

OPTIMAL FEASIBLE SOLUTIONS TO A ROAD FREIGHT TRANSPORTATION PROBLEM

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ABSTRACT

For twenty decades, there is a visible ever forward advancement in the technology of mobility, vehicles and transportation system in general. However, there is no "cure-all" remedy ideal enough to solve all life problems but mathematics has proven that if the problem can be determined, it is most likely solvable. New methods and applications will keep coming to making sure that life problems will be solved faster and easier. This study is to adopt a mathematical transportation problem in the Coca-Cola company aiming to help the logistics department manager of the Asejire and Ikeja plant to decide on how to distribute demand by the customers and at the same time, minimize the cost of transportation. Here, different algorithms are used and compared to generate an optimal solution, namely; North West Corner Method (NWC), Least Cost Method (LCM) and Vogel's Approximation Method (VAM). The transportation model type in this work is the Linear Programming as the problems are represented in tables and results are compared with the result obtained on Maple 18 software. The study shows various ways in which the initial basic feasible solutions to the problem can be obtained where the best method that saves the highest percentage of transportation cost with 12.54% for this problem is the NWC. The NWC produces the optimal transportation cost which is 517,040 units.

Keywords: *Linear Programming, Transportation Problem, Optimal solution.*

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1. Introduction

One major problem that companies, organizations and firms faced is the transportation problem. The transportation problem began to get a shape as a problem in 1871 by a French economist and mathematician called Gaspard Monge, the transportation problem was first studied in 1920 as a problem by Sarbjit (2012).

The transportation problem applies to industries, companies, communication network, genetics, transportation schedule and allotment. The transportation models or problems are primarily concerned with how a product can best be transported from different factories or plants (origins) to several warehouses (destinations). The goal of every transportation problem is to reach the requirements of the destination with which the capacity constraints at the minimum possible cost of production operates. It is necessary to understand that movement of goods from any source to any destination will require that cost is being minimized to maximize profit.

Let's consider a condition in which there are nine distinct sources i.e., $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9$ and have to meet the request of also nine destinations, say $Y_1, Y_2, Y_3, Y_4, Y_5, Y_6, Y_7, Y_8, Y_9$. The number of goods available at each source is specified as $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9$ and the number of goods requested at each destination as $y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8, y_9$. The cost of moving goods from the source to the destination is tabulated and denoted as m_{ij} where the subscripts (1-9) indicate the cell, given the cost of moving from the source (origin) i to destination j , therefore m_{47} is the cost of moving goods from source x_4 to destination y_7 . Figure 1 below is an example of a Road Freight Transportation network model.

