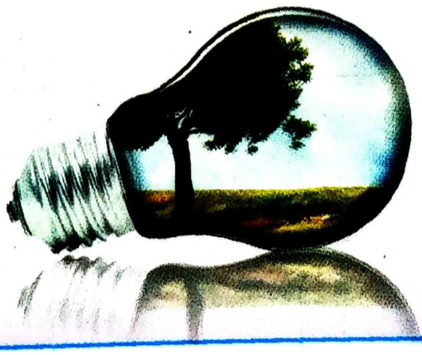
TECHNOLOGY FOR SELF RELIANCE

SCHOOL OF MANAGEMENT TECHNOLOGY (SMAT)

THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE,
ONDO STATE, NIGERIA

1st INTERNATIONAL CONFERENCE (SMAT 2017)



THEME

MANAGEMENT, TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

CONFERENCE HANDBOOK/ BOOK OF ABSTRACTS

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TUESDAY, 28TH - FRIDAY, 31ST MARCH, 2017

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CONFERENCE HANDBOOK/BOOK OF ABSTRACTS

Edited by:
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ISBN: 978-978-54000-4-5

KEYNOTE PRESENTATION

NIGERIA'S DESCENT INTO A CONSUMER NATION
Sustainable Industrialization and Development

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Paper Delivered at the First International Conference on Management, Technology and Sustainable Development
School of Management Technology
Federal University of Technology, Akure
Akure, Ondo State, Nigeria

TRANSPORTATION MODELLING: AN APPROACH FOR SUSTAINABLE TRANSPORT SYSTEM IN THE MANUFACTURING INDUSTRY

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ABSTRACT

This paper examined the physical distribution of finished product of a manufacturing industry so as to have an optimal allocation of shipment of products between the warehouses/depots and the dealers/distributors. The paper harnessed technological know-how to sustain transportation and logistics services in the country and to enhance a good decision making process for the transport industry in Nigeria. In the study, transportation model was deployed in solving the transportation algorithm using Tora 2.0 version software. Significantly, cost and time savings can be achieved using the models developed for determining the cheapest methods of transporting goods from several origins to different destinations. It is therefore recommended that the management of the organization should integrate operation research techniques in their decision making 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 the outcome of this study as a guide.

Keywords: Transportation model, minimization, optimal allocation and sustainable transport

1. Introduction

The development of transport services and infrastructure to handle freight flows has become an important factor of economic competition between regions and destinations. From this study the researchers observed that supply chain management is a recent development in the field of distribution and logistics. It helps trading and manufacturing companies and the government to distribute products within Nigeria. Many companies use the terms 'logistics' and 'supply chain' to describe a process in which internal and external units are merged to minimise cost and maximise profit in the shipment of their finished products to their customers and consumers (Nwaogbe-Obioma, Ukaegbu & Omoke, 2012). The management of transportation activities and functions is vital for efficient and effective movement of passengers and freight.

Freight transportation encompasses the movement of a wide variety of products, from comparatively low value-to-weight commodities such as grain, palm oil, crude oil and gravel, to high value-to-weight items such as computer parts, cosmetics, beverages and pharmaceuticals. It includes the transportation of easily perishable items such as fresh fruits and vegetables, a wide range of refrigerated items, and a growing number of time-sensitive items for which on-time delivery is crucial to business success. Products also need to be moved in an environmentally sound and socially acceptable manner (Nwaogbe-Obioma et al. 2013). One of the most important and successful applications of quantitative analysis in solving business problems has been in the physical distribution of products, commonly referred to as transportation problems. Basically, the purpose is to minimise the cost of shipping goods from one location to another so that the needs of each destination are met and every shipping location operates at the right capacity. However, quantitative analysis has been used for many problems other than the physical distribution of goods. For example, it has also been used to place employees in certain positions within an organisation (sometimes called the assignment problem) (Reeb & Leavengood, 2002).

