Transportation Algorithm with Volume Discount on Distribution Cost (A Case Study of the Nigerian Bottling Company Plc Owerri Plant)

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Abstract This study is focused on the Application of Transportation Algorithm with volume Discount on distribution cost using Nigerian Bottling Company Plc Owerri Plant. This paper is intended to determine the quantity of Fanta (in crates), Coke (in crates) and Sprite (also in crates) that the Company should distribute in a month in order to minimize transportation cost and maximize profit. A problem of this nature was identified as a Nonlinear Transportation Problem (NTP), formulated in mathematical terms and solved by the Karush-Kuhn-Tucker (KKT) optimality condition for the NTP. A statistical software package was used to obtain the initial basic feasible solution using the Least Cost Method. Thus, analysis revealed that the optimal solution that gave minimum achievable cost of supply was the supply of 5000 crates of Fanta and 6000 crates of the same product to Umuahia market zone and Afikpo respectively. 7000 crates of Coke, 9000 crates and 1000 crates of the same product should be supplied to Orlu, Mbaise, and Afikpo market zones respectively. 6000, and 5000 crates of Sprite should be allocated to Mbaise and Umuahia market zones respectively, at a total cost of N377,000.

Keywords: Karush-Kuhn-Tucker, nonlinear transportation, volume discount, concave cost


1. Introduction

When considering transportation, various considerations are apparent. This consideration includes port selection, inland movement, and port to port carrier selection and delivery movement. In addition to these transportation concerns, distribution-related considerations must also be given attention, especially; packing/packaging, transit insurance, terms of sale, import duties, handling/loading and method of financing. Nevertheless, even freight companies projecting large volume movements can encounter serious transportation problem in organizing for distribution (Reep and Leaegood; 2002).

In the linear transportation problem (ordinary transportation problem) the cost per unit commodity shipped from a given source to a given destination is constant, regardless of the amount shipped. It is always supposed that the mileage (distance) from every source to every destination is fixed. To solve such transportation problem we have the streamlined simplex algorithm which is very efficient. However, in reality, we can see at least two cases that the transportation problem fails to be linear.

First, the cost per unit commodity transported may not be fixed for volume discounts sometimes are available for large shipments. This would make the cost function either piecewise linear or just separable concave function. In this case the problem may be formulated as piecewise linear or concave programming problem with linear constraints.

Second, in special conditions such as transporting emergency materials when natural calamity occurs or transporting military during war time, where carrying network may be destroyed, mileage from some sources to some destination are no longer definite. So the choice of different measures of distance leads to nonlinear (quadratic, convex, etc.) objective function.

In nonlinear transportation problem, its solution is more complex than that of linear transportation problem. In this work, solution procedures to the generalized transportation problem taking nonlinear cost function are investigated. In particular, the nonlinear transportation problem considered in this paper is stated as follows;

- We are given a set of n sources of commodity with known supply capacity and a set of m destinations with known demands.
- The function of transportation cost is nonlinear and differentiable for a unit of product from each source to each destination.
2. Review of Related Literatures

Zangiabadi and Maleki (2007) presented a fuzzy 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 focused on minimizing the negative deviation variables formed to obtain a compromise solution of the multi-objective transportation problem.

Lau et al. (2009) presented an algorithm called the fuzzy logic guided non-dominated sorting genetic algorithm to solve the multi-objective transportation problem that deals with the optimization of vehicle routing in which multiple depots, multiple customers, and multiple products were considered. Since the total traveling time is not always restrictive as a time constraint, the objective considered comprises not only the total traveling distance, but also the total traveling time. Lohgaonkar and Bajaj (2010) used fuzzy programming technique with linear and non-linear membership function (hyperbolic, exponential) to find the optimal compromise solution of a multi-objective capacitated transportation problem.

Caputo (2006) presented a methodology for optimally planning long-haul road transport activities through proper aggregation of customer orders in separate full-truckload or less-than-truckload shipment in order to minimize total transportation cost. He has demonstrated that evolutionary computation technique may be effective in tactical transportation planning long-haul road transport activities through proper aggregation of customer orders in separate full-truckload or less-than-truckload shipment in order to minimize total transportation cost. This research seeks to apply the existing general nonlinear programming algorithms to solve our problem.