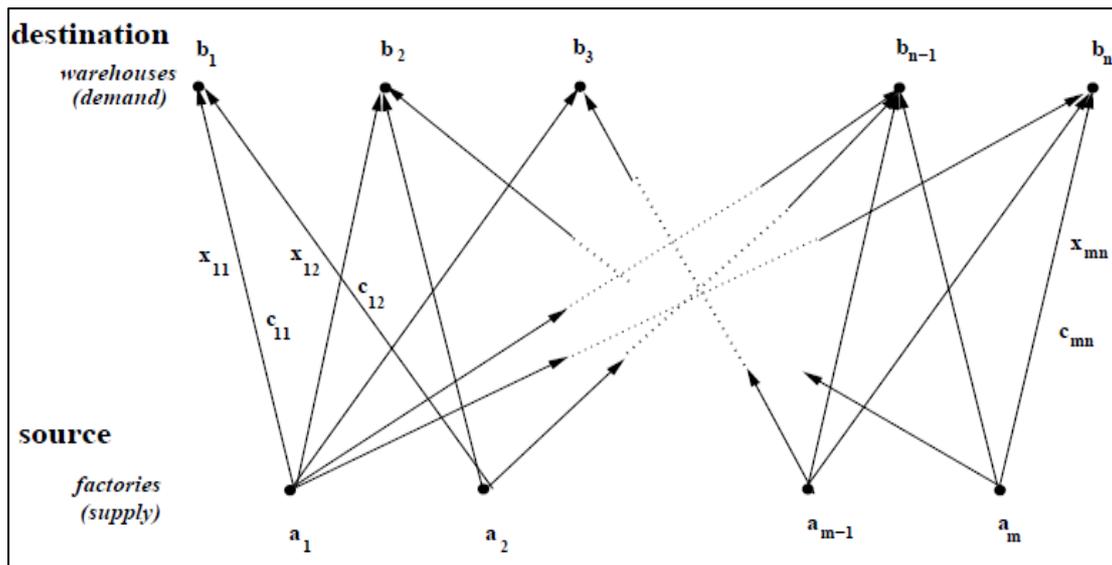


Figure 1: Transportation model with m source and n destinations

The objective of the transportation problem is to satisfy the requirement of the destination(s), to transport goods/passengers from the source/plants at different locations to their customers at various destinations.

The Linear Programming method is a useful tool for dealing with such a problem as a transportation problem. There are several assumptions in using the linear programming method. That includes that each source can supply a fixed number of units of products, usually called the capacity or availability, and each destination has a fixed demand, usually known as a requirement.

2. Literature Review

Study shows that the most successful application in the optimization field is the transportation problem - the best optimization problem that can be applied to a real-life problem is transportation. Asase (2011) worked on the transportation problem also, using Guinness Ghana Limited in Kumasi. In the study, these three algorithms: Vogel, North-West Corner, and Least Cost method are tested for optimality. The details method using Stepping Stone method and the Modified Distribution Method (MODI) are used to solve the problem solved using the management scientist 5.0 software.

Shraddha (2017) compared several methods of solving the transportation problem by evaluating the similarities and differences among the objectives of these methods. The methods

are then used to solve the transportation problem of the Millennium Herbal Company and the results obtained are compared.

Bit *et al.* (1992) considered a k-objective transportation problem formulated by fuzzy numbers and used alpha - cut to obtain a transportation problem in the fuzzy sense expressed in linear programming form. Bit *et al.* (1992) introduced an additive fuzzy programming model for the multi-objective transportation problem. The method aggregates the membership functions of the objectives to construct the relevant decision function. Weights and priorities for non-equivalent objectives are also incorporated in the method. Their model gave a non-dominated solution which is nearer to the best-compromised solution.

Latunde (2019), Latunde *et al.* (2019), Latunde & Bamigbola (2018), Latunde *et al.* (2016) worked on deriving and analysing the optimal values in some optimization problems of transportation, engineering and asset management by the method of sensitivity analysis of model parameters.

Dantzig (1963) used the simplex method to determine the solution of transportation as the primal simplex transportation. Using the Column minima method, Row minima, Matrix minima method, Vogel's approximation method and the North West Corner Rule, he obtained the initial basic feasible solutions of the transportation problem and to get the optimal solution transportation problem, he used the Modified Distribution (MODI).

Farnalskiy (2010) worked on the application of linear programming by utilizing the real-life data from SMT transport and services Ltd that operates on the Russian market as a case study in minimizing the cost of transportation. Different transportation modelling approaches and the ways to forecast in the flow of transportation of cargo containers with semi-processed goods on the selected routes from some origins (suppliers) $i=1...n$ to different destinations $j=1...m$, were considered. The solution to the problem forecast was obtained by a technique called trend adjusted forecast approach.

Salami (2014) worked on the application of transportation linear programming algorithms to cost reduction in Nigeria soft drinks industry. The data collected from the Distribution Department of 7-up Bottling Company Plc., Ilorin, Kwara State, Nigeria was analysed and the results obtained as transportation cost using three distinct methods namely; Vogel's approximation method, North West Corner Rule and the Least-Cost Method are the same. He hereby recommends to the 7-up Bottling Company Plc., that any of the three methods can be adopted.

