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

James I. Galadima, J. David, Obioma R. Nwaogbe, Victor Omoke, Ikechukwu A. Diugwu

Abstract—The major objective of this study is to determine an optimal way of transporting specified quantities of 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 of 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 enhances the competitiveness 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 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 (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 organizations 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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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 (\( d \)), source (\( s \)), demand (\( D \)), and cost (\( C \)), a transportation problem can be put in a standard form:

**2 TRANSPORTATION 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]. Sivarethiamohan [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:

\[
\text{Minimise:} \sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij} C_{ij} \\
\text{subject to:} \sum_{j=1}^{n} X_{ij} \leq S_i \quad \text{for } i = 1, 2, 3, ..., m \quad \text{(supply)} \\
\sum_{i=1}^{m} X_{ij} \leq D_j \quad \text{for } j = 1, 2, 3, ..., n \quad \text{(demand)} \\
X_{ij} \geq 0 \quad \text{for all } i \text{ and } j
\]

\( S_i = a \) = quantity of commodity available at origin, \( i \); \( D_j = b \) = quantity of commodity needed at source, \( j \); \( C_{ij} \) = cost of transporting one unit of commodity from origin \( i \) to destination \( j \); \( X_{ij} \) = cost of transporting one unit of commodity from origin \( i \) to destination \( j \).
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 1
**Quantity Supplied from Factory to Depots**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Depots</th>
<th>Yogurt (in cartons per year)</th>
<th>Juice (in cartons per year)</th>
<th>Total (in cartons per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minna</td>
<td>7,200</td>
<td>7,200</td>
<td>14,400</td>
</tr>
<tr>
<td>2</td>
<td>Kaduna</td>
<td>8,640</td>
<td>5,760</td>
<td>14,400</td>
</tr>
<tr>
<td>3</td>
<td>Abuja (1)</td>
<td>4,800</td>
<td>4,800</td>
<td>9,600</td>
</tr>
<tr>
<td>4</td>
<td>Abuja (2)</td>
<td>11,520</td>
<td>7,680</td>
<td>19,200</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>32,160</td>
<td>25,440</td>
<td>57,600</td>
</tr>
</tbody>
</table>

### Table 2
**Quantity Demanded by Customers from Depots**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Customers</th>
<th>Yogurt (in cartons per year)</th>
<th>Juice (in cartons per year)</th>
<th>Total (in cartons per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zungeru</td>
<td>960</td>
<td>960</td>
<td>1,920</td>
</tr>
<tr>
<td>2</td>
<td>Bida</td>
<td>480</td>
<td>720</td>
<td>1,200</td>
</tr>
<tr>
<td>3</td>
<td>Tunga</td>
<td>960</td>
<td>1,440</td>
<td>2,400</td>
</tr>
<tr>
<td>4</td>
<td>Central market</td>
<td>1,440</td>
<td>1,440</td>
<td>2,880</td>
</tr>
<tr>
<td>5</td>
<td>Sabo</td>
<td>1,440</td>
<td>960</td>
<td>2,400</td>
</tr>
<tr>
<td>6</td>
<td>Amigo</td>
<td>1,440</td>
<td>960</td>
<td>2,400</td>
</tr>
<tr>
<td>7</td>
<td>Next</td>
<td>1,920</td>
<td>960</td>
<td>2,880</td>
</tr>
<tr>
<td>8</td>
<td>Park &amp; shop</td>
<td>1,200</td>
<td>1,200</td>
<td>2,400</td>
</tr>
<tr>
<td>9</td>
<td>Ceddi plaza</td>
<td>1,440</td>
<td>960</td>
<td>2,400</td>
</tr>
<tr>
<td>10</td>
<td>Grand square</td>
<td>1,440</td>
<td>1,440</td>
<td>2,880</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,720</td>
<td>11,040</td>
<td>23,760</td>
</tr>
</tbody>
</table>

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 (₦)**

<table>
<thead>
<tr>
<th>Factory</th>
<th>Depots</th>
<th>Yogurt</th>
<th>Juice</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maizube farm</td>
<td>Minna</td>
<td>10</td>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

### Table 4
**Transportation Costs/Carton from Depots to Customers (₦)**

<table>
<thead>
<tr>
<th>Depots</th>
<th>Zungeru</th>
<th>Bida</th>
<th>Tunga</th>
<th>Central</th>
<th>Sabo</th>
<th>Amigo</th>
<th>Next</th>
<th>Park &amp; shop</th>
<th>Ceddi plaza</th>
<th>Grand Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minna</td>
<td>25</td>
<td>80</td>
<td>20</td>
<td>20</td>
<td>84</td>
<td>86</td>
<td>71</td>
<td>84</td>
<td>84</td>
<td>70</td>
</tr>
<tr>
<td>Kaduna</td>
<td>105</td>
<td>168</td>
<td>84</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td>50</td>
<td>48</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>Abuja (1)</td>
<td>107</td>
<td>172</td>
<td>86</td>
<td>50</td>
<td>60</td>
<td>40</td>
<td>30</td>
<td>60</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>Abuja (2)</td>
<td>105</td>
<td>168</td>
<td>84</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td>50</td>
<td>24</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

