than any other element. For instance, while [12] observes that transportation cost could be as much as a third of the operating cost of a supply chain, [13] believe that transportation cost is about 61.4% of all logistics cost. Therefore, if cost, according to [14] is a key performance measure in the management of a supply chain, then the transportation component of the supply chain must be effectively managed in order to enhance the overall performance of the supply chain [10]. Again, according to [13], product availability is a critical measure of the performance of logistics and the supply chain; and the supply chain being the lifeblood of the corporation , its efficiency and effectiveness in delivering products greatly impact on sales revenue [15].

In many organisations today, a major challenge confronting managers is how best to optimally allocate scarce resources to their various activities or projects. It is in this regard that some aspects of linear programming (LP) come handy. Marriott [16] describes LP as a schedule of actions used to maximise or minimise a linear function of several variables when all, or some of these variables are subjected to constraints that are expressed in linear terms either as equations or inequalities.

Gupta and Hira [17] note that, generally, LP problems can be expressed either in a standard form as follows:

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$$Maximise\ (or\ minimise) Z = \sum_{j=1}^{n} c_j\, x_j, \qquad (1)$$

$$subject\ to \quad \sum_{j=1}^{n} a_{ij}\, x_j = b_i, i = 1, 2, 3, \ldots, m,$$

$$x_j \geq 0, j = 1, 2, \ldots, n,$$

$$and \quad b_i \geq 0.$$

or in a matrix-vector form,

$$Maximise\ (or\ minimise) Z = cx,$$

$$subject\ to \quad Ax = b,$$

$$x \geq 0,$$

$$b \geq 0,$$

An optimal solution to an LP problem is only possible if carried out with certain requirements and assumptions ([18], [17]) and could be achieved through several methods such as the Simplex method and Transportation Model [17]. However, although the Simplex method could be applied to any LP problem for which there exists a solution, computation using this method becomes more burdensome as the number of variables and constraints increase; hence the preference for the distribution or transportation method or model [17].

2 TRANSPORTATON PROBLEMS

A transportation problem is a class of linear programming problems about networks, in which an attempt is made to minimize the cost of delivering integral quantities of goods produced at a given plant(s) to given outlets while balancing supply and demand [19]. The objective of the transportation model is to minimize the cost associated with the transportation of goods from points of supply to a number of different destinations, in a way that satisfies destination requirement(s) within plant capacity limits [20]. Sivarethinamohan [20] notes that for a given supply (S_i), demand (D_j), and cost (C_{ij}), a transportation problem can be put in a standard form:

$$Minimise: \sum_{i=1}^{m}\sum_{j=1}^{n} X_{ij}\, C_{ij}$$

$$subject\ to: \sum^{n} X_{ij} \leq S_i \qquad for\ i = 1, 2, 3, \ldots, m \quad (supply)$$

$$\sum^{m} X_{ij} \leq D_i \qquad for\ j = 1, 2, 3, \ldots, n \quad (demand)$$

$$X_{ij} \geq 0 \qquad for\ all\ i\ and\ j$$

$S_i = a_i$ = quantity of commodity available at origin, i; $D_i = b_i$ = quantity of commodity needed at source, j; C_{ij} = cost of transporting one unit of commodity from origin i to destination to destination j; X_{ij} = cost of transporting one unit of commodity from origin i to destination to destination j

The formulation of any transportation problem is predicated on a clear indication of the quantity of a product that the plant can supply in a given period (i.e. capacities or supplies); the level or forecast of demand (or requirements); as well as unit cost (shipping and possibly production).

Existing works suggest that two types of transportation problems – the balanced transportation problem and unbalanced transportation problem – exist. According to [20],

i) in a balanced transportation problem, the total supply equals total demand:

$$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_j$$

ii) whereas in an unbalanced transportation problem, total supply is not equal to total demand requirement

$$\sum_{i=1}^{m} S_i \neq \sum_{j=1}^{n} D_j$$

When $\sum_{i=1}^{m} S_i \geq \sum_{j=1}^{n} D_j$, a dummy destination is created to absorb the excess supply; but if $\sum_{i=1}^{m} S_i \leq \sum_{j=1}^{n} D_j$, a dummy source is created to absorb the excess demand [20].