Considering the work titled the optimization techniques of transportation for three variables, Rekha (2013) used four methods, namely; the Northwest Corner Method, the Least Cost Method, the Vogel and the MODI method, vividly explain the steps to each method and the steps to determine the optimal solution and comparison between the MODI method and every other method. The objective of her work is to get the shortest, best and cheapest route to satisfying the demand from any destination.

Pursula & Miittymaki (2001) in their book Mathematical Methods on Optimization in Transportation Systems shared the book to two distinct parts, (i) Public Transport Models and (ii) General Transport Models. In the first part they carefully dealt with the prevention of delay in railway traffic by optimization and simulation, then the heuristic for scheduling buses and drivers for an ex-urban public transport computing with bus-driver dependencies. They worked on the functionality of the simulation program Simu+++ and Dispo+++, developed at the Institute of Transport, Railway Construction and Operation in the University of Hanover, Germany.

Susanta (2019) used a new approach called Palsu's Favorable Cost Method and gave some numerical examples. This method is useful to directly solve the transportation problem without finding its initial basic feasible solution. He then compared the result with the NorthWest Corner Method, Row Minimum Method, Least Cost Method, Vogel's

Approximation Method and then concluded that the Palsu's Favorable Cost Method gave the best result.

One of the major problems faced in the Coca-cola company is how the cost of freight transportation can be optimized. Thus, the aim of this work is to minimize the total cost of transportation from Asejire and Ikeja plant to different distributors in Ibadan, Oyo state such that the optimal solution is feasible. The cost of transportation of a full truck of 1530 crates of beverages are expressed in Nigeria Naira (million), the quantity of goods demand and the supply is determined by the number of crates. The information presented is for 12 months, from April 2017 to March 2018.

3. Methodology

This section talks about minimizing the translocation costs of goods transportation from the factories to the distributors (warehouses) with supply say X and demand Y respectively. The monetary expense of transportation from the factories, i.e., from plant i to the warehouse j is referred to in this work as transportation cost. We have the cost of transportation to be c_{ij} .

3.1 The Transportation Problem

The transportation method of linear programming is applied to the problems related to the study of the efficient transportation routes i.e., how efficiently the product from different sources of production is transported to the different destinations such that the total transportation cost is minimized. Numbers of cells occupied is $x+y-1$, where x is the numbers of rows and y the number of columns.

The following methods of North-West Corner, Least Cost method and Vogel Approximation method are utilised such that the optimal feasible solution is obtained where the cost of transporting x units of product to the destination y is obtained.

3.2 North-West Corner

The North-West Corner method is one of the major methods adopted to compute and ensure the initial basic feasible solution of a transportation problem. It is popular because of its simplicity to use. North-west was given as a name to this approach because units are selected from the extreme left corner.

The prerequisite of getting a solution to this transportation problem is that demand must be equal to supply as agreed conventionally. If we have demand in excess than supply, then we add dummy variables to it. The dummy origin supplied here is the difference between the total supply and total demand. It is noted that the cost associated with the dummy origin is always zero.

The details algorithm of North-West Corner Method are as follows:

- i. Select the upper left-hand corner within the supply and demand, assign as many units as possible, it must satisfy the destination for demand but supply in surplus.
- ii. Move horizontally if the unit left can be satisfied or else check down to see if it can satisfy.
- iii. Allocate as much as you can to the next adjacent feasible cell.
- iv. Lastly, we make sure we re-practice Step 3 until demand and supply of origin and destination get saturated. Then the total cost can be computed.

Consider the example represented in Figure 2 for detail calculation.

