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Analysis of Cost Optimization of Transportation in Akure, Nigeria

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Abstract: The transportation problem is a type of linear programming where the goal is to transport homogeneous products from various origins to different destinations while minimizing the total transportation cost. Recently, companies have realized the importance of reducing transportation costs and have turned to operations research techniques to optimize the process. This paper aims to develop an optimization model using linear programming to solve the transportation cost problem of Akure Bus Terminals. The model focuses on the operations of each park: North gate, Road-block, Benin Garage, Peace mass transit, and Ondo garage, and their routes to commercial cities such as Lagos, Ibadan, Benin, Abuja, and Kano. Data collection was done through questionnaires to both transporters and passengers to determine the cost of road transportation per trip in Ondo state. The study makes suggestions for reducing transportation costs to and from Akure, Ondo state.
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1. Introduction

All business environments face the challenge of transporting goods from factories to customers to maximize profits In order to maximize profits, businesses in all environments encounter the problem of transporting goods from factories to customers. The transportation problem is a fundamental aspect of network flow challenges that seeks to minimize costs and maximize profits, reducing costs and increasing profits are the primary objectives of network flow challenges that aim to solve transportation problems. Transportation models facilitate the proper flow of raw materials and finished products from sources to destinations while minimizing total costs, by determining optimal transportation schedules that consider supply and demand limits, transportation models ensure efficient and cost-effective flow of goods from factories to customers. The study focuses on minimizing transportation costs in Akure, Ondo state, by optimizing transportation schedules. This study aims to evaluate and optimize transportation schedules to reduce costs in Akure, Ondo State .Road transportation accounts for more than 90% of goods and passenger movement in Nigeria, making it the most widely used mode of transportation .In Nigeria, road transportation is the primary mode of transportation used for over 90% of all goods and passenger movement.

The study focused on using Vogel Approximation Method of Transportation Model to minimize transportation costs from various parks in Akure, Ondo State to their respective destinations. The data was collected through a designed questionnaire administered to transporters and passengers between Feb. 2022 to June 2022. The linear programming technique was used to solve the transportation problem. The objective of the study was to determine the best transportation schedule that minimizes transportation costs with supply and demand limits and to evaluate supply chain optimization with respect to the cost of transportation. The study was limited to cost minimization in the transportation schedule of Akure bus terminals, and various locations were considered for the optimization of the transportation problem. The result of the study will be useful for making strategic decisions by the logistic managers of Akure bus terminal.

2. Review of Literature

A change or development is called a movement and is a paramount aspect of humanactivity, it is said that all living things must move. This is so important to the organization. Without movement, no economy, no achievement, no progress for the development of any society, transportation is significant as it facilitate community development, optimum utilization of resource, allows and enhances the movement of people offers accessibility tohitherto inaccessibility areas easy. The economic development of many nations could behindered due to lack of transport facilities since transportation forms the basis of all socio- economy interaction. (5) suggest a general methodology based on robustoptimization to address the problem of optimally controlling a supply chain subject to stochastic demand in discrete time. Optimal supply chain management has been extensively studied in the past using dynamic programming (5).

2.1 Transportation Model

Transportation plays a critical role in the economy as it enables the movement of goods and people from one location to another. Improving transportation efficiency has the potential to reduce costs, increase productivity and boost economic growth. The studies described in the passage demonstrate the use of mathematical techniques and algorithms to optimize transportation operations and achieve these benefits. These include various methods of integer programming, dynamic programming and search heuristics. Such techniques can be used not only in the transportation of goods but also in the supply chain of agricultural commodities, energy plants, and logistics service providers. Additionally, using software packages such as QM and TORA can help to make strategic decisions and minimize transportation costs. By leveraging these techniques, transportation providers can improve their operations, enhance their competitiveness and contribute to the growth of the economy. However, transportation plays a critical role in driving economic growth and development. A well-functioning transportation system enables the efficient movement of goods and people, facilitates trade, and enhances connectivity between regions. Therefore, transportation improvements are essential to support economic growth and development. By using mathematical and optimization techniques, transportation problems can be solved efficiently and effectively, leading to cost savings, increased productivity, and improved service quality(8). It is crucial for policymakers, transportation planners, and logistics managers to consider various transportation solutions and optimization techniques to ensure sustainable and efficient transportation systems, leading to overall economic development and growth.