Producers contribute significantly to the supply chain and inventory plays a major role in the efforts to deliver the product at the right place and on time. Longer lead times in shipping products will result in the need for ordering larger batch sizes. If the transport can be optimised and the lead time reduced, the buffer will be reduced and, in turn, inventory costs (capital costs) will be reduced. Furthermore, an efficient transport system will help to reduce inventory cost by minimising cost and time if the shortest route or network is found (Nwaogbe-Obioma et al. 2013). The supply chain is the lifeblood of the corporation and sales revenue depends on the efficiency of the supply chain and its effectiveness in delivering products (Dittman, Slone & Mentzer, 2010). Indeed, product availability is a critical measure of the performance of logistics and the supply chain (Coyle, Bardi & Langley, 2009). A problem at any of the logistics nodes can lead to unavailability of products to the various customers. Examples of problems that can disrupt the supply chain and lead to unavailability of either raw materials or finished products include demand-and-supply issues, product quality problems, and internal or external problems that affect the organization (Nawogbe-Obioma et al. 2013).

Supply chain management not only results in many valuable logistical improvements such as reduction in costs and decrease in cycle time, but also makes companies more competitive in today's dynamic market (Viswanadham & Gaonkar, 2003). Supply chain management is an integration of the business processes from the suppliers to provide products, services and information to the end customer, and also adds value for the end user and other stakeholders (Lambert & Cooper, 2000). Cost minimization of product transshipment for physical distribution management study was carried out by Nwaogbe-Obioma et al. (2013), in the study the researchers' concluded that one of the major tools for solving minimization and maximization problem in the logistics and supply chain management real life problem is transportation model. Furthermore, least cost method was used to minimize cost of distribution. Hence, significant savings was achieved by using techniques available for determining the cheapest methods of transporting goods from several origins to several destinations. Cost minimisation is a very useful approach to the solution of transportation problems.

Nwaogbe-Obioma, et al. (2014) studied travelling salesman routing problems in Akwa ibom State, Nigeria using dynamic programming approach. In their study on Travelling Salesman Routing Problems, they found the optimal distance for the sales man's trip and also minimized the cost of transportation by deploying Floyd's shortest route algorithm contained in version 2.0 of Tora software. Galadima et al. (2015) studied farm product distribution in Nigeria using transportation modeling. In their study, the result of the analysis shows that the transportation cost of the product were minimized to N712,800.00, compared to the current cost (N849,600.00); representing a 16.10% savings or (N136,800.00). Their policy implication was that the Management of the organization should adopt the routes used in the study in order to reduce the overhead (distribution) cost and boost its profit.

1.1 Objective of the study

The objective of the study is to determine the optimal allocation of shipments of two manufactured products between depots and the end users. The study is necessary because of the high operating costs associated with physical distribution when deliveries are not properly planned and evaluated with reference to alternative strategies. Planning adds the most value in making complex cost decisions and reducing high operating costs. A case study was deployed in the analysis. The supply chain management of Godrej Nigerian Ltd (a soap manufacturing company in Nigeria) was considered. The company is a part of the Godrej Group, based in India. It started operating in Nigeria in June 2010 and produces Tura soaps, creams and lotions.

1.2 Transportation models

A transportation model is concerned with the transport of goods from several supply locations to several customer locations. For physical distribution (transportation) of goods, supply locations (called origins) and a specified order have to be matched with a variety of transportation routes and a variety of costs. The structure of a transportation problem involves a large number of shipping routes from several supply origins to several demand destinations (Sharma, 2009). Determining optimal routes to minimise costs associated with physical distribution management has been a serious challenge to managers. However, linear programming can be used to generate practical applications of the model, which often serves more as a theoretical framework than offering empirical solution.

The principal objective, therefore, is to formulate the problem of finding the minimum-cost route as a transshipment model and then solve the transshipment model by transportation techniques. In the transshipment model, a commodity is allowed to pass transiently through other sources and destinations before it reaches its final, designated destination. The entire supply from all sources could potentially pass through a transshipment point before the products are moved to their final destination. This means that each source or destination node in the transportation network can be considered as both a transient source and a transient destination. Thus, the number of sources equals the sum of sources and destinations in the corresponding transportation model. The most important requirement of the transportation problem is advance knowledge of the method of distributing flows from each source to each destination, which is also a cost determinant. This view is corroborated by Sharma (2009).