3. Methodology

3.1. The Karush-Kuhn-Tucker (KKT) Optimality Condition for Nonlinear Programming Problem

Given the non linear programming problem (NPP):

\[
\begin{align*}
\min \ f(x) \ & \text{ s.t. } g_i(x) \leq 0 \ \ i = 1,\ldots,k \\
h_j(x) & = 0 \ \ j = 1, \ldots,l
\end{align*}
\]

(1)

Theorem 1: Given the objective function \( f: \mathbb{R}^n \rightarrow \mathbb{R} \) and the constraint function are \( g_r: \mathbb{R}^n \rightarrow \mathbb{R} \) and \( h_i: \mathbb{R}^n \rightarrow \mathbb{R} \) and \( I = \{ i: g(x^*) = 0 \} \). In addition, suppose they are continuously differentiable at a feasible point \( x^* \) and \( Vg_i(x^*) \) for \( i \in I \) and \( Vh_j(x^*) \) for \( j = 1, \ldots, l \) be linearly independent. If \( x^* \) is minimizer of the problem (NPP), then there exist scalars \( \lambda \); \( \lambda \geq 0 \); \( \mu_j \); \( j = 1, \ldots, l \), called Lagrange multipliers, such that

\[
\begin{align*}
\nabla f(x^*) + \sum_{i=1}^k \lambda_i \nabla g_i(x^*) + \sum_{j=1}^l \mu_j \nabla h_j(x^*) & = 0 \\
\lambda_i g_i(x^*) & = 0; \lambda_i \geq 0; \mu_j \in \mathbb{R}
\end{align*}
\]

(2)
3.1.2. Karush-Kuhn-Tucker Sufficient Optimality Conditions for Convex Npp

Further, if f and each \( g_i \) are convex, each \( h_j \) is affine, then the above necessary optimality conditions will be also sufficient (Simons; 2006).

Justification

Let \( x \) be any feasible point different form \( x^* \). From the first KKT conditions we obtain

\[
\nabla f(x^*)(x - x^*) = - \sum_{i=1}^{k} \lambda_i \nabla g_i(x^*)(x - x^*) + \sum_{j=1}^{l} \mu_j \nabla h_j(x^*)(x - x^*)
\]

Since each \( g_i(x) \) is convex, \( \lambda_i \geq 0 \) and \( \nabla h_j(x^*)(x - x^*) = 0 \), we also have

\[
\nabla f(x^*)(x - x^*) \leq - \sum_{j=1}^{l} \lambda_j g_j(x) \geq 0
\]

From convexity of \( f(x) \), therefore, we get

\[
f(x) - f(x^*) \geq 0 \Rightarrow f(x^*) \leq f(x) \text{ for any feasible } x
\]

4. Solution Procedures to the Nonlinear Transportation Problem (Ntp)

In this section, we consider a transportation problem with nonlinear cost function. We try to find different solution procedures depending on the nature of the objective function. Before going to the different special cases, let’s formulate the KKT condition and general algorithm for the problem.

Given a differentiable function \( C: \mathbb{R}^{nm} \rightarrow \mathbb{R} \).

We consider a nonlinear transportation problem (NTP)

\[
\min C(x)
\]

\[\text{s.t. } Ax \leq b \]

\[x \geq 0\] (3)

where

\[
x = \begin{pmatrix} x_{11} \\ x_{ij} \\ \vdots \\ x_{nm} \end{pmatrix}; b = \begin{pmatrix} s_1 \\ \vdots \\ s_n \\ d_1 \\ \vdots \\ d_m \end{pmatrix}; A = \begin{pmatrix} 1 & 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & 1 & \cdots & 1 \end{pmatrix}
\]

The KKT Optimality Condition for the NTP

The transportation table is given as:

\[
\begin{array}{cccccc}
\frac{\partial C(\mathbf{x})}{\partial x_{11}} & \cdots & \cdots & \cdots & \frac{\partial C(\mathbf{x})}{\partial x_{1m}} & s_i \\
\frac{\partial C(\mathbf{x})}{\partial x_{ij}} & \cdots & \cdots & \cdots & \frac{\partial C(\mathbf{x})}{\partial x_{jm}} & s_j \\
\frac{d_i}{d_i} & \cdots & \frac{d_1}{d_i} & \cdots & \frac{d_m}{d_i} & u_i \\
\vdots & \ddots & \ddots & \ddots & \ddots & \ddots \\
\end{array}
\]

where \( \mathbf{x} \) is the current basic solution.