The solution to a linear programming problem using the transportation model or problem is guided by certain assumptions. For instance, there are observations that a transportation problem must satisfy the requirement condition (each source having a fixed supply of units, and each destination having a fixed demand for units); cost assumption which states that the cost of distributing a product from a source to a destination is directly proportional to the number of units distributed; a feasibility solution property such that for a destination (j), source (i), demand (d), supply (s) then,

$$\sum_{i=1}^{m} s_i = \sum_{j=1}^{n} d_j$$

3 MATERIALS AND METHODS

3.1 Materials

Maizube Farms Limited produces yoghurt and fruit juice in Minna, Niger State, Nigeria. Between August 2013 and July 2014, a total number of 144,000 cartons of yoghurt and 115,200 cartons of fruit juice were produced by the company. The average quantity of the products supplied to depots and warehouses are shown on **Table 1**, while **Table 2** shows the quantities of the products demanded by customers.

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TABLE 1

QUANTITY SUPPLIED FROM FACTORY TO DEPOTS

S/N	Quantity supplied (in cartons per year)			Total
	Depots	Yoghurt	Juice	
1	Minna	7,200	7,200	14,400
2	Kaduna	8,640	5,760	14,400
3	Abuja (1)	4,800	4,800	9,600
4	Abuja (2)	11,520	7,680	19,200
	Total	32,160	25,440	57,600

TABLE 2

QUANTITY DEMANDED BY CUSTOMERS FROM DEPOTS

S/N	Quantity demanded (in cartons per year)			Total
	Customers	Yoghurt	Juice	
1	Zungeru	960	960	1,920
2	Bida	480	720	1,200
3	Tunga	960	1,440	2,400
4	Central market	1,440	1,440	2,880
5	Sabo	1,440	960	2,400
6	Amigo	1,440	960	2,400
7	Next	1,920	960	2,880
8	Park & shop	1,200	1,200	2,400
9	Ceddi plaza	1,440	960	2,400
10	Grand square	1,440	1,440	2,880
	Total	2,720	11,040	23,760

The cost of transporting a carton of product from the factory (source) to various depots and customers (destination) range between ₦10 and ₦172, as shown on **Tables 3** and **4** below.

TABLE 3

TRANSPORTATION COST/CARTON FROM FACTORY TO DEPOTS (₦)

Factory	Depots			
Maizube	Minna	Kaduna	Abuja (1)	Abuja (2)
farm	10	30	25	15

TABLE 4

TRANSPORTATION COSTS/CARTON FROM DEPOTS TO CUSTOMERS (₦)

Depots	Zungeru	Bida	Tunga	Central market	Sabo	Amigo	Next Stores	Park & shop	Ceddi plaza	Grand square
Minna	25	80	20	20	84	86	71	84	84	70
Kaduna	105	168	84	20	20	60	50	48	48	40
Abuja (1)	107	172	86	50	60	40	30	60	60	50
Abuja (2)	105	168	84	40	48	60	50	24	25	20

3.2 Method

Both primary and secondary data were used in the research. While the primary data was collected using questionnaires and interviews (face to face as well as through telephone conversations), secondary data came from existing records about the company. The respondents were drawn from Maizube Farms as well as their customers (buyers) employees (supervisors, drivers, store keepers etc.) of the producing company as well as the buying companies.

The solution to a transportation problem could be found using methods such as the Least Cost Rule, North-West Corner Rule, Simplex Method, Vogel's Approximation Method among others. For instance, [21] used the least cost rule method to determine the optimal allocation of shipments (least cost) of two manufactured products between depots and places of consumption. For this study, the Vogel's Approximation Method (VAM) has been chosen because its iterations are more effective and not bourgeois like others. This model determines the initial solution and a feasible solution which must satisfy all the supply and demand constraints, with a view to determining the optimal allocation of limited resources to meet given objectives. Tora software version 2.0 was used in the analysis.