Improvements to transportation can be treated as a large-scale mixed-integer linear programming problem. In a study by (10), the distribution of a bottled liquid product was optimized through a 3-stage logistics system consisting of plants, distributors, and dealer. They formulated the problem using a 0-1 integer programming model, which included depot setup costs, delivery costs, and constraints on supply, demand, truck load capacity, and driver hours. The model further addressed customer allocation and depot location.

In (1), an integer programming model was developed to optimize a vehicle routing problem. The goal was to minimize the total distance traveled while delivering a single commodity from a central depot to multiple customer locations with known demand using a fleet of vehicles with identical capacity and relaxed total distance restrictions. The model included a sub-tour elimination constraint and was optimized using the branch and bound method. The CPLEX software was employed to solve the relaxed sub-problems.

Additionally, (3) used the tableau search heuristic approach to address a distribution problem that involves multi-trip vehicle routing and scheduling. The model considered constraints such as delivery time windows, multiple vehicle capacities, restricted access to some customers for certain vehicles, and driver maximum driving time with breaks.

In (4), the authors focused on the truck and trailer routing problem, a variant of the vehicle routing problem that considers real-world scenarios in which fleets of trucks and trailers service customers. The sub-tours are initiated at a customer on the main tour, where the truck disconnects, parks, attaches a trailer, and continues servicing customers on the sub-tour. The objective is to minimize the total distance traveled or costs incurred by the fleet. The authors used tabu search and deterministic annealing to solve the problem.

In (7), the authors addressed a transportation problem for a logistics service provider. The goal was to satisfy transportation requests between distribution centers, where each order had a specified size that fills a truck and a time window for pickup and delivery. Since consolidation was not an option, each order was transported directly from its source to its destination. In the context of agricultural commodities, (2) utilized dynamic programming (DP) to optimize the supply chain of willow biomass fuel to an energy plant. The DP approach encompassed not only transportation but also crucial aspects such as harvesting and natural drying of the biomass fuel. While linear programming (LP) and generalized minimum cost network flow approach are typically used for solving transportation problems, these methods are limited to single objective optimization with a focus on minimizing costs.(6) applied a GP model with penalty functions to optimize management decision-making in oil refineries in transshipment problems. They used linear programming and software packages like QM and TORA to run the model to optimality. Another study was conducted to minimize transportation costs at the Bus Terminal in Akure, Ondo state using transportation problem techniques like the Vogel Approximation method (V.A.M), the North West Corners method, and the Least Corner method. The results showed that the V.A.M was the best approach and could help to minimize transportation costs at the factory to N132 700 000.00million. By improving transportation connections from Akure to other commercial states in Nigeria, the research work could aid in improving the Gross Domestic Product (GDP), which is a commonly used measure of the size of an economy.

2.2. Akure Bus Terminal

There are different bus terminal in Akure. The bus terminal can travel from Akure to any location of one kind with different individual reasons like, trade, business, appointment, relocation, retirement, excursion, visitation, employment, political purpose and all. Since Akure city is expensive in produce i.e. high standard of living. Things are not cheaper in Akure compare to other Western Nigeria states. Things like: clothes, food stuffs, house rent, transportation fare and many more. This Paper will only look into commercial states from Akure bus terminal since there are much in bus terminal in Akure, Recognized bus terminal in Akure will be dealt with, which are: North gate bus terminus ,Roadblock bus terminus, Benin bus terminus, Peace Mass Transit, Ondo bus terminus.