	W_1	W_2	W_3	W_4	Supply
F_1	10	0	20	11	20
F_2	12	7	9	20	25
F_3	0	14	16	18	15
Demand	10	15	15	20	

Figure 2: Transportation tableau with 3 factories and 4 warehouses

- i. Here, $m_{11} = 10$. Rule out the first column, The goods left in the first row is 10.
- ii. $m_{12} = 10$. Rule out the first row. 5 goods are now available in the second column.
- iii. $m_{22} = 5$. Rule out the second column. 20 goods are left in the second row.
- iv. $m_{23} = 15$. Rule out the third column. We have 5 goods available left in the second row.
- v. Now, the column remaining in the fourth column, therefore m_{24} and m_{34} are the ones left to deal with. We can only allocate 5 goods and 15 goods to the second row and the third row respectively. We just allocate to m_{24} , 5 goods and m_{34} , 15 goods, then the fourth column demand has been met.

The initial basic feasible solution is given as $m_{11} = 10, m_{12} = 10, m_{22} = 5, m_{23} = 15, m_{24} = 5, m_{34} = 15$. The remaining entries are considered non-basic, therefore they are equal to zero. The solution is 6 because it must have $m+n-1 = 6$ basic variables. It is equally important to note that the entries for total supply are equal to the total demand.

3.3 Least Cost Method

Least Cost Method is another method used to obtain the initial basic feasible solution for the transportation problem. This Least Cost Method is more preferable than the North West Corner Method because it produces a more efficient initial basic feasible solution than the North West Corner Method since it puts in consideration the cost variables in the problem.

The details algorithm for Least Cost Method is as follows:

- i. Here, we allocate every possible cell with the least unit cost in all the entries of the tableau. If the least unit cost appears more than once then choose randomly.
- ii. Rule out the row or rule out the column which has been supplied. If a row is satisfied simultaneously as its respective column then rule out only one of them.
- iii. To those rows and columns that have not been ruled out, adjust their supply and demand.
- iv. When all left is just one row or column, the variables left are basic and are allocated to the only feasible they fit in.

From the example in Figure 2, we have:

- i. m_{12} and m_{31} have zero cost as their entry, so we randomly choose $m_{1,2}$ i.e the first and assign $m_{12} = 15$.
- ii. Rule out the second column. The goods left in the first row is 5, $m_{31} = 10$. Rule out the first column which is 1.
- iii. The goods left in the third row is 5, meanwhile $m_{23} = 15$. Rule out the third column. The goods left in the second row is 10.

- iv. Now, the fourth column is the only entry left and so all the entries in this column will be basic. The only feasible allocation is $m_{14} = 5$, $m_{24} = 10$ and $m_{34} = 5$ respectively.
- v. Considering the numbers of the initial basic feasible solution we have $m_{12} = 15$, $m_{31} = 10$, $m_{23} = 15$, $m_{14} = 5$, $m_{24} = 10$ and $m_{34} = 5$, that is also 6 basic solutions. Every other entry left are non-basic and are therefore considered to be zero.

3.4. Vogel Approximation Method

Vogel's Approximation Method is good in solving transportation problems because the initial basic feasible solution obtained by this method is always close to the optimal solution. There is a major difference between the North-West Corner Method and the Vogel's Approximation Method. In the North-West Corner, we select the upper left-hand corner in the solution tableau but for the Vogel's approximation method, the first step is to compute differences in each row and also each column before we select a cell. The row difference and the column difference are defined as follows:

- i. RD_i: This is the amount gotten after subtracting the smallest from the next smallest unit cost say c_{ij} which remain under consideration in row i , $i = 1, \dots, m$.
- ii. CD_j: This is the amount gotten after subtracting the smallest from the next smallest unit cost say c_{ij} which remain under consideration in the column j , $j = 1, \dots, n$. The row differences and the column differences are used to make a more convenient selection of a cell in the solution tableau; a selection based on the unit transportation costs.

The details algorithm of Vogel Approximation method are as follows:

- i. Get the amount for RD_i and CD_j. Among the rows and columns still under consideration, find the one with the largest difference, and find in it the cell (i,j) with the smallest unit transportation cost c_{ij} .
- ii. Assign to the variable with the largest feasible amount consistent with the row and the column requirements of that cell, that is, the value: $x_{ij} = \min a_i, b_j$.