The transshipment problem is concerned with allocating and routing flows of finished products or raw materials from a supply center to the destination via intermediate nodes (transshipment nodes). Furthermore, supply centers generate a surplus that must be distributed and each destination generates a given deficit. Intermediate nodes neither generate nor absorb flow. The total supply must equal the demand; if not, dummy nodes should be introduced appropriately. An industrial organisation may utilise a large number of distribution channels to make finished goods available to its customers, who may be spread over a large area. The transshipment problem thus assumes great importance in any manufacturing company.

For most manufacturing companies in Nigeria it is not financially viable to transport directly from the factory to the various demand destinations. This is due lack good road network in many cities. The high costs involved, together with the prevailing market conditions, force the decision maker to consider alternative channels of transporting the company's products. As bad roads make it difficult for companies, especially the ones operating in the south-eastern part of Nigeria, to transport their products to their customers, they often employ third-party logistics firms that are involved with warehousing, transport or indirect transportation channels. The products are therefore transported through one or more intermediate stages before reaching the final customer (demand destination). This approach is adopted by many industries in Nigeria. For example, Godrej Nigeria Ltd and Promasidor Ltd. European Soap Limited use an indirect transportation method, with Manufacturers Distribution Services (MDS) Logistics providing warehousing and other transport companies take care of transporting their products. Companies such as PZ Cussons PLC, Nigerian Breweries, Guiness Breweries and Rackit Benkiser use third-party logistics for distribution to their own warehouses.

2. METHODOLOGY

In solving a transportation problem, there are many methods that may be used. However, in this study we focused on the Vogel approximation method. This model determines the initial solution and a feasible solution satisfy all the supply and demand constraints, and also determines the optimal allocation of limited resources to meet given objectives. The resources may be labour, materials, goods, machines, vehicles, etc (Taha, 2007). Tora 2.0 version software will be used to run the analysis

2.1 Formulation of transportation model

A transportation model must include origins (plants or factories where products are produced) and demands of the finished products made by customers at various destinations. The reason for this is to achieve a certain objective, such as profit maximization or cost minimization. In this transportation model, let *m* factory (Aba) be the supplier of the products to *n* warehouses (Aba, Calabar, Enugu, Onitsha and Port Harcourt). In this case, Aba is the only factory and the warehouses or depots are Aba, Enugu, Onitsha, and Port Harcourt. (see Figure 1).

Let the factory or source of supply i (i = 1, 2, 3……, m) produce ai units and the destination j (j = 1, 2, 3,….., n) require bj units. The cost of transportation from factory i to warehouse j is cij.

The decision variable of this problem will be xij, which is the amount of transported from factory i to warehouse j (see Table 5 and Table 6).

$Min\ Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij}$ …. [Eqn1]

$S.\ T.\quad \sum_{j=1}^{n} X_{ij} = ai,$ for $i = 1, 2, \ldots, m$ [Eqn2]

$\sum_{j=1}^{n} X_{ij} = bj, for\ j = 1,2, \ldots n,$ [Eqn3]

$X_{ij} \geq 0$ for all i and j. [Eqn 4]

The feasible solution property: a transportation problem will have a feasible solution if, and only if:

$$\sum_{i=1}^{m} Si = \sum_{j=1}^{n} dj \ldots \qquad \text{[Eqn 5]}$$

Where: a_i = number of units being supplied by source i

d_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.