3. Methodology

Transportation Model

The main focus of transportation models is to determine the most effective way to transport products from various production plants to a multitude of destinations, while minimizing transportation costs. The ultimate goal of the model is to ensure that all destination requirements are met, within the constraints of the operating environment. In any situation where there is physical movement of goods and people from one place to another, transportation costs need to be minimized in order to maximize profit. Transportation problems inevitably arise in such situations. The purpose of a transportation model is to assist top management in determining the number of people and goods that should be transported from the source location (park) to each destination, in order to fulfill the transportation company's overall demand and minimize transportation costs. Overall, transportation models are concerned with creating a plan that achieves the minimum possible cost of transporting goods from a given source (park) to multiple destinations (8).

A transportation problem involving the transportation of passengers from a park to various destinations was solved using linear programming. The objective function was set to minimize transportation costs. The solution involved the use of double subscripted decision variables.

4. 4. Method of Analysis

The method used for this analysis is Vogel Approximation Method of Transportation Model This is selected as the best used model because is one of the method used to calculate theinitial basic feasible solution to a transportation problem. It is an iterative procedure such thatin each step, we should find the penalty of each available row and column by taking the leastcost and second least cost.

The survey data were analyzed using Operation research technique. Specifically the use of linear programming tools to model the problem. The Transportation model, a popular approach in Literature, was adopted for this study to determine the minimum cost of LAN for transporting a product from various parts to different destinations.

Table 4.1.1: Distance from parks to destination

	Distance to destination in km				
Parks	Lagos	Ibadan	Benin	Kano	Abuja
FUTA Northgate	217	181	-	-	-
Roadblock	217	181	-	-	-
Benin	-	-	113	641	422
Ondo	217	-	113	-	422
PMT	217	181	113	641	422

Source: Author's field survey, 2022

Table 4.1.2: Constraint Cost per month

TRANSPORTATION EXPENSES

	MONTH					
COST ELEMENT	February	March	April	May	June	Total
Maintenance	80 000	80 000	80 000	80 000	80 000	400 000
Fuel	300 000	300 000	300 000	300 000	300 000	1 500 000
License	20 000	20 000	20 000	20 000	20 000	20 000
Personnel	8 000	8 000	8 000	8 000	8 000	40 000
Loading/off Loading	30 000	30 000	30 000	30 000	30 000	150 000
						752 000

Source: Author's field survey, 2022

Table 4.1.3: Transportation cost (nm) per busload per park

	Transportation cost Nm per bus Per destination (5 months)				
Park	Lagos	Ibadan	Benin	Kano	Abuja
FUTA North gate	1.6058	1.3394			
Roadblock	1.6058	1.3394			
Benin			0.8362	4.7434	3.1228
Ondo	1.6058		0.8362		3.1228
PMT	1.6058	1.3394	0.8362	4.7434	3.1228

Source: Author's field survey, 2022

*(217 km x 2) x (30days x 5months) x (N25 per km) = N1 605 800

Table 4.1.4: Transportation table

Parks	Lagos	Ibadan	Benin	Kano	Abuja	Supply
FUTA North gate	13500 4200	16200 3200				7400
Roadblock	13500 4200	13500 3200				7400
Benin			13500 3000	10500 8000	8400 12000	23000
Ondo	10500 4500		12600 3500	10500 8500		16500
PMT	6300 4700	4200 3800	6300 3700	8400 8500	6300 12700	33400
Demand	17 600	10 100	10 200	24700	24600	

Source: Author's field survey, 2022

*Number of Passengers X Number of daily trip per park

*18 x 5 =90, 90 x 28days=2520+2790+2700+2790+2700=13500

Table 4.1.5 Transportation Problem

	TRANSPORTATION(NM) COST PER BUSLOAD PER DESTINATION					
Parks	Lagos	Ibadan	Benin	Kano	Abuja	Supply
North gate	1.6058	1.3394				29 700
Roadblock	1.6058	1.3394				27 000
Benin			0.8362	4.7434	3.1228	31 500
Ondo	1.6058		0.8362		3.1228	36 600
PMT	1.6058	1.3394	0.8362	4.7434	3.1228	31 500
Dummy						3 450
Demand	29 850	27 150	31 650	36 600	34 500	