Adjust the supply a_i and the demand b_j as follows:

- i. If the minimum is a_i , then the supply of the origin O_i becomes zero, and the row i is eliminated from further consideration. The demand b_j is replaced by $b_j - a_i$
- ii. If $a_i = b_j$, then the adjusted values for the supply a_i becomes zero and the demand b_j becomes zero also. The row i and the column j are eliminated from further consideration.
- iii. Two cases may arise: If only one row or only one column is left, then any remaining cells (i,j), that is, variables x_{ij} associated with these cells, are selected and the goods left are assigned to them. Then stop, otherwise, go to Step 1.

4. Mathematical Formulation and Analysis

Suppose a company has x warehouse and the number of retailers to be y , we can only ship one product from x to y . We can build a mathematical model for the following transportation problem. Table 1 shows sample of cost table for a transportation problem.

Table 1: Sample of a cost table for transportation problem

	X_1	X_2	X_3	X_4	Supply
Y_1	1	2	4	4	6
Y_2	4	3	2	0	8
Y_3	0	2	2	1	10
Demand	4	6	8	6	24

where X_i implies the supply to the warehouses and Y_j is the demand by the retailer outlets.

Let companies producing goods at different places (factories) say "m" factories, from $i = 1,2,3, \dots, m$. Also, it supplies to different distributors or warehouses, we have this to be S_i , $i=1,2,3,\dots,n$. The demand from the factory reaches all requested places (say, wholesalers). The demand from the last wholesaler is the jth place, we call this D_j .

The problem of the company is to get goods from factory i and supply to the wholesaler j , the cost is c_{ij} and this transportation cost is linear. By formulation, if we transport a_{ij} numbers of goods from factory i to wholesaler j , then the cost is $c_{ij}a_{ij}$.

4.1 Data Collection

The Coca-cola Company is the world largest beverage company. Coca-Cola owns and markets more than five hundred (500) nonalcoholic beverage brands. These are categorised to:

1. Sparkling soft drinks
2. Water and enhanced water
3. Sports drinks (juice and dairy)
4. Plant-based beverages (tea and coffee)
5. Energy drinks.

Like every other beverages company, the Coca-Cola company has its product available to consumers in over two hundred (200) countries transport goods through the network of Company-owned or -controlled bottling. The network constitutes of distribution operations, independent bottling partners, distributors, wholesalers and retailers. Table 2 summarises the demand and supply between all the plants and the distribution centres considered in this study.

Table 2: Demand and Supply from Asejire and Ikeja Plants (in thousand units)

	FID	Akin	Oniyele	MGR	Adhex	FDR	Vero	BnB	Mimz	Nuhi	Ile-Iwe	Supply
Asejire	206	182	242	277	196	212	200	276	192	150	303	1320
Ikeja	180	206	235	261	177	197	212	255	200	198	295	1210
Demand	200	200	250	280	200	220	220	270	180	210	300	2530

Note the following shortforms of the distribution centres in Table 2.

- FID – Fidelity Depot
- Akin – Akin Depot
- Oniyele – Oniyele Depot
- MGR – Madam Margaret Depot
- Adhex – Adhex Depot
- FDR – Fadare and Sons Depot
- Vero – Veronica Depot

BnB – Bolu and Bola Depot
 Mimz – Mimz Depot
 Nuhi – Nuhi Depot
 Ile-Iwe – Ile-Iwe Depot

4.2 Problem Formulation

Let Y_1 = factory at Asejire and Y_2 = the factory at Ikeja, X_{ij} = the units transported in crates from factory i to warehouse j respectively and $i = 1,2,3...m,n$. and $j = 1,2,3...,m,n$. Therefore, x_{11} represent the units shipped from Asejire plant to FID warehouse, x_{12} implies to Akin up to x_{1m} which is from Asejire to Nuhi and lastly x_{1n} which is to Ile-Iwe.