4 FORMULATION OF TRANSPORTATON MODEL

The transportation problem is shown schematically in **Figure 1** below.

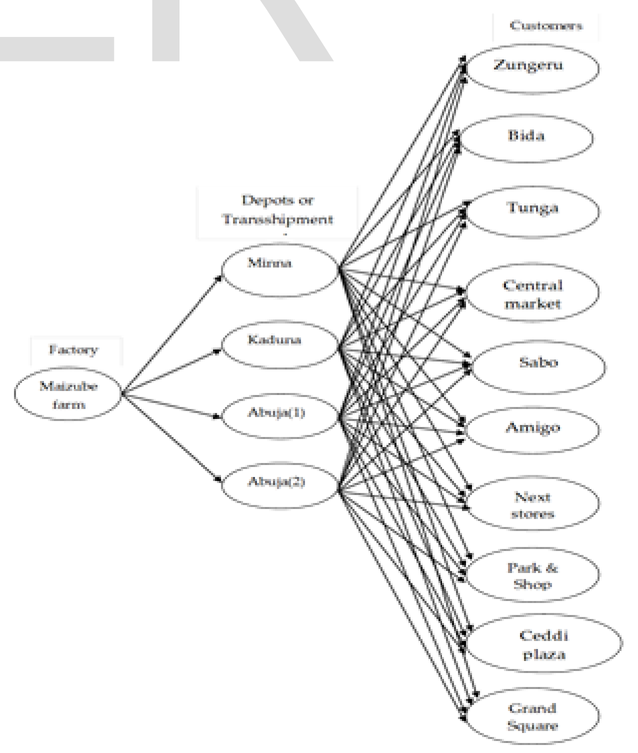

Fig. 1. Maizube farm product distribution network

For the above distribution network, let the factory or source of

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supply i (i = 1, 2, 3……, m) produce a_i units, and the destination j (j = 1, 2, 3,….., n) require b_j units. The cost of transportation from factory i to warehouse j is C_{ij}. The decision variable of this problem will be X_{ij}, which is the transportation cost from factory i to warehouse j. Thus:

X_{ij} = number of juice and yoghurt produced in a year i for ssupply in a year j
C_{ij} = transportation cost associated with each unit of X_{ij}
b_j = number of scheduled for supply in a year j
a_i = production of juice and yoghurt in a year i

The general transportation problem is guven as:

Objective Function

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

Subject to constraints

$$\sum_{j=1}^{n} Xij = \mathrm{ai},\ i = 1, 2, \ldots, m$$

$$\sum_{i=1}^{m} Xij = \mathrm{bj},\ j = 1, 2, \ldots, n$$

and $Xij \geq 0$ for all i and j

Z= Objective that minimized transportation cost;
a_i = number of units being supplied by source i;
b_j = number of units being received by destination j;
C_{ij} = cost per unit distributed from source i to destination j;
X_{ij} = amount distributed from source i to destination j

4.1 Formulation of Maizube Farm Problem

The transportation problem stated in Section 4.0 above could be summarised in a transportation matrix as shown in **Table 5** below.

TABLE 5

TRANSPORTATION MATRIX OF PRODUCT DISTRIBUTION

Aggregating the information contained on Tables 1 to 5 above, the transportation problem could be specified as:

$$\text{Minimise } Z = 10x_{11}+25x_{12}+80x_{13}+20x_{14}+20x_{15}+84x_{16}+86x_{17}+71x_{18}+84x_{19}+84x_{1,10}+70x_{1,11}$$
$$30x_{21}+105x_{22}+168x_{23}+84x_{24}+20x_{25}+20x_{26}+60x_{27}+50x_{28}+48x_{29}+48x_{2,10}+40x_{2,11}$$
$$25x_{31}+107x_{32}+172x_{33}+86x_{34}+50x_{35}+60x_{36}+40x_{17}+30x_{38}+60x_{39}+60x_{3,10}+50x_{3,11}$$
$$15x_{41}+105x_{42}+168x_{43}+84x_{44}+40x_{45}+48x_{46}+60x_{47}+50x_{48}+24x_{49}+25x_{4,10}+20x_{4,11}$$