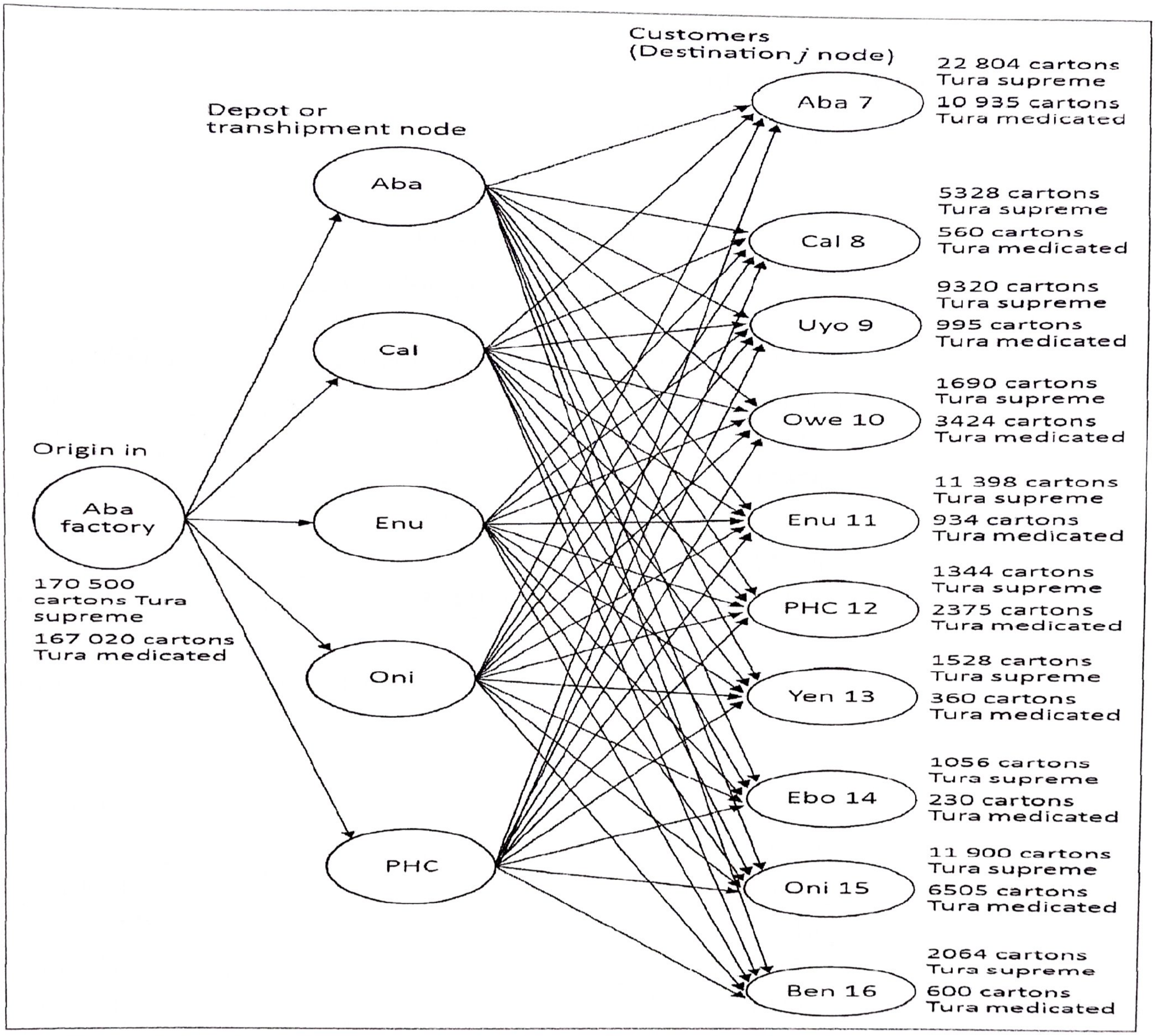
Transportation problem modelling shows that:

x_{ij} = number of soaps produced in a year i for supply in a year j

c_{ij} = cost associated with each unit of x_{ij}

b_j = number of scheduled for supply in a year j

a_i = production of soaps in a year i



Ben, Benue; Cal, Calabar; Ebo, Ebonyi; Enu, Enugu; Oni, Onitsha; Owe, Owerri; Phc, Port Harcourt;