Same as above, x_{21} represents the units shipped from Ikeja Plant to FID warehouse, x_{22} ps from Ikeja to Akin up to x_{2m} which is from Ikeja to Nuhi and lastly from Ikeja is x_{2n} which is to Ile-Iwe. With the knowledge of Table 2, the 12 months transportation cost can be considered as:

$$\text{Min } Z = 206x_{11} + 182x_{12} + 242x_{13} + 277x_{14} + 196x_{15} + 212x_{16} + 200x_{17} + 276x_{18} + 192x_{19} + 150x_{1m} + 303x_{1n} + 180x_{21} + 206x_{22} + 235x_{23} + 261x_{24} + 177x_{25} + 197x_{26} + 212x_{27} + 255x_{28} + 200x_{29} + 198x_{2m} + 295x_{2n}$$

Subject to:

The available supply constraint is given by:

$$\begin{aligned} x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} + x_{19} + x_{1m} + x_{1n} &\leq 1320 \\ x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{25} + x_{27} + x_{28} + x_{29} + x_{2m} + x_{2n} &\leq 1210 \end{aligned}$$

Likewise the demand constraint is as computed below:

$$\begin{aligned} x_{11} + x_{21} &\leq 200 \\ x_{12} + x_{22} &\leq 200 \\ x_{13} + x_{23} &\leq 250 \\ x_{14} + x_{24} &\leq 280 \\ x_{15} + x_{25} &\leq 200 \\ x_{16} + x_{26} &\leq 220 \\ x_{17} + x_{27} &\leq 220 \\ x_{18} + x_{28} &\leq 270 \\ x_{19} + x_{29} &\leq 180 \\ x_{1m} + x_{2m} &\leq 210 \\ x_{1n} + x_{2n} &\leq 300 \end{aligned}$$

$$\forall i = 1,2. j = 1,2...,m,n.$$

Here, m represents Nuhi Depot and n represents Ile-Iwe Depot.

The problem is to find the minimum cost of transporting those goods. The condition that must be satisfied here is that we must meet the demand at each of the wholesalers' request and supply cannot exceed. Therefore, linearly, the problem can be expressed as follows:

$$\text{min } \sum_{i=1}^m \sum_{j=1}^n c_{ij} a_{ij} \tag{1}$$

The number of goods transported from the factory i :

$$\sum_{j=i}^n a_{ij}. \tag{2}$$

Meanwhile recall, a_{ij} is the good transported i to j . From the factory, you can transport any goods to any of the wholesalers $j=1,2,\dots,n$. Here, (2) above is the addition of all goods supplied by the factory i from the first wholesaler to the last.

The goods cannot be more than the request to be supplied to the wholesaler, we, therefore, have it that:

$$\sum_{j=i}^n \leq S_i \forall i = 1,2,\dots,m. \tag{3}$$

Similarly, the constraints to make sure demand is met at all wholesalers point:

$$\sum_{i=i}^n \geq D_j \forall j = 1,2,\dots,n. \tag{4}$$

There would be excess demand if the sum of all supply is not more than the demand as such, the request from the wholesalers will be much after supplies have been made to avoid this, therefore, have that:

$$\sum_{i=i}^n D_j \leq \sum_{i=i}^m S_i, \tag{5}$$

If this is not holding, then the demand cannot be met. Hence, there must be enough possibly excess supply to be sure that demand is met. It is also fair to assume that the quantities demand is exactly equal to the quantities supplied.

$$\sum_{i=i}^n D_j = \sum_{i=i}^m S_i, \tag{6}$$

When this happens, it means the plan for transportation cost is perfect and the supply meets the wholesalers' need at every point and disposed of all goods that left the factory. Therefore, at the cost c_{ij} , m supplies for $i=1,2,3,\dots,m$, S_i and n demands D_j for $j=1,2,3,\dots,n$. The major work is finding a transportation schedule denoted by x_{ij} to get a solution to:

$$\min \sum_{i=1}^m \sum_{j=1}^n x_{ij} c_{ij} \tag{7}$$

subject to:

$$\sum_{j=i}^n = S_i \forall i = 1,2,\dots,m. \tag{8}$$

$$\sum_{i=i}^n = D_j \forall j = 1,2,\dots,n. \tag{9}$$

4.2 Results

In this section, results from several methods are described. Table 3, 4 and 5 show the total transportation cost of transporting the demand form both plants to the distribution centres using North West Corner (NWC) method, Least Cost method and Vogel's Approximation method respectively.