The Lagrange function for the NTP is formulated as

\[
z(x, \lambda, w) = C(x) + w^T (b - Ax) - \lambda x
\]

The optimal point \( \mathbf{x} \) should satisfy the KKT conditions:

\[
\nabla z = \nabla C(\mathbf{x}) - \lambda \mathbf{x} = 0
\]

\[
\lambda \geq 0 \quad \nabla z = 0
\]

Specifically for each cell \((i, j)\) we have

\[
\frac{\partial z}{\partial x_{ij}} = \frac{\partial C(\mathbf{x})}{\partial x_{ij}} - (u_i + v_j)e_k - \lambda_{ij} = 0
\]

\[
\lambda_{ij}x_{ij} = 0
\]

\[
x_{ij} \geq 0
\]

\[
\lambda_{ij} \geq 0
\]

Where \( k = 1 \ldots nm \) and \( w = (u, v) = (u_1, u_2, \ldots, u_n, v_1, \ldots, v_m) \), \( e_k \in \mathbb{R}^{m+n} \) is a vector of zeros except at position \( k \) which is \( 1 \).

From the conditions (5) and \( \lambda_k \geq 0 \), we get,

\[
\frac{\partial z}{\partial x_{ij}} = \frac{\partial C(\mathbf{x})}{\partial x_{ij}} - (u_i + v_j) \geq 0
\]

\[
x_{ij} \frac{\partial z}{\partial x_{ij}} = x_{ij} \left( \frac{\partial C(\mathbf{x})}{\partial x_{ij}} - (u_i + v_j) \right) = 0
\]

\[
x_{ij} \geq 0
\]

General solution procedure for the NTP.

Initialization

Find an initial basic feasible solution \( \mathbf{x} \).

Iteration

Step I: If \( \mathbf{x} \) is KKT point, stop. Otherwise go to the next step.

Step II: Find the new feasible solution that improves the cost function and go to step 1 (Kidist; 2007).

5. Transportation Problem With Concave Cost Functions

For large distributions, volume discount may be available sometimes. In this case the cost function of the
transportation problem generally takes concave structure for it is separable and the marginal cost (cost per unit commodity distributed) decreases with increase in the amount of distribution; because of the total cost increase per addition of unit commodity distributed. The discount 1. May be either directly related to the unit commodity. 2. Or have the same rate for some amount.

Case 1: If the discount is directly related to the unit commodity, the resulting cost function will be continuous and have continuous first partial derivatives.

Nonlinear programming formulation of such a problem is given by

\[
\min \sum_{i=1}^{n} \sum_{j=1}^{m} C_{ij}(x_{ij})
\]

\[
s.t \sum_{j=1}^{m} x_{ij} = s_{i}, \quad j = 1, 2, \ldots, m
\]

\[
\sum_{i=1}^{n} x_{ij} = d_{j}, \quad i = 1, 2, \ldots, n;
\]

Where \( C_{ij} : \mathbb{R} \rightarrow \mathbb{R} \).

6. The Transportation Concave Simplex Algorithm (Tcs)

Initialisation
Find the initial basic feasible solution using some rule like west corner rule.

Iteration
Step 1: Determine the values of \( u_{i} \) and \( v_{j} \) from the equation,

\[
\frac{\partial C(x)}{\partial x_{Bij}} = (u_{i} + v_{j}) = 0
\]

Where \( x_{Bij} \) are the basic variables.

Step 2: If

\[
\frac{\partial C(x)}{\partial x_{ij}} = (u_{i} + v_{j}) \geq 0
\]

for all \( x_{ij} \) – non basic, stop, \( x \) is KKT point. Otherwise go to step 3.