Subject to:

Capacity constraints

$$x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{1,10}+x_{1,11} \leq 14400$$
$$x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}+x_{28}+x_{29}+x_{2,10}+x_{2,11} \leq 14400$$
$$x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{17}+x_{38}+x_{39}+x_{3,10}+x_{3,11} \leq 9600$$
$$x_{41}+x_{42}+x_{43}+x_{44}+x_{45}+x_{46}+x_{47}+x_{48}+x_{49}+x_{4,10}+x_{4,11} \leq 19200$$

Demand constraints

$$x_{11}+x_{21}+x_{31}+x_{41}=1920$$
$$x_{12}+x_{22}+x_{32}+x_{42}=1200$$
$$x_{13}+x_{23}+x_{33}+x_{43}=2400$$
$$x_{14}+x_{24}+x_{34}+x_{44}=2880$$
$$x_{15}+x_{25}+x_{35}+x_{45}=2400$$
$$x_{16}+x_{26}+x_{36}+x_{46}=2400$$
$$x_{17}+x_{27}+x_{37}+x_{47}=2880$$
$$x_{18}+x_{28}+x_{38}+x_{48}=2400$$
$$x_{19}+x_{29}+x_{39}+x_{49}=2400$$
$$x_{1,10}+x_{2,10}+x_{3,10}+x_{4,10}=2800$$

and

$$x_{11}, x_{12}, x_{13} \ldots x_{1,11} \geq 0$$

TABLE 6

TRANSPORTATION COST FROM DEPOTS TO CUSTOMERS (₦)

Supply/ demand	Zungeru	Bida	Tunga	Central market (Kaduna)	Sabo (Kaduna)	Amigo stores	Next stores	Park & Shop	Ceddi plaza	Grand square	supply
Minna	25	80	20	70	84	84	71	84	84	70	14,400
Kaduna	105	168	86	20	20	60	50	48	48	40	14,400
Abuja(1)	107	172	86	50	60	40	30	60	60	50	9,600
Abuja(2)	105	168	84	40	48	60	50	24	25	20	19,200
Demand	1,920	1,200	2,400	2,880	2,400	2,400	2,880	2,400	2,400	2,880	-

4.2 Data Analysis

After three iterations (3) of the data using the Vogels approximation method, a transportation cost of ₦818,400.00 was got after the first iteration, ₦760,800.00 at the end of the second iteration 2 and ₦712,800.00 after the third iteration. The transportation model tableaus of these are presented on **Tables 7, 8, and 9** below, while the output summary of the iteration that yielded the minimum transported cost (N712,800.00) is shown on **Table 10.**

TABLE 7

TRANSPORTATION COST AFTER ITERATION 1

	Names		D1 Zungeru v1=25.00	D2 Bida v2=80.00	D3 Tunga v3=20.00	D4 Central Market v4=40.00	D5 Sabo v5=20.00	D6 Amigo v6=60.00	D7 Next Stores v7=50.00	D8 Park & Shop v8=24.00	D9 Ceddi Plaza v9=25.00	D10 Grand Square v10=20.00	D11 Dummy v11=0.00	supply
S1	Minna	u1=0.00	25.00 **1920** 0.00	80.00 **1200** 0.00	20.00 **2400** 0.00	70.00 -30.00	84.00 -64.00	86.00 -26.00	71.00 -21.00	84.00 -60.00	84.00 -59.00	70.00 -50.00	0.00 **8880** 0.00	**14400**
S2	Kaduna	u2=0.00	105.00 -80.00	168.00 -88.00	84.00 -64.00	20.00 20.00	20.00 **2400** 0.00	50.00 10.00	50.00 0.00	48.00 -24.00	48.00 -23.00	40.00 -20.00	0.00 **12000** 0.00	**14400**
S3	Abuja(1)	u3=0.00	107.00 -82.00	172.00 -92.00	84.00 -64.00	50.00 -10.00	60.00 -40.00	40.00 20.00	80.00 -30.00	60.00 -36.00	60.00 -35.00	50.00 -30.00	0.00 **9600** 0.00	**9600**
S4	Abuja(2)	u4=0.00	105.00 -80.00	168.00 -88.00	84.00 -64.00	40.00 **2880** 0.00	48.00 -28.00	60.00 **2400** 0.00	50.00 **2880** 0.00	24.00 **2400** 0.00	25.00 **2400** 0.00	20.00 **2880** 0.00	0.00 **3360** 0.00	**19200**
	Demand		1920	1200	2400	2880	2400	2400	2880	2400	2400	2880	33840	

