The Cost of Transporting Oil: a Case Study of Saudi Arabia

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***Abstract*— A special class of linear programming (LP) in operations research (OR) is the transportation problem (TP), which is the most important and successful implementation (OR). The transportation problem is an important aspect that has been studied in many processes including the field of study. Therefore, it is used to simulate many real -life problems. The main purpose of the method of solving the shipping problem is to reduce the cost or time of shipping. Initial Basic Feasible Solution (IBFS). The transportation problem can be solved using the northwest corner rule, the minimum cost method, and the Vogel approximation. In this paper, we used the Vogel approximation, the optimistic optimization conditions are confirmed. Therefore, the problem of optimizing the transporting of products is very important for different disciplines. (*Abstract*)**

***Keywords*— Transportation problem, Operation research, linear programming (LP)** *(key words)*

I. INTRODUCTION

When we talk about transportation, we are talking about moving something (people, animals or goods) from one point to other point by different transportation methods. The different modes of transportation are air transportation, water transportation, and land transportation, including rail transportation, road transportation and off-road transportation. Generally, transportation is used to move people, animals, or goods from one place to another. On the other hand, vehicles refer to transportation facilities used to transport people or goods according to the selected mode (animals, vehicles, cars, planes, ships, trucks, trains, etc.). (Litman, T. 2009)

In this paper we will talk about the problem of transportation which is very popular among many specific linear programming problems it is the called transportation problem. The model which customarily has been referred to as transportation problem comprises not only the delivery planning problem with given supplies and demands and with the criterion of minimizing the total transportation cost. Many other decision-making problems, whose contents are quite different from that of the delivery planning problem, reduce themselves to the transportation problem. For example, this is the case for the periodical production planning problem with given demands for the product in consecutive periods and with the criterion of minimization of the total production and storage cost. There exist effective algorithms solving the transportation problem in the case when all coefficients in the model, i.e. the supply and demand values as well as the unit transportation costs, are given in a precise way. In practice, however, this condition may not be fulfilled. For example, the unit transportation costs are rarely constant and predictable. Therefore, it seems that the ability to define and to determine the optimal solution of the transportation problem with fuzzy cost coefficients may be important. This is exactly the topic of our paper. (Chanas, S., & Kuchta, D., 1996)

II. METHODOLOGY

A. Research Approach

The methodical prepare of collecting and analyzing specific information show arrangement to vital request and evaluate result comes about is call data collection approach. Information collecting go through either one of two stages: first one is the essential information collection which comprise of raw information that can be separated into quantitative and qualitative strategies. Taking after, the second stage is the secondary information collection, which referred to as the used information collection of an ancient information that's already existed by another users.

Moreover, the type of strategy that will be utilized in this study will include the quantitative research strategy that's a primary strategy, since it includes mathematical calculation. An example of that would be an old data that give an overview of the situation. Since the study is based on data registered in the system used in Saudi Electricity Company called (SAP), quantitive research is the best approach to take.

The nature of the research problem being addressed which is the cost of transporting oil from point to point, the data collection completely depends on the registered data in the SAP system used in the company for the whole year of 2020. Analyzing the data related to the size of demand of receivers points which are generation power plants in Saudi Electricity Company, the size of supply of supplying points which are Aramco supplying stations and the cost of transporting the oil from supplying points to receiving point. All these data would be retrieved from the SAP system.

B. Research Design

The goal of research design is to combine relevance to the research intent with efficiency in procedure when collecting and analyzing data.

One of the earliest and most important applications of linear programming has been the formulation and solution of the transportation problem as a linear programming problem.

That is determining the optimal shipping schedule of a single commodity between sources and destinations. The objective is to determine the number of units to be shipped from the source i to the destination j, so that the total demand at the destinations is completely satisfied and the cost of transportation is minimum.

In this research problem to minimize the cost of transporting oil from different supplying points to different receiving points, there are several initial basic feasible solution methods and optimal methods for solving transportation problems satisfying supply and demand. The most three popular methods are Northwest Corner Method (NWCM), least Cost Method (LCM) and Vogel's Approximation Method (VAM) used to find initial basic feasible solution for the transportation model. For optimal solution we have used the Modified Distribution (MODI) Method.

Let us assume in general that there are m - sources S1, S2, ..., Sm with capacities a1, a2, ... , am and n - destinations (sinks) with requirements b1, b2, ..., bn respectively. The transportation cost from i th - source to the j th - sink is cij and the amount shipped is xij.

If the total capacity of all sources is equal to the total requirement of all destinations, what must be the values of xij with i = 1, 2, ..., m and j = 1, 2, ..., n for the total transportation cost to be minimum?

		(Sink) Destination						Availability
		D1	D2				Dn	ai
Sources	S1	C11	C12					a1
	S2	C21	C22					a2
	:	:	:					:
	:	:	:					:
	:	:	:					:
	Sm	Cm1	Cm2				Cmn	am
Demand (bi)		b1	b2				bn	$\sum a_i = \sum b_i$

(Table 3.2.1)

Upon examining the above statement of the problem, we realize that it has an objective function which is,

$$F(x) = c11\ x11 + ... + c21\ x21 + ... + c2n\ x2n + ... + cm1\ xm1 + ... + cmn\ xmn = \Sigma\ Cij\ Xij$$

(Formula 3.2.1)

Secondly, in view of the condition that the total capacity is equal to the total requirement, i.e.,

$$\Sigma\ ai = \Sigma\ bj, \qquad \text{(Formula 3.2.2)}$$

The individual capacity of each source must be fully utilized, and the individual requirement of each destination must likewise be fully satisfied. Hence, we have m capacity constraints and n requirements constraints. The capacity constraints impose on the solution the condition that the total shipments of all destinations from any source must be equal to the capacity of that source.