Step 3: Calculate

\[
\frac{\partial z}{\partial x_{t}} = \left[ \frac{\partial C(x)}{\partial x_{ij}} \right]_{ij} - u_{i} - v_{j}
\]

\( x_{t} \) will enter the basis. Allocate \( x_{t} = 0 \) where \( \theta \) is found as in the linear transportation case.

Adjust the allocations so that the constraints are satisfied.

Determine the leaving variable say \( x_{lok} \), where \( x_{lok} \) is the basic variable which comes to zero first while making the adjustment. Then find the new basic variables and go to step 1.

7. Data Analysis

The Nigerian Bottling Company Plc Owerri Plant, a distributor of various kinds of drinks located in Owerri Imo State Nigeria; sell the same product to different market segments within the neighborhood. For the sake of this work, only five market segments (Mbaise, Orlu, Aba, Umuahia, and Afikpo) and three soft drinks (Fanta, Coke and Sprite) shall be taken for this study. The cost of purchasing and transporting the drinks from the traders place to the market centres is given in Table 1 below.

Table 1. Cost of Transporting the Drinks to the various market zones

<table>
<thead>
<tr>
<th>Availability</th>
<th>Market segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbase</td>
<td>Orlu</td>
</tr>
<tr>
<td></td>
<td>Aba</td>
</tr>
<tr>
<td></td>
<td>Umuahia</td>
</tr>
<tr>
<td></td>
<td>Afikpo</td>
</tr>
<tr>
<td>Fanta 11000</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>11000</td>
</tr>
<tr>
<td>Coke 17000</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>17000</td>
</tr>
<tr>
<td>Sprite 11000</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>11000</td>
</tr>
<tr>
<td>Requirement of Drinks</td>
<td>6000</td>
</tr>
<tr>
<td></td>
<td>7000</td>
</tr>
<tr>
<td></td>
<td>9000</td>
</tr>
<tr>
<td></td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>7000</td>
</tr>
</tbody>
</table>

All the value in the Table 1 apart from requirements and supply are in Nigerian Currency (Naira) value. The Policy of the Company assumes discounts on each product transported from source to destination and it is directly related to the unit commodity purchased and transported, and the percentage discounts are shown in Table 2.

Table 2. Percentage Discounts

<table>
<thead>
<tr>
<th>Product</th>
<th>Mbaise</th>
<th>Orlu</th>
<th>Aba</th>
<th>Umuahia</th>
<th>Afikpo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fanta</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Coke</td>
<td>0.03</td>
<td>0.01</td>
<td>0.02</td>
<td>0.013</td>
<td>0.03</td>
</tr>
<tr>
<td>Sprite</td>
<td>0.02</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

The problem is to determine how many creates of each product to be transported from the source to each destination on a monthly basis in order to minimize the total transportation cost.

Table 3. Forming the transportation tableau

<table>
<thead>
<tr>
<th>Availability</th>
<th>Market segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbaise</td>
<td>Orlu</td>
</tr>
<tr>
<td></td>
<td>Aba</td>
</tr>
<tr>
<td></td>
<td>Umuahia</td>
</tr>
<tr>
<td></td>
<td>Afikpo</td>
</tr>
<tr>
<td>Demand 6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

To form the transportation tableau, let \( i = \) product to be supplied; \( j = \) destination of each product; \( S_{i} = \) the capacity of source node \( i \) , \( d_{j} = \) the demand of destination \( j \); \( x_{ij} = \) the total capacity from source \( i \) to destination \( j \); \( c_{ij} = \) the per unit of transporting commodity from \( i \) to destination \( j \). If we suppose that discount is given on each crate transported from \( i \) to \( j \), then the non-linear transportation problem can be formulated as

\[ \text{Minimize} \]

\[ 14x_{11} + 8x_{12} + 11x_{13} + 12x_{14} + 8x_{15} + 12x_{21} + 10x_{22} + 7x_{23} + 15x_{24} + 11x_{25} + 10x_{31} + 9x_{32} + 14x_{33} + 13x_{34} + 15x_{35} \]

\[ \text{Subject to:} \]