Total cost (Objective value) = ₦818,400.00

TABLE 8

TRANSPORTATION COST AFTER ITERATION 2

	Names		D1 Zungeru v1=25.00	D2 Bida v2=80.00	D3 Tunga v3=20.00	D4 Central Market v4=20.00	D5 Sabo v5=20.00	D6 Amigo v6=60.00	D7 Next Stores v7=50.00	D8 Park & Shop v8=24.00	D9 Ceddi v9=25.00	D10 Grand Square v10=20.00	D11 Dummy v11=0.00	supply
S1	Minna	u1=0.00	25.00 **1920** 0.00	80.00 **1200** 0.00	20.00 **2400** 0.00	70.00 -50.00	84.00 -64.00	86.00 -21.00	71.00 -21.00	84.00 -60.00	84.00 -59.00	70.00 -50.00	0.00 **8880** 0.00	**14400**
S2	Kaduna	u2=0.00	105.00 -80.00	168.00 -88.00	84.00 -64.00	20.00 **2880** 00.00	20.00 **2400** 0.00	50.00 10.00	50.00 0.00	48.00 -24.00	48.00 -23.00	40.00 -20.00	0.00 **9120** 0.00	**14400**
S3	Abuja(1)	u3=0.00	107.00 -82.00	172.00 -92.00	86.00 -66.00	50.00 -30.00	60.00 -40.00	40.00 20.00	80.00 -30.00	60.00 -36.00	60.00 -35.00	50.00 -30.00	0.00 **9600** 0.00	**9600**
S4	Abuja(2)	u4=0.00	105.00 -80.00	168.00 -88.00	84.00 -64.00	40.00 -20.00	48.00 -28.00	60.00 **2400** 0.00	50.00 **2880** 0.00	24.00 **2400** 0.00	25.00 **2400** 0.00	20.00 **2880** 0.00	0.00 **6240** 0.00	**19200**
	Demand		1920	1200	2400	2880	2400	2400	2880	2400	2400	2880	33840	

Total cost (Objective value) = ₦760800.00

TABLE 9

TRANSPORTATION COST AFTER ITERATION 3

	Names		D1 Zungeru v1=25.00	D2 Bida v2=80.00	D3 Tunga v3=20.00	D4 Central Market v4=20.00	D5 Sabo v5=20.00	D6 Amigo v6=40.00	D7 Next Stores v7=50.00	D8 Park & Shop v8=24.00	D9 Ceddi Plaza v9=25.00	D10 Grand Square v10=20.00	D11 Dummy v11=0.00	supply
S1	**Minna**	u1=0.00	25.00 / **1920** / 0.00	80.00 / **1200** / 0.00	20.00 / **2400** / 0.00	70.00 / -50.00	84.00 / -64.00	86.00 / -46.00	71.00 / -21.00	84.00 / -60.00	84.00 / -59.00	70.00 / -50.00	0.00 / **8880** / 0.00	**14400**
S2	**Kaduna**	u2=0.00	105.00 / -80.00	168.00 / -88.00	84.00 / -64.00	20.00 / **2880** / 0.00	20.00 / **2400** / 0.00	50.00 / -10.00	50.00 / 0.00	48.00 / -24.00	48.00 / -23.00	40.00 / -20.00	0.00 / **9120** / 0.00	**14400**
S3	**Abuja(1)**	u3=0.00	107.00 / -82.00	172.00 / -92.00	86.00 / -66.00	50.00 / -30.00	60.00 / -40.00	40.00 / **2400** / 0.00	80.00 / -30.00	60.00 / -36.00	60.00 / -35.00	50.00 / -30.00	0.00 / **7200** / 0.00	**9600**
S4	**Abuja(2)**	u4=0.00	105.00 / -80.00	168.00 / -88.00	84.00 / -64.00	40.00 / -20.00	48.00 / -28.00	60.00 / -20.00	50.00 / **2880** / 0.00	24.00 / **2400** / 0.00	25.00 / **2400** / 0.00	20.00 / **2880** / 0.00	0.00 / **8640** / 0.00	**19200**
	Demand		**1920**	**1200**	**2400**	**2880**	**2400**	**2400**	**2880**	**2400**	**2400**	**2880**	**33840**	