Source: Author's field survey, 2022

We introduced a variable (dummy), to make the transportation problem a balanced one

*(30days x 198 x 5months) x amount = 29 700 busloads (passengers + loads) (supply)

*(30 days x 199 x 5months) x amount = 29 850 busloads (passengers + loads) (demand)

4.2 Result Using QM

QM software is used to solve the Linear Programming of the transportation problem

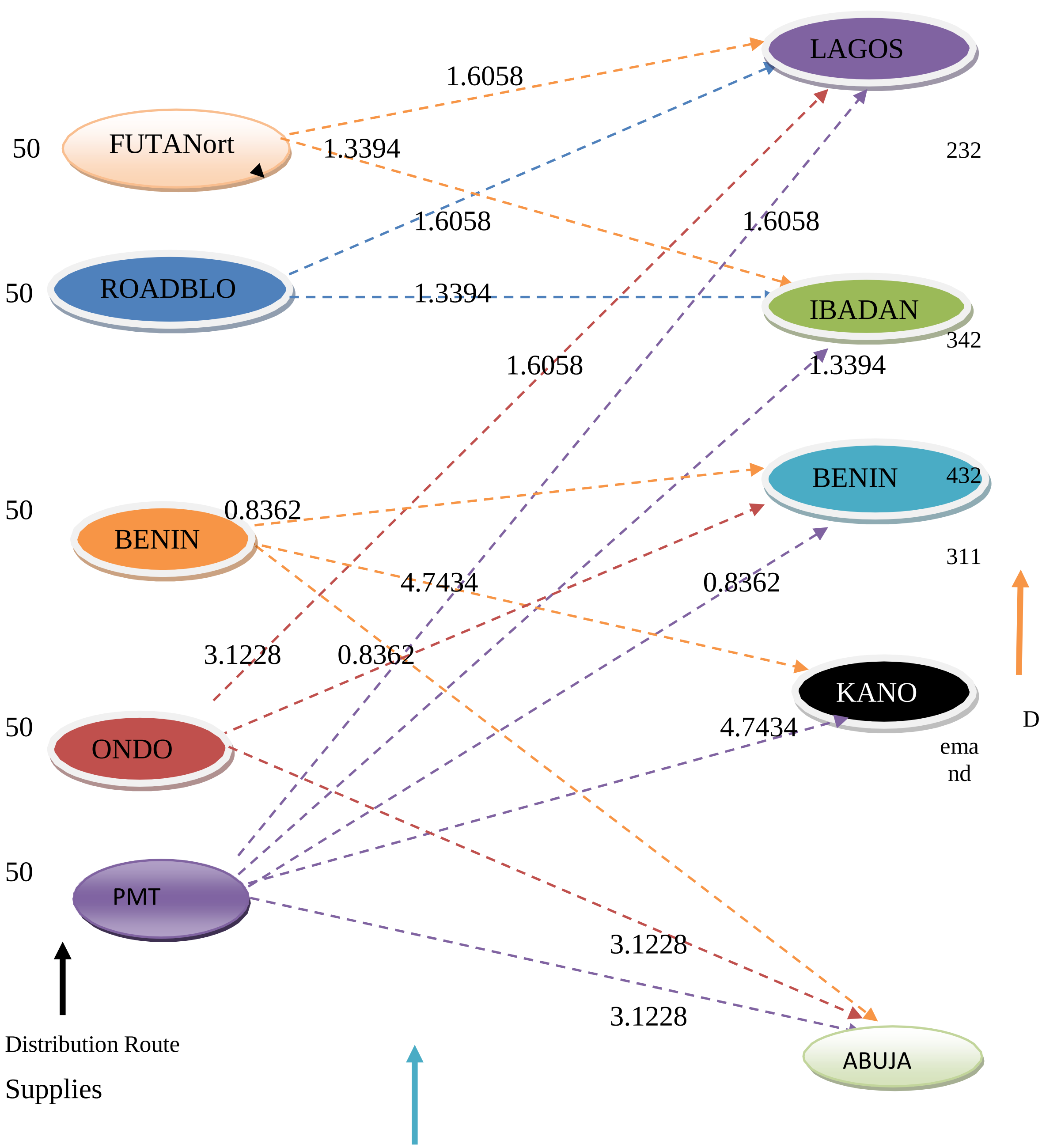
Table 4.2.1 shows that the transportation company total cost of N283,381,316 million, for transportation from the respective parks to its respective destination for 5 months. As can be seen from tables 4.2, there are some differences in transportation costs because of difference in the number of busloads per destination and distances from parks to destinations.

