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On The Use of Transportation Techniques to Determine the Cost of Transporting Commodity

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Abstract: *This paper aims at identifying an effective and appropriate method of calculating the cost of transporting goods from several supply centers to several demand centers out of many available methods. Transportation algorithms of North-West corner method (NWCM), Least Cost Method (LCM), Vogel's Approximation Method (VAM) and Optimality Test were carried out to estimate the cost of transporting produced newspaper from production center to ware-houses using Statistical software called TORA. The results revealed that: NWCM = 36,689,050.00, LCM = 55,250,034.00, VAM = 29,097,700.00 and Optimal solution = 19,566,332.00. It was discovered that Vogel's Approximation method gives the transportation cost that closer to optimal solution. Also, the study revealed that a production center should be created at northern part of Nigeria to replace the dummy supply center used in the analysis, so as to make production capacity equal to requirement.*
Key Words*: algorithm, transportation, optimal solution, degeneracy, dummy.*

I. Introduction

In the theory of production, what to produce and for whom to produce are critical problems encounter by many producers in developing countries such as Nigeria. After solving the stated problems, cost of production is another economic problem contributing to the price of a produced commodity. This is revealing from economic perspective that says price of commodity greatly rely on the cost of producing such commodity. One of the confounding determinants of production cost is cost of transporting manufactured goods from supply centers to demand centers. This paper attempted at providing an appropriate method of calculating the cost of transporting a homogeneous product from manufacturing centers to consumption centers so as to guide the company in minimizing the cost of moving her products to demand areas.

The study of transportation problem helps to identify optimal transportation routes along with units of commodity to be shipped in order to minimize total transportation cost (J.K Sharma 2009). Transportation problem arises where there exist the need to move a set of items from the number of different sources (with each source having certain capacity) to a number of destination (with each destination requiring a certain capacity). One of the models that explained the study of transportation problem is Linear Programming (LP), but important application of this linear programming is in the area of physical distribution of goods and services after production to the consumption centers (Richard Bronson et al. 1997). At times, transportation problem can be expressed in terms of LP model which can be solved by the simplex method or other methods of solving a system of linear equations. There are various types of transportation models and the simplest of them was first presented by F.L Hitchcock (1941) and developed by T.C. Koopmans (1949) and G.B. Dantzing (1951). Later, several models and methods have been subsequently developed.

Transportation problem solution attempts to minimize total transportation cost and at the same time satisfy the destination requirement given the transportation cost per unit. The transportation problem is a form of linear programming problem, therefore, is an allocation problem for which a special technique or method of providing solution to a problem has been developed. However, the transportation algorithm is specially design to provide optimum solution to problems arise as a result of transporting product or allocation of services or delivery from several origins to various destinations, where the total requirements at each destination are known quantities, thus, deciding along which routes are the best they should be dispatched.
In business, sources could be factories and destinations could be warehouses or customer's shops. It should be noted that transportation problems are usually minimization problems.

The limitation of linear programming model is involvement of a large number of variables and constraints that may takes a long time to solve manually. This problem is solved by the researchers, through the help of statistical software called TORA.

II. Some Useful Concepts Used

i. **Unbalanced Transportation Problem:** A transportation problem is said to be unbalanced when the total demand is not equal to the total supply. In this situation, there will be need to create a dummy and this depends on the excess or shortage between the demand and the supply. That is there will be need to create dummy demand if supply is greater than demand or dummy supply if the demand is greater than supply with zero cost of transportation.

ii. **Balanced Transportation Problem:** A transportation problem is said to be balanced when the total demand is equal to the total supply. That is $\sum_{i=1}^{m} a_i = \sum_{j=11}^{n} b_i$