\[ x_{11} + x_{12} + x_{13} + x_{14} + x_{15} = 11000, \]
\[ x_{21} + x_{22} + x_{23} + x_{24} + x_{25} = 17000, \]
\[ x_{31} + x_{32} + x_{33} + x_{34} + x_{35} = 11000, \]
\[ x_{11} + x_{21} + x_{31} = 6000, x_{12} + x_{22} + x_{32} = 7000, \]
\[ x_{13} + x_{22} + x_{33} = 9000, x_{14} + x_{24} + x_{34} = 10000, \]
\[ x_{14} + x_{25} + x_{33} = 7000 \]

\[ \text{Where} \]
If we allow the following discounts on each transported product \( I \) from the source to each of the destinations, we obtain the cost function

\[
c_{ij} = c_{x} x_{ij} - p_{x} x_{ij}
\]

which can be expressed as;

\[
c_{11} = 14 x_{11} - 0.01 x_{12},
\]

\[
c_{12} = 8 x_{12} - 0.04 x_{12},
\]

\[
c_{13} = 11 x_{13} - 0.02 x_{13},
\]

\[
c_{14} = 12 x_{14} - 0.04 x_{14},
\]

\[
c_{15} = 8 x_{15} - 0.02 x_{15},
\]

\[
c_{21} = 12 x_{21} - 0.03 x_{21},
\]

\[
c_{22} = 10 x_{22} - 0.01 x_{22},
\]

\[
c_{35} = 15 x_{35} - 0.02 x_{35},
\]

\[
c_{33} = 3 x_{33} - 0.02 x_{33},
\]

The tableau is then developed as below;

\[
\begin{pmatrix}
\text{Fanta} & \text{Coke} & \text{Sprit} & \text{Abiko} & s_1 & u_1 \\
4.4 & 1.8 & 11 & 12 & 1.8 & 11000 & u_1 \\
4.2 & 1.0 & 11 & 12 & 1.5 & 17000 & u_1 \\
4.0 & 1.0 & 11 & 15 & 1.5 & 11000 & u_2 \\
\end{pmatrix}
\]

Using the least cost method, we get the initial basic solution as shown below.

\[
\begin{pmatrix}
\text{Fanta} & \text{Coke} & \text{Sprit} & \text{Abiko} & s_1 & u_1 \\
4.4 & 1.8 & 11 & 12 & 1.8 & 11000 & u_1 \\
4.2 & 1.0 & 11 & 12 & 1.5 & 17000 & u_1 \\
4.0 & 1.0 & 11 & 15 & 1.5 & 11000 & u_2 \\
\end{pmatrix}
\]

The presence of a negative value for the reduced cost signifies non optimality; hence we readjust. It is obvious that from the above, the minimum reduced costs for the non-basic variable is \( X_{25} \). Therefore \( X_{25} \) should enter the basis since it is the only negative reduced cost.

\[
\begin{pmatrix}
\text{Fanta} & \text{Coke} & \text{Sprit} & \text{Abiko} & s_1 & u_1 \\
4.4 & 1.8 & 11 & 12 & 1.8 & 11000 & u_1 \\
4.2 & 1.0 & 11 & 12 & 1.5 & 17000 & u_1 \\
4.0 & 1.0 & 11 & 15 & 1.5 & 11000 & u_2 \\
\end{pmatrix}
\]

The tableau is then developed as below;
The basic variable with the least value among the corners having signed in the loop is the leaving variable. Hence, \( X_{24} \) with the least value of 1 is the leaving variable. Thus, we increase the corners with + sign by 1, reduce the ones with – sign by 1. The adjusted tableau becomes:

\[
\begin{array}{c|ccccccc|c}
\text{Mbaiae} & Olu & Aka & \text{Umuahia} & \text{Afikpo} & s. & u. \\
\hline
\text{Fanta} & 15 & 10 & 11 & 5 & 12 & 6 & 8 & 11 & 0 \\
\text{Coke} & 12 & 12 & 10 & 9 & 7 & 15 & 11 & 11 & 17 & 0 & 5 & 35 & 0 \\
\text{Sprite} & 16 & 10 & 12 & 14 & 5 & 13 & 13 & 15 & 11 & 0 & 5 & 0 & 0 \\
\hline
\alpha_f & 7000 & 9000 & 5000 & 7000 & 5000 & 7000 & 5000 & 7000 & 5000 & 1000 & 5000 & 1000 & 5000 \\
\nu_f & 8.32 & 6.23 & 3.03 & 11.36 & 7.72 \\
\end{array}
\]