Figure 1: Network model of the Distribution

3. Data

The sample comprises the production and depot stocks of the leading soap and cosmetics manufacturing company in Nigeria (Godrej Group). This sample size was determined as a function of data availability and in line with recommendations on the minimum sample size required to estimate the number of parameters in the models being tested (Staat, 2001; Zhang & Bartels, 1998). The required secondary data are mainly taken from various company depots and the main factory warehouse in Aba. The depots are in Aba, Calabar, Onitsha, Enugu, and

PortHarcourt. Furthermore, the study focuses on the regional operations in the South-East and some part of South-South region. Important statistics, cost of transportation and depots/factory output, +relating to the sample are summarised in Table 1 and Table 2.

Table 1: Quantity supplied from factory to Depot or Warehouse.

	Quantity Supplied (in Cartons per yr)		
Depot/Warehouse	**Tura Medicated**	**Tura Supreme**	**Total**
ABA	12625	37375	**50000**
CALABAR	4519	13298	**17817**
ENUGU	3275	9200	**12475**
ONITSHA	12445	22300	**34745**
PORTHARCOURT	6575	5700	**12275**
TOTAL	**39439**	**87873**	**127312**

Table 2: Quantity demanded from factory to Depot or Warehouse.

	Quantity Demanded (in Cartons per yr)		
Depot/Warehouse	**Tura Medicated**	**Tura Supreme**	**Total**
ABA	10935	22804	**33739**
OWERRI	1690	3424	**5888**
CALABAR	560	5328	**10315**
PORTHARCOURT	2375	1344	**5114**
ONITSHA	6505	11900	**12332**
EBONYI	230	1056	**3719**
BAYELSA	360	1528	**1888**
ENUGU	934	11398	**1286**
BENUE	600	2064	**18405**
AKWA IBOM	995	9320	**2664**
TOTAL	**25184**	**70166**	**95350**

Table 3: Input Grid of Transportation cost, Supply and Demand

		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Supply
	S/D Name	ABA	CAL	UY	OW	ENU	PH	YEN	EBO	ONI	BEN	
S1	ABA	15	70	30	30	60	45	90	90	40	120	50000
S2	CAL	70	15	35	100	90	90	105	100	100	110	17817
S3	ENU	60	90	85	105	15	100	140	50	40	90	12475
S4	ONI	40	100	65	60	40	90	120	80	15	80	34745
S5	PH	45	90	70	40	100	15	30	150	90	160	12275
Demand		33739	5888	10315	5114	12332	3719	1999	1286	18405	2664	

Table 4: Iteration 1 of Vogel Approximation Result

Iter 1	ObjVal=	1940080.00	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	Supply
	Name		ABA	CAL	UY	OW	ENU	PH	YEN	EBO	ONI	BEN	DummyD	
			v1=15.00	V2=15.00	V3=30.00	V4=30.00	V5=40.00	V6=15.00	V7=30.00	V8=75.00	V9=15.00	V10=80.00	V11=0.00	
S1	ABA	u1=0.00	15.00	70.00	30.00	30.00	60.00	45.00	90.00	90.00	40.00	120.00	0.00	
			33739		**10315**	**5114**							**832**	**50000**
			0.00	-55.00	0.00	0.00	-20.00	-30.00	-60.00	-15.00	-25.00	-40.00	0.00	
S2	CAL	u2=0.00	70.00	15.00	35.00	100.00	90.00	90.00	105.00	100.00	100.00	110.00	0.00	
				5888									**11929**	**17817**
			-55.00	0.00	-5.00	-70.00	-50.00	-75.00	-75.00	-25.00	-85.00	-30.00	0.00	
S3	ENU	u3=25.00	60.00	90.00	85.00	105.00	15.00	100.00	140.00	50.00	40.00	90.00	0.00	
							11189			**1286**				**12475**
			-70.00	-100.00	-80.00	-100.00	0.00	-110.00	-135.00	0.00	-50.00	-35.00	-25.00	