In this paper, we have unbalanced transportation problem, because the total demand is greater than total supply. However, dummy supply with zero cost of transportation was created to make total supply equal total demand and transportation algorithm of North-West Corner Method, Least Cost Method, Vogel's Approximation Method as well as Optimization test were adopted to calculate the cost of transporting a homogenous commodity (Newspaper) from supply centers to demand centers. Later, the result of NWCM, LCM and VAM are compared with the result of optimality test to identify the method that gives minimum value of the total cost of transporting the product under study (newspaper).

iii. **Degeneracy:** A basic feasible solution of any standard transportation problem with m sources of supply and n demand destination require that allocation be made in (column + row – 1). Degeneracy of a solution occurs when the resources of a row are exhausted and the requirements of a column are satisfied by a single allocation. So, if this happens, it is important to calculate the shadow cost and the only solution is to treat one of the unoccupied cells as if it was occupied cell or as if it had a zero allocation.

iv. Optimality: In transportation problem, an optimal solution is a solution obtained and there is no other set of transportation routes (allocations) that will further reduce the total transportation cost.

III. Material and Methods

Data used for this research was provided by African Newspapers of Nigerian Plc (Nigerian Tribune). The data covered ten years of supplying Newspapers from 3 supply centers or plants (Ibadan, Abuja and Port-Harcourt) to 12 demand centers (Abeokuta, Ado-Ekiti, Ilorin, Osogbo, Kano, Sokoto, Jos, Warri, Benin, Owerri, Enugu and Makurdi) between 2001 and 2010.

A transportation problem involves M sources, each of which has available a_i (i=1,2,…..m) units of a homogeneous product and n destination, each of which requires b_j (j=1,2,……n) units of the product (Newspaper). The numbers a_j and b_j are positive integers. The cost C_{ij} of transporting one unit of product from the i^{th} destination is given for each i and j.

It is assumed that total supply and total demand are equal that is

$$\sum_{i=1}^{m} a_i = \sum_{j=11}^{n} b_i$$

The above equation is guaranteed by creating either a fictitious destination with a demand equal to the surplus, if total demand is less than the total supply, or a fictitious source with a supply equal to the shortage if total demand exceeds total supply.

If x_{ij} represent the number of units to be shipped from sources i to j, mathematical model for the problem is

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

Subject to

$$\sum_{j}^{n} X_{ij} \le a_i \quad \text{for all } i$$

$$\sum_{i}^{m} X_{ij} \ge b_j \quad \text{for all } j$$

$$X_{ij} \ge 0, \quad \Sigma a_i \ge \Sigma b_j \quad C_{ij} \ge 0$$

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Layout of transportation problem:

	D_1	D_2	…	D_n	Supply
S_1	C_{11} X_{11}	C_{12} X_{12}	… …	C_{1n} X_{1n}	a_1
S_2	C_{21} X_{21}	C_{22} X_{22}	… …	C_{2n} X_{2n}	a_2
S_3	C_{31} X_{31}	C_{32} X_{32}	… …	C_{3n} X_{3n}	a_3
. . .	. . .	. . .	… … …	. . .	. . .
S_m	C_{m1} X_{m1}	C_{m2} X_{m2}	… …	C_{mn} X_{mn}	a_m
Demand	b_1	b_2	…	b_n	$\sum_{i=1}^{m} a_i = \sum_{j=11}^{n} b_i$

Table 1:

where:

C_{ij} is the cost of transporting unit from depot i to destination j.

X_{ij} is the quantity allocated to destination j from depot i .

S_i is the source of depot i

D_j is the destination j

a_i is the capacity of source or distribution centre i

b_j is the demand or requirement of destination j

$\sum_{i=1}^{m} a_i = \sum_{j=11}^{n} b_i$ is the total

Algorithms

The first approximation or computation system is always integral and therefore serves as optimal solution, rather than determining the approximation by a direct application of the simplex method specialized to detect the optimal solution, transportation algorithms of NWCM, LCM, and VAM are employed. To use any one of the stated algorithms, one must follow the following steps:

1. Computation of initial basic feasible solution.
2. Testing the optimality of the solution in step 1
3. Improving the solution established in step1 when it is not optimal
4. Repeating steps (2) and (3) until the optimal solution is obtained.