The reduced costs for the non-basic ones at a basic feasible point,

\[
\begin{equation}
\begin{aligned}
\bar{x}^2 &= \begin{pmatrix} x_{11}, x_{12}, x_{13}, x_{B14}, x_{B15}, x_{B21}, x_{B22}, \\
& x_{B32}, x_{B24}, x_{B25}, x_{B31}, x_{32}, x_{33}, x_{34}, x_{35} \end{pmatrix} \\
&= (0, 0, 0, 0, 3, 6, 0, 7, 0, 1, 6, 0, 0, 3, 0, 0)
\end{aligned}
\end{equation}
\]

Will be;

\[
\begin{align*}
\frac{\partial f}{\partial x_1} &= \frac{\partial f(\bar{x})}{\partial x_1} - u_1 - v_1 = 5.68 \\
\frac{\partial f}{\partial x_{32}} &= \frac{\partial f(\bar{x})}{\partial x_{32}} - u_3 - v_2 = 1.31 \\
\frac{\partial f}{\partial x_{11}} &= \frac{\partial f(\bar{x})}{\partial x_{11}} - u_4 - v_2 = 1.75 \\
\frac{\partial f}{\partial x_{33}} &= \frac{\partial f(\bar{x})}{\partial x_{33}} - u_3 - v_3 = 9.53 \\
\frac{\partial f}{\partial x_{33}} &= \frac{\partial f(\bar{x})}{\partial x_{33}} - u_4 - v_3 = 7.97 \\
\frac{\partial f}{\partial x_{35}} &= \frac{\partial f(\bar{x})}{\partial x_{35}} - u_3 - v_5 = 5.84 \\
\frac{\partial f}{\partial x_{21}} &= \frac{\partial f(\bar{x})}{\partial x_{21}} - u_2 - v_1 = 0.07 \\
\frac{\partial f}{\partial x_{24}} &= \frac{\partial f(\bar{x})}{\partial x_{24}} - u_2 - v_4 = 0.03
\end{align*}
\]

Since all the reduced costs for the non-basic variables are all positive, it implies \( \bar{x}^2 \) is the KKT optimality point. Since optimal solution is our primary goal, we then proceed to make our allocation and calculate our total optimal cost of transportation. Hence, the feasible solution that 5000 crates of Fanta and 6000 crates of the same product should be supplied to Umuahia market zone and Afikpo respectively. 7000 crates of Coke, 9000 crates and 1000 crates of the same product should be supplied to Orlu, Mbaiae, and Afikpo market zones respectively. 6000, and 50000 crates of Sprite should be allocated to Mbaiae and Umuahia market zones respectively. Total cost = 5000 (12) + 6000(8) + 7000(10) + 9000(7) + 1000(11) + 6000 (10) + 5000(13) = $377, 000.

8. Conclusion

We have described the transportation problem of Nigerian Bottling Company Plc Owerri Plant as a non-linear transportation problem. We also applied KKT optimality algorithm to solve the company’s problem. Note that our research focused on the model of the non-linear transportation problem for a particular company in Nigeria. It can however be applied to any situation that can be modeled as such.

This paper aimed at solving transportation problem with volume discount on quantity of goods shipped which is a non-linear transportation problem. Using KKT optimality algorithm, with a set of data from a Nigerian company, it was observed that the optimal solution that gave minimum achievable cost of supply was the supply of 5000 crates of Fanta and 6000 crates of the same product to Umuahia market zone and Afikpo respectively. 7000 crates of Coke, 9000 crates and 1000 crates of the same product should be supplied to Orlu, Mbaiae, and Afikpo market zones respectively. 6000, and 5000 crates of Sprite should be allocated to Mbaiae and Umuahia market zones respectively, at a cost of $377, 000.

Using the more scientific transportation problem model for the company’s transportation problem gave a better result. Management may benefit from the proposed approach for their transportation problem purposes. We therefore recommend that the transportation problem model should be adopted by the company for their transportation problem planning.

References