The next information of interest is the monthly demand and supply of the transportation trips. There is a network presentation of the transportation cost and to each destinations below:

4.3 TRANSPORTATION COST PER BUSLOAD

Park Destination

121



4.3.1 Formulation of transportation problem as a linear programming model

The objective function can be represented as:

Minimize Z = 1.6058X11 + 1.3394X12 + 1.6058X21 + 1.3394X22 + 0.8362X33 +4.7434X34 + 3.1228X35 + 1.6058X41+ 0.836243 + 3.122845 + 1.6058X51 + 1.3394X52 + 0.8362X53 + 4.7434X54 + 3.1228X55 {i.e. cost of transporting from Akure parks todestination} ………………………………...

Subject to:

X11+X12+X13+X14+X15 ≤ 29700

X21+X22+X23+X24+X25 ≤27000

X31+X32+X33+X34+X35 ≤31500

X41+X42+X43+X44+X45 ≤ 36600

X51+X52+53+54+X55 ≤ 31500

X61+X62+X63+X64+X65 ≤3450

X11 X21 X31 X41 X51 ≥29850

X12 X22 X32 X42 X52 ≥ 27150

X13 X23 X33 X43 X53 ≥ 31650

X14 X24 X34 X44 X54 ≥ 36600

X15 X25 X35 X45 X55 ≥ 34500

X16 X26 X36 X46 X56 - ----

And X11, X12,.................................. 65 all such values are ≥ 0

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

Subject to:

$\sum X_{ij} = S_i$, i = 1, 2 ...m

$\sum X_{ij} = D_j$, j = 1, 2...n $X_{ij} \geq 0$ for all i and j.

Solving the above transportation problem using TORA softwarepackage will result:

Minimum transportation cost Z = N132 700million.

X1= X12 = 29700.00, X2 = X21 = 1350.00 , X2 = X22 = 25500.00, X2 = X23 = 150.00, X3 = X34 =29850.00, X3 = X35 = 1650.00, X4 = X42 = 11100.00, X4= X45 = 25500.00,X5 =X52 = 3450, X5 = X53 = 31500

While other variables has zero value.

The approximated amount (N132 700million) represents the minimum transportation costsfor the transportation from the five parks to the five destinations. From the computer output/ result sheet, values in the VALUE Column are assigning to ourvariables to determine the bus schedules for the Transportation company

.

4.5.1 Result of the Analysis Using TORA

Table 4.5.2.1: Transportation Company Bus schedule

Park	Destination	Amount Shipped	Objective Coeffient	Objective Contribution
FUTA North-Gate	Lagos	0.00		0.00
FUTA North-Gate	Ibadan	29700		919.89
FUTA North-Gate	Benin	0.00		0.00
FUTA North-Gate	Kano	0.00		0.00
FUTA North-Gate	Abuja	0.00		0.00
Roadblock	Lagos	1350		7195.95
Roadblock	Ibadan	25500		5005.00
Roadblock	Benin	150		7193.25
Roadblock	Kano	0.00		0.00
Roadblock	Abuja	0.00		0.00
Benin	Lagos	0.00		0.00
Benin	Ibadan	0.00		0.00
Benin	Benin	0.00		0.00
Benin	Kano	29850		26480.85
Benin	Abuja	1650		32519.34
Ondo	Lagos	11100		26346.60
Ondo	Ibadan	0.00		0.00
Ondo	Benin	0.00		0.00
Ondo	Kano	0.00		0.00
Ondo	Abuja	25500		1002.02
Peace Mass Transit	Lagos	0.00		0.00
Peace Mass Transit	Ibadan	3450		0.00
Peace Mass Transit	Benin	31500	0.84	26346.60
Peace Mass Transit	Kano	0.00		0.00
Peace Mass Transit	Abuja	0.00		0.00
Total Transportation cost				**N132,649.44Million**