Data presentation, analysis and interpretation of results

The data collected from Nigerian Tribune is summarized on table 2 and the results of analyses are presented on table 3, 4, 5 and 6:

Supply/demand centers	***IBADAN ₦***	***ABUJA ₦***	***PORT HARCOURT ₦***	***DUMMY ₦***	***REQUIREMNT***
Abeokuta	9	38	45	0	867650
Ado	16	29	33	0	1466217
Ilorin	15	24	30	0	2878598
Osogbo	10	32	37	0	2252565
Kano	40	16	24	0	413468
Sokoto	52	19	28	0	765150
Jos	49	17	38	0	603336
Warri	53	33	13	0	645788
Benni	38	42	21	0	1997399

Owerri	44	37	12	0	1249873
Enugu	52	39	17	0	1024606
Makurdi	59	21	41	0	341292
CAPACITY	673,000	530,000	409400	12893542	14,505942

Table 2.

North - West Corner Method (NWCM)

Table:3 OBJECTIVE FUNCTION: 36,689,050.00

	ABEOKUTA	ADO	ILORIN	OSOGBO	KANO	SOKOTO	JOS	WARRI	BENIN	OWERRI	**ENIUGU**	MARKURDI	**SUPPLY**
IBADAN	**673000**												**673000**
ABUJA	**194650**	**335350**											**530000**
PORT HARCOURT		**409400**											**409400**
DUMMY		**721467**	**2878598**	**2252565**	**413468**	**765150**	**603336**	**645788**	**1997399**	**1249873**	**1024606**	**341292**	**12893542**
DEMAND	**867650**	**1466217**	**2878598**	**2252565**	**413468**	**765150**	**603336**	**645788**	**1997399**	**1249873**	**1024606**	**341292**	

Least Cost Method (LCM)

Table:4 OBJECTIVE FUNCTION: 55,250,034.00

	ABEOKUTA	ADO	ILORIN	OSOGBO	KANO	SOKOTO	JOS	WARRI	BENIN	OWERRI	**ENIUGU**	MARKURDI	**SUPPLY**
IBADAN											**673000**		**673000**
ABUJA											**188708**	**341292**	**530000**
PORT HARCOURT										**246502**	**162898**		**409400**
DUMMY	**867650**	**1466217**	**2878598**	**2252565**	**413468**	**765150**	**603336**	**645788**	**1997399**	**1003371**			**12893542**
DEMAND	**867650**	**1466217**	**2878598**	**2252565**	**413468**	**765150**	**603336**	**645788**	**1997399**	**1249873**	**1024606**	**341292**	

Vogel's Approximation Method (VAM)

Table:5 OBJECTIVE FUNCTION: 29,097,700.00

	ABEOKUTA	ADO	ILORIN	OSOGBO	KANO	SOKOTO	JOS	WARRI	BENIN	OWERRI	**ENIUGU**	MARKURDI	**SUPPLY**
IBADAN	**673000**												**673000**
ABUJA	**194650**			**335350**									**530000**
PORT HARCOURT										**409400**			**409400**
DUMMY		**1466217**	**2878598**	**1917215**	**413468**	**765150**	**603336**	**645788**	**1997399**	**840473**	**1024606**	**341292**	**12893542**
DEMAND	**867650**	**1466217**	**2878598**	**2252565**	**413468**	**765150**	**603336**	**645788**	**1997399**	**1249873**	**1024606**	**341292**	