Table 3: The NWC cost table from Asejire and Ikeja Plants (in thousand units)

	FID	Akin	Oniyele	MGR	Adhex	FDR	Vero	BnB	Mimz	Nuhi	Ile-Iwe	Supply
Asejire	200	200	250	280	200	190						1320
Ikeja						30	220	270	180	210	300	1210
Demand	200	200	250	280	200	220	220	270	180	210	300	2530

The total transportation cost, therefore, for the North-West Corner Method from Table 3 is calculated as follows:

$$(206 \times 200) + (182 \times 200) + (243 \times 250) + (277 \times 280) + (196 \times 200) + (212 \times 190) + (197 \times 30) + (212 \times 220) + (255 \times 270) + (200 \times 180) + (215 \times 300) = 41,200 + 36,400 + 60,500 + 72,560 + 39,200 + 40,280 + 5,910 + 46,640 + 68,850 + 36,000 + 64,500 = \$517,040 \text{ (Nigerian currency).}$$

Table 4: The LCM solution table from Asejire and Ikeja Plants (in thousand units)

	FID	Akin	Oniyele	MGR	Adhex	FDR	Vero	BnB	Mimz	Nuhi	Ile-Iwe	Supply
Asejire		200		280			220	230	180	210		1320
Ikeja	200		250		200	220		40			300	1210

The transportation cost therefore for Least Cost Method from Table 4 above is calculated as:

$$(206 \times 200) + (182 \times 200) + (243 \times 250) + (277 \times 280) + (196 \times 200) + (212 \times 190) + (197 \times 30) + (212 \times 220) + (255 \times 270) + (200 \times 180) + (215 \times 300) = 36,400 + 77,560 + 44,000 + 63,480 + 34,560 + 31,500 + 36,000 + 58,750 + 35,400 + 43,340 + 10,200 + 64,500 = \$535,690 \text{ in Nigerian currency.}$$

Table 5: The VAM solution table from Asejire and Ikeja Plants (in thousand units)

	FID	Akin	Oniyele	MGR	Adhex	FDR	Vero	BnB	Mimz	Nuhi	Ile-Iwe	Supply
Asejire	200	200					220	10	180	210	300	1320
Ikeja			250	280	200	220		260				1210
Demand	200	200	250	280	200	220	220	270	180	210	300	2530

The transportation cost therefore for Vogel’s Approximation Method from Table 5 above is calculated as:

$$(206 \times 200) + (182 \times 200) + (200 \times 220) + (192 \times 180) + (210 \times 150) + (303 \times 300) + (235 \times 250) + (261 \times 280) + (200 \times 172) + (220 \times 197) + (260 \times 255) = 41,200 + 34,400 + 44,000 + 2,760 + 34,560 + 90,900 + 36,000 + 58,750 + 73,080 + 34,340 + 43,430 + 66,300 = \$525,690 \text{ in Nigerian currency.}$$

However, solving the identified problem directly on the Maple 18 software, we obtained the transportation cost to be \$546,919 in Nigerian currency. This is used to verify the closeness of the various manual methods of solving transportation problems to the computer-based on Maple 18. Table 6 shows the cost values of these different approaches to the problem.