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 Transportation Model

The transportation problem is shown schematically in Figure 1 below.
supply \( i (i = 1, 2, 3, \ldots, m) \) produce \( a_i \) units, and the destination \( j (j = 1, 2, 3, \ldots, n) \) 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:

\[
X_{ij} = \text{number of juice and yoghurt produced in a year } i \text{ for supply in a year } j
\]

\[
C_{ij} = \text{transportation cost associated with each unit of } X_{ij}
\]

\[
b_j = \text{number of scheduled for supply in a year } j
\]

\[
a_i = \text{production of juice and yoghurt in a year}
\]

The general transportation problem is given as:

**Objective Function**

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

**Subject to constraints**

\[
\sum_{i=1}^{n} X_{ij} = a_i, i = 1, 2, \ldots, m
\]

\[
\sum_{j=1}^{m} X_{ij} = b_j, j = 1, 2, \ldots, n
\]

\[
\text{and } X_{ij} \geq 0 \text{ for all } i \text{ and } j
\]

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

**Minimise**

\[
Z = 10x_{11} + 25x_{12} + 80x_{13} + 20x_{14} + 20x_{15} + 84x_{16} + 86x_{17} + 71x_{18} + 84x_{19} + 84x_{21,1} + 70x_{1,11}
\]

\[
30x_{21} + 105x_{22} + 168x_{23} + 84x_{24} + 20x_{25} + 20x_{26} + 60x_{27} + 50x_{28} + 48x_{29} + 48x_{2,10} + 40x_{2,11}
\]

\[
25x_{31} + 107x_{32} + 172x_{33} + 86x_{34} + 50x_{35} + 60x_{36} + 40x_{37} + 30x_{38} + 60x_{39} + 60x_{3,10} + 50x_{3,11}
\]

\[
15x_{41} + 105x_{42} + 168x_{43} + 84x_{44} + 40x_{45} + 48x_{46} + 60x_{47} + 50x_{48} + 24x_{49} + 25x_{4,10} + 20x_{4,11}
\]

**Subject to:**

**Capacity constraints**

\[
x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} + x_{19} + x_{1,10} + x_{1,11} \leq 14400
\]

\[
x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} + x_{28} + x_{29} + x_{2,10} + x_{2,11} \leq 14400
\]

\[
x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + x_{38} + x_{39} + x_{3,10} + x_{3,11} \leq 9600
\]

\[
x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} + x_{48} + x_{49} + x_{4,10} + x_{4,11} \leq 19200
\]

**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

\[
x_{11,1} \cdots x_{1,11} \geq 0
\]
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 (₦712,800.00) is shown on Table 10.

<table>
<thead>
<tr>
<th>Names</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
<th>D7</th>
<th>D8</th>
<th>D9</th>
<th>D10</th>
<th>D11 Dummy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minna</td>
<td>280</td>
<td>64</td>
<td>20</td>
<td>72</td>
<td>30</td>
<td>20</td>
<td>168</td>
<td>84</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>Kaduna</td>
<td>86</td>
<td>168</td>
<td>30</td>
<td>20</td>
<td>168</td>
<td>84</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>Abuja(1)</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Abuja(2)</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
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<td>200</td>
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</tr>
</tbody>
</table>

Total cost (Objective value) = ₦818,400.00

<table>
<thead>
<tr>
<th>Names</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<th>D6</th>
<th>D7</th>
<th>D8</th>
<th>D9</th>
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<td>240</td>
<td>240</td>
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<tr>
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<td>200</td>
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</tbody>
</table>

Total cost (Objective value) = ₦760,800.00

<table>
<thead>
<tr>
<th>Names</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
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<th>D6</th>
<th>D7</th>
<th>D8</th>
<th>D9</th>
<th>D10</th>
<th>D11 Dummy</th>
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<td>200</td>
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<td>200</td>
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</tr>
<tr>
<td>Abuja(2)</td>
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<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
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</tr>
</tbody>
</table>

Total cost (Objective value) = ₦712,800.00
TABLE 9
TRANSPORTATION COST AFTER ITERATION 3