Optimal Solution

From	To	Amt. Shipped	Obj. Coeff.	Obj. Contrib.
S1: IBADAN	D1: ABEOKUTA	673000	9.00	6057000.00
S2: ABUJA	D5: KANO	413468	16.00	6615488.00
S2: ABUJA	D7: JOS	116532	17.00	1981044.00
S3: PORTHARCOURT	D10: OWERRI	409400	12.00	4912800.00
S4: DUMMY	D1: ABEOKUTA	194650	0.00	0.00
S4: DUMMY	D2: ADO	1466217	0.00	0.00
S4: DUMMY	D3: ILORIN	2878598	0.00	0.00
S4: DUMMY	D4: OSOGBO	2252565	0.00	0.00
S4: DUMMY	D6: SOKOTO	765150	0.00	0.00
S4: DUMMY	D7: JOS	486804	0.00	0.00
S4: DUMMY	D8: WARRI	645788	0.00	0.00
S4: DUMMY	D9: BENIN	1997399	0.00	0.00
S4: DUMMY	D10: OWERRI	840473	0.00	0.00
S4: DUMMY	D11: ENUGU	1024606	0.00	0.00
S4: DUMMY	D12: MARKUDI	341292	0.00	0.00

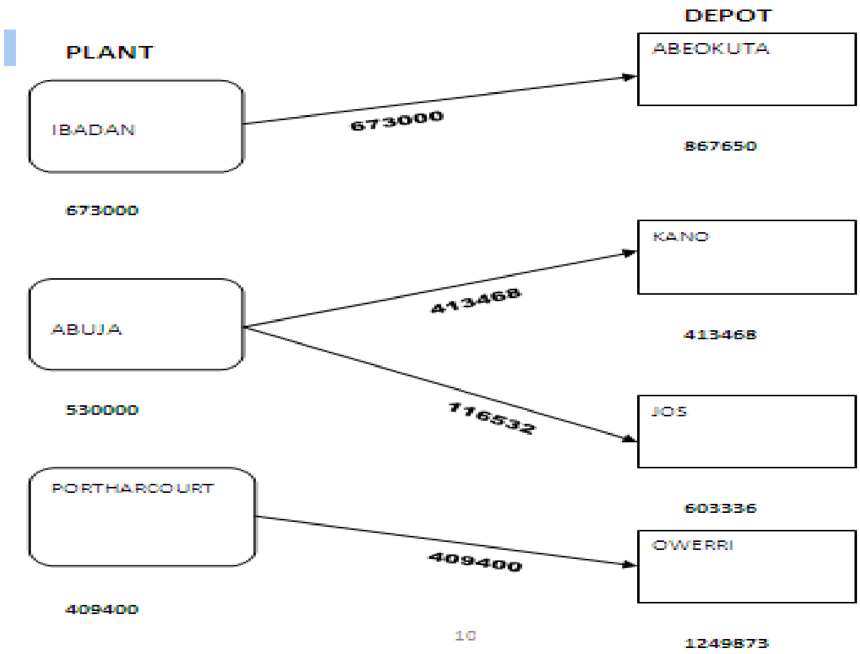
Table: 6 **OBJECTIVE VALUE : 19,566,332.00**

IV Discussion

The vogel's approximation method gives the total cost (29,097,700:00) that is close to the real optimal solution (19,566,332.00) which is minimum cost of transportation

Also, the cost estimated through the north-west corner method (36,689,050.00) is better than the one obtained through least cost method (55,250,034.00).

The network diagram below shows all the routes that can be used in other to minimize the total cost of transportation.



V. Conclusion

The data on the supply center capacity per year and the unit cost of transporting newspaper from each of the three (3) sources to twelve (12) destinations was analyzed in this research work, so as to obtain the optimum transportation cost and optimum transportation cost estimated is ₦19, 566, 332.00.

Also, Vogel's approximation method gave the value (₦29, 097, 700.00) that is closer to optimum solution. However, VAM is the best method out of suggested methods.

A dummy supply center with ten years capacity of 12,893,542 is created to make transportation problem a balanced one.

Also, the study revealed that a production center should be created at northern part of the country (Nigeria) to replace the dummy supply center used in the analysis, so as to make production capacity equal to requirement.

V. References

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