Table 6: Comparison of Transportation Cost value based on solutions methods

Methods	Cost Value (\$ in Nigerian currency)
North-West Corner Method	517,040
Least Cost Method	535,690
Vogel's Approximation Method	525,690

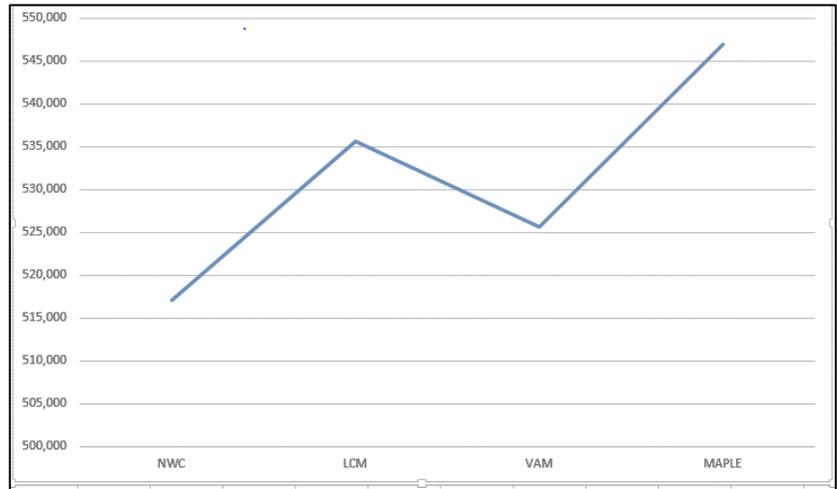


Figure 3: Comparisons of Methods based on Cost Value (\$ in Nigerian Currency)

Table 6 shows that the North West Corner Method produces the best transportation cost for this problem. Since the North-West corner Method yields the transportation cost to be \$517,040, the Least Cost Method produces \$535,690 and the Vogel's Approximation Method gives \$525,690.

The reduced cost of value percent =

$$\frac{\text{InitialCost} - \text{OptimizedCost}}{\text{InitialCost}} \times 100 \tag{10}$$

The initial transportation cost is obtained by multiplying the demand from each warehouse by the highest unit of supply in the same column and optimized cost, in this case, is for each method analysed. Thus, we have:

$$\begin{aligned} & (206 \times 200) + (182 \times 200) + (242 \times 250) + (277 \times 280) + (196 \times 200) + (212 \times 220) + (212 \times 220) + (276 \times 270) + (200 \times 180) + (198 \times 210) + (303 \times 300) \\ & = 41,200 + 36,400 + 60,500 + 77,560 + 39,200 + 46,640 + 46,640 + 74,520 + 36,000 + 41,580 + 90,900 = \$591,140. \end{aligned}$$

For NWC, the reduced cost is:

$$\frac{591,140 - 517,040}{591,140} \times 100\% = 12.54\%$$

For LCM, the reduced cost is:

$$\frac{591,140 - 535,690}{591,140} \times 100\% = 9.38\%$$

For VAM, the reduced cost is:

$$\frac{591,140 - 525,690}{591,140} \times 100\% = 11.07\%$$

The initial transportation cost is obtained by multiplying the demand from each Depot by the highest unit of supply in the same column. The North-West Corner method produces the optimum reduced cost of the problem 12.54%.

The Coca-Cola company problem was solved with three distinct methods namely; the North-West Corner Method, The Least Cost Method and the Vogel's Approximation and then compared with the result computed by the linear programming module on Maple 18 software. Figure 3 shows that the North-West Corner Method produces the optimal transportation cost which is \$517,040. Also, The North-West Corner method produces the optimum reduced cost of the problem 12.54%.

5. Conclusion

Since the transportation problem is one of the major focus in optimization and relating fields, the problem of road freight transportation that exists in a Coca-Cola company was formulated as a linear programming problem, solved and characterized using various approaches. The computational results provided the minimal total transportation cost and the values that will optimize the cost of supplying, the number of cases to supply and where to supply more cases. The study shows various ways in which the solution to the problem can be obtained. However, the best method that will save the highest percentage of transportation cost.

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