<table>
<thead>
<tr>
<th>Names</th>
<th>D1 Zungeru v1=25.00</th>
<th>D2 Bida v2=80.00</th>
<th>D3 Tunga v3=20.00</th>
<th>D4 Central Market v4=20.00</th>
<th>D5 Sabo v5=20.00</th>
<th>D6 Amigo v6=40.00</th>
<th>D7 Next Stores v7=50.00</th>
<th>D8 Park &amp; Shop v8=24.00</th>
<th>D9 Ceddi Plaza v9=25.00</th>
<th>D10 Grand Square v10=20.00</th>
<th>D11 Dummy v11=0.00</th>
<th>supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Minna</td>
<td>u1=0.00</td>
<td>25.00</td>
<td>80.00</td>
<td>20.00</td>
<td>-50.00</td>
<td>84.00</td>
<td>86.00</td>
<td>-21.00</td>
<td>-59.00</td>
<td>70.00</td>
<td>0.00</td>
<td>8880</td>
</tr>
<tr>
<td>S2 Kaduna</td>
<td>u2=0.00</td>
<td>105.00</td>
<td>168.00</td>
<td>20.00</td>
<td>-46.00</td>
<td>50.00</td>
<td>50.00</td>
<td>-23.00</td>
<td>40.00</td>
<td>0.00</td>
<td>9120</td>
<td>0.00</td>
</tr>
<tr>
<td>S3 Abuja(1)</td>
<td>u3=0.00</td>
<td>107.00</td>
<td>172.00</td>
<td>60.00</td>
<td>-10.00</td>
<td>60.00</td>
<td>60.00</td>
<td>-20.00</td>
<td>50.00</td>
<td>0.00</td>
<td>7200</td>
<td>0.00</td>
</tr>
<tr>
<td>S4 Abuja(2)</td>
<td>u4=0.00</td>
<td>105.00</td>
<td>168.00</td>
<td>20.00</td>
<td>-20.00</td>
<td>50.00</td>
<td>50.00</td>
<td>-20.00</td>
<td>20.00</td>
<td>0.00</td>
<td>8640</td>
<td>0.00</td>
</tr>
<tr>
<td>Demand</td>
<td>1920</td>
<td>1200</td>
<td>2400</td>
<td>2880</td>
<td>2400</td>
<td>2880</td>
<td>2400</td>
<td>2880</td>
<td>2400</td>
<td>2880</td>
<td>33840</td>
<td></td>
</tr>
</tbody>
</table>

Total cost (Objective value) = ₦712800.00

TABLE 10
LEAST RANSPORTATION COST OUTPUT SUMMARY

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Quantity Shipped</th>
<th>Objective Coefficient (₦)</th>
<th>Objective Contribution (₦)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Minna</td>
<td>D1: Zungeru</td>
<td>1920</td>
<td>25.00</td>
<td>480000.00</td>
</tr>
<tr>
<td>S1 Minna</td>
<td>D2: Bida</td>
<td>1200</td>
<td>80.00</td>
<td>960000.00</td>
</tr>
<tr>
<td>S1 Minna</td>
<td>D3: Tunga</td>
<td>2400</td>
<td>20.00</td>
<td>480000.00</td>
</tr>
<tr>
<td>S1 Minna</td>
<td>D11: Dummy</td>
<td>8880</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>S2: Kaduna</td>
<td>D4: Central Market</td>
<td>2880</td>
<td>20.00</td>
<td>576000.00</td>
</tr>
<tr>
<td>S2: Kaduna</td>
<td>D5: Sabo</td>
<td>2400</td>
<td>20.00</td>
<td>480000.00</td>
</tr>
<tr>
<td>S2: Kaduna</td>
<td>D11: Dummy</td>
<td>9120</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>S3: Abuja (1)</td>
<td>D6: Amigo</td>
<td>2400</td>
<td>40.00</td>
<td>960000.00</td>
</tr>
<tr>
<td>S3: Abuja (1)</td>
<td>D11: Dummy</td>
<td>7200</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>S4: Abuja (2)</td>
<td>D7: Next Stores</td>
<td>2880</td>
<td>50.00</td>
<td>1440000.00</td>
</tr>
<tr>
<td>S4: Abuja (2)</td>
<td>D8: Park &amp; Shop</td>
<td>2400</td>
<td>24.00</td>
<td>576000.00</td>
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<tr>
<td>S4: Abuja (2)</td>
<td>D9: Ceddi Plaza</td>
<td>2400</td>
<td>25.00</td>
<td>600000.00</td>
</tr>
<tr>
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<td>D10: Grand Square</td>
<td>2880</td>
<td>20.00</td>
<td>576000.00</td>
</tr>
<tr>
<td>S4: Abuja (2)</td>
<td>D11: Dummy</td>
<td>8640</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total Minimum Cost = ₦712800.00
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 supplying the quantity of 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 using 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 reorder 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.

REFERENCES