Source: Author's field survey, 2022

This computer result shows the procedures to obtain the optimal solution of the problem. Thisinvolves six (6) iterations and in each of the iteration different solutions were obtained. The optimal solution of the problem was obtained in 6th iteration. Where we have the summary of the sensitivity analysis of the problem.

The amount (N132 649.44million) represents the minimum transportation costs to transport its passengers and loads from the five parks to the five destinations.

Further interpreted that:

For variable X53, which is Peace mass transit to Ibadan Destination, the Value is a total of3450.00 busloads per month. For X12, which is FUTA Northgate Park to Ibadan Destination the number of busloads forthe five months is 29700.00, For variable X53, which is Roadblock to Benin Destination, the Value is a total of 150.00busloads per month.

For X21, which is Roadblock Park to Lagos Destination, the number of busloads for the five months is 25500.00

For X22, which is Roadblock Park to Ibadan Destination, the number of busloads for the five months is 1350.00

For X34, which is Benin Park to Kano Destination, the number of busloads for the five months is 29850.00

For X35, which is Benin Park to Abuja Destination, the Value is a total of 1650.00 busloadsper month.

For X45, which is Ondo Park to Abuja Destination, the number of busloads for the five months is 25500.00

For X42, which is Ondo Park to Lagos Destination, the number of busloads for the five months is 11100.00

For X53, which is Peace mass transit park to Benin Destination, the number of busloads for the five months is 31500.00

Summary

The study found that Akure Bus Terminal can save up to N132,700,000.00 million in transportation costs by applying transportation optimization techniques such as the Vogel Approximation Method. This cost savings can significantly improve the profitability of the business, leading to sustainable growth and development. The study also identifies the need for policymakers and transportation planners to prioritize investments in transportation infrastructure, maintenance, and modernization to address the challenges facing the transportation sector in Nigeria. Investments in modernizing the transportation sector will not only lead to cost savings but also enhance the safety, reliability, and efficiency of the transportation system.

Conclusion

In this paper, the problem was solved by using QM and TORA software package. The minimum cost for the operation was obtained as approximately N132 700million, which was smaller compared with the original cost (N284,133,316million).

Consequently, the Linear Programming and Sensitivity Analysis methods developed in this work yields an efficient compromise solution and overall decision maker to see exactly wherethey can make improvement for satisfaction.

However, the results showed that 68% of the company total expenditure under transportation sector for five months was on fuel, while 18%, 7% and 5% and 2% were on maintenance, Loading, License and Tax respectively.

It also recommends that the issue of conventional wisdom (i.e. if it is not broke, then don't fixit or that parts are expendable to some degree) should be eliminated.

5. RECOMMENDATIONS

This Paper does not end this way there are more to be done, this proposes the following:

i. The reduction in cost of maintenance per bus. That will be on Federal and State basis.
The Government should help solve the fuel scarcity and fuel subsidy.

ii. Non park transportation should not be encouraged, for the bad effect in the country

iii. Cost of maintenance should be reduced by the transporters.

iv. Non Terminal transportation should not be encouraged, for the bad effect in the country.

v. In order to make data –driven decisions to optimize transportation operations. This includes employing advanced analytics to analyze data on factors such as traffic patterns, passenger demand, and fuel efficiency, and using these insights to make informed decisions about route optimization and scheduling. Additionally, it suggests exploring alternative fuel sources and technologies, such as electric or hybrid buses, to further reduce costs and improve efficiency. By taking a data-driven approach and embracing innovation, transportation providers can improve operations and deliver more efficient and cost-effective services to passengers.

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