S4	**ONI**	**u4=0.00**		40.00	100.00	65.00	60.00	40.00	90.00	120.00	80.00	15.00	80.00	0.00	
								1143				**18405**	**2664**	**12533**	**34745**
				-25.00	-85.00	-35.00	-30.00	0.00	-75.00	-90.00	-5.00	0.00	0.00	0.00	
S5	**PH**	**u5=0.00**		45.00	90.00	70.00	40.00	100.00	15.00	30.00	150.00	90.00	160.00	0.00	
									3719	**1999**				**6557**	**12275**
				-30.00	-75.00	-40.00	-10.00	-60.00	0.00	0.00	-75.00	-75.00	-80.00	0.00	
	Demand			**33739**	**5888**	**10315**	**5114**	**12332**	**3719**	**1999**	**1286**	**18405**	**2664**	**31851**	

TABLE 5: Transportation Model Output Summary

From	To	Amt Sipped	Qty Coeff	Obj. Contrib.
S1: ABA	D1: ABA	33739	15.00	506085.00
S1: ABA	D3: UY	10316	30.00	309450.00
S1: ABA	D4: OW	5114	30.00	153420.00
S1: ABA	D1: DummyD	832	0.00	0.00
S2: CAL	D2: CAL	5888	15.00	88320.00
S2: CAL	D11: DummyD	11929	0.00	0.00
S3: ENU	D5: ENU	11189	15.00	167835.00
S3: ENU	D8: EBO	1286	50.00	64300.00
S4: ONI	D5: ENU	1143	40.00	45720.00
S4: ONI	D9: ONI	18405	15.00	276075.00
S4: ONI	D10: BEN	2664	80.00	213120.00
S4: ONI	D11: DummyD	12533	0.00	0.00
S5: PH	D6: PH	3719	15.00	55785.00
S5: PH	D7: YEN	1999	30.00	59970.00
S5: PH	D11: DummyD	6557	0.00	0.00

Objective Value (minimum cost) = **1940080.00**

4. DISCUSSION

Based on the analysis using the Tora software, the vogel approximation result gave only one iteration as shown in tables 4. Moreso, the final optimal solution shows various objective coefficients with policy implications which can be derived from table 5 above. From the transportation model output summary in Table 5, the total cost of transporting the products at minimal cost is N1, 940,080. The result shows that the Aba depot has a surplus of 832 cartons of the product after supplying the quantity demanded from the depot or warehouse by the customers. A dummy variable is therefore introduced to balance the transportation model as the demand is not equal to supply of the product. The Aba depot is the most cost-effective supply point for Aba, Uyo and Owerri customers. The Calabar depot supplies Calabar and has a surplus of 11 929 cartons of the product; a dummy variable is introduced to balance the transportation model. The Enugu depot supplies Enugu, Ebonyi and Benue customers with the required quantity of the products. Furthermore, the Onitsha depot supplies customers in Onitsha and has a surplus of 12 533 units, thereby introducing a dummy variable to balance the model in order to run the analysis and have a successful result. Finally, the Port Harcourt depot supplies Port Harcourt and Yenagoa customers and has a surplus of 6557 unit and this leads to introduction of dummy variable. Table 5 which is the final optimal solution show how the company can make their distribution and minimize cost and time. Their policy on economic way of distribution can be achieved through this solution.

5. CONCLUSION

This paper explored the transportation optimization model to solve the physical distribution problem of finished products from several depots (destination) in order to get a minimum cost and time for efficient distribution. The transportation problem was formulated as a linear programming problem, and solved using Vogel's approximation method (VAM), with Tora 2.0 version software to obtain the optimal solution. Significantly, cost and time savings can be achieved using the models developed for determining the cheapest methods of transporting goods from several origins to different destinations. It is therefore recommended that the management of the organization should integrate operation research techniques in their decision making 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 the outcome of this study as a guide.

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