Total cost (Objective value) = ₦712800.00

TABLE 10

LEAST RANSPORTATION COST OUTPUT SUMMARY

From	To	Quantity Shipped	Objective Coefficient (₦)	Objective Contribution (₦)
S1: Minna	D1: Zungeru	1920	25.00	48000.00
S1: Minna	D2: Bida	1200	80.00	96000.00
S1: Minna	D3: Tunga	2400	20.00	48000.00
S1: Minna	D11: Dummy	8880	0.00	0.00
S2: Kaduna	D4: Central Market	2880	20.00	57600.00
S2:Kaduna	D5: Sabo	2400	20.00	48000.00
S2: Kaduna	D11: Dummy	9120	0.00	0.00
S3: Abuja (1)	D6: Amigo	2400	40.00	96000.00
S3: Abuja (1)	D11: Dummy	7200	0.00	0.00
S4: Abuja (2)	D7: Next Stores	2880	50.00	144000.00
S4: Abuja (2)	D8: Park & Shop	2400	24.00	57600.00
S4: Abuja (2)	D9: Ceddi Plaza	2400	25.00	60000.00
S4: Abuja (2)	D10: Grand Square	2880	20.00	57600.00
S4: Abuja (2)	D11: Dummy	8640	0.00	0.00
	Total Minimum Cost			712800.00

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5 Discussion Of Result

The information contained on Table 10 (the summary of the transportation model output) shows that the total minimal cost of transporting the product from the depots to the various destinations is ₦712,800.00. From Table 9, it could be seen that the depots have surpluses after supplying the quantity of products demanded by the customers. For instance, Minna depot has a surplus of 8,880 cartons of the product after supplies; 9,120 cartons for Kaduna depot; 7,200 cartons for Abuja (1) depot; 8,640 units for the Abuja (2) depot. Consequently, as the demand from customers is less than the stocks, dummy variables were introduced to balance the transportation model of the factory. The result shown above is suggests that Minna depot is the most cost-effective point for Zungeru, Bida and Tunga customers.

From the results obtained, the minimized objective of the overall transportation cost per carton of the products to the depots and customers is ₦712,800.00 against an original transportation cost of ₦849,600.00, thus saving Maizube Farms about ₦ 136,800.00 from transportation cost of their products.

6 Conclusion

The research explored the transportation model of optimization to solve the physical distribution problem of finished products from several depots (destination) in order to get a minimum cost (optimal) for distributing the products of the company. The transportation problem was formulated as a linear programming problem, and solved sing Tora 2.0 version software to obtain the optimal solution, using Vogel's approximation method (VAM). Product distribution management from the factory to different destinations was studied to arrive at a certain result that would simultaneously increase the company's profit and enhance the cost minimization approach. This was with a view to finding the optimal allocation in transporting two manufactured products from the factory to different destinations.

It is anticipated that the solution provided is necessary due to the high operating costs associated with physical distribution when deliveries are not properly planned. Significantly, savings can be achieved by using techniques developed for determining the cheapest methods of transporting goods from several origins to different destinations. It is therefore recommended that the management of Maizube Farms Limited should integrate operation research techniques in their decision making processes (including logistics and production processes). There is also a need to pay more attention to re-order levels in order to avoid surplus supplies which can lead to deficit in the future. There is equally a need for rational decisions on the transportation costs associated with each depot, using this outcome of this study as a guide.

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