Thus,

$$xi1 + xi2 + ... + xin = ai, i = 1, 2, ..., m.$$

On the other hand, the requirement constraints require that the demand of every destination be fully satisfied by the total shipments from all sources.

Thus,

$$x1j + x2j + ... + xmj = bj, j = 1, 2, ..., n.$$

Thirdly, there are the usual non-negativity constraints, i.e. $xij \geq 0$ for all i and j. They are based on the practical aspect that either we shall send some positive quantity or no quantity from any source to any sink.

To sum up all formulas above, we have the following mathematical formulation of the transportation problem:

We create transportation table filled by the demand's quantity, Supply quantity and the transporting cost from supplying points to receiving points where the last column shows the total supply of each supplying points, the last row shows the total demands of each receiving points, and the cells in between show the cost of transporting the product. As shown in (Table 3.2.1).

III. ALGORITHMS OF THE THREE INITIAL BASIC FEASIBLE SOLUTION METHODS.

A. North-West Corner Method (NWCM) Algorithm:

Step 1: Select the North-West (upper left-hand) corner cell of the transportation table and allocate units according to the supply and demand. (Table 3.2.1)
Step 2: If the demand for the first cell is satisfied, then move horizontally to the next cell in the second column. (Table 3.2.1)
Step 3: If the supply for the first row is exhausted, then move down to the first cell in the second row. (Table 3.2.1)
Step 4: Continue the process until all supply and demand values are exhausted. (Table 3.2.1)

B. Least Cost Method (LCM) Algorithm

Step 1: First examine the cost matrix and choose the cell with minimum cost and then allocate there as much as possible. If such a cell is not unique, select arbitrary any one of these cells. (Table 3.2.1).
Step 2: Cross out the satisfied row or a column. If either a column or a row is satisfied simultaneously, only one may be crossed out. (Table 3.2.1)
Step 3: Write the reduced transportation table and repeat the process from step 1 to step 2, until one row or one column is left out. (Table 3.2.1)

C. Vogel's Approximation Method (VAM) Algorithm.

In this study we will focus on Vogel's Approximation Method (VAM) because the Vogel's approximation method (VAM) usually produces an optimal or near- optimal starting solution. One study found that VAM yields an optimum solution in 80 percent of the sample problems tested.

This method takes costs into account in allocation. Five steps are involved in applying this heuristic:

Step 1: Determine the difference between the lowest two cells in all rows and columns, including dummies. (Table 3.2.1).

Step 2: Identify the row or column with the largest difference. Ties may be broken arbitrarily. (Table 3.2.1).

Step 3: Allocate as much as possible to the lowest-cost cell in the row or column with the highest difference. If two or more differences are equal, allocate as much as possible to the lowest-cost cell in these rows or columns. (Table 3.2.1).

Step 4: Stop the process if all row and column requirements are met. If not, go to the next step. (Table 3.2.1).

Step 5: Recalculate the differences between the two lowest cells remaining in all rows and columns. Any row and column with zero supply or demand should not be used in calculating further differences (Table 3.2.1). Then go to Step 2.

D. Optimality Test for Transportation problem.

After finding the basic feasible solution, we check the optimality of the solution by the method we used. There are basically two methods to find the optimality:

a) Modified Distribution Method (MODI)
b) Steppingstone Method.

The modified distribution method, also known as MODI method or (u - v) method provides a minimum cost solution to the transportation problem. In the steppingstone method, we have to draw as many closed paths as equal to the unoccupied cells for their evaluation. To the contrary, in MODI method, only closed path for the unoccupied cell with highest opportunity cost is drawn.

Steps:

1. Use any of the three methods given below to determine the initial basic feasible solution:
a) Northwest corner rule
b) Matrix minimum method
c) Vogel approximation

2. Determine the value of the dual variables ui and vj, use ui + vj = cij

3. Use Δij=cij – (ui + vj) The computer will cost.

4. Check the sign of each opportunity cost.

a) If the opportunity cost of all unoccupied cells is positive or zero, the given solution is the optimal solution.

b) If the opportunity cost of one or more vacant units is negative, the given solution is not the best solution and can further save transportation costs.

5. Select the unoccupied cell with the smallest negative opportunity cost as the cell to be included in the next solution.

6. Draw a closed path or loop for the unoccupied unit selected in the previous step. Please note that right-angle turns in this path are only allowed at occupied cells and original unoccupied cells.

7. Specify alternate plus and minus signs at unoccupied cells at the corner points of the closed path and use plus signs at the cells being evaluated.

8. Determine the maximum number of cells that should be allocated to this empty cell. The minimum value with a negative position on the closed path indicates the number of units that can be transported to the incoming unit. Currently, this amount is included in all cells in the focus of closed road corners marked with more symbols, and it is subtracted from cells marked with a minus sign. In this way, an empty cell becomes a related cell.

9. Repeat the whole process until the optimal solution is obtained.

IV- DISCUSSION AND CONCLUSION

This chapter contains a wide scope of discussion, explanation and data analysis outcomes validation. Further, the chapter elaborates on the section of research restrictions and prospectus for future studies.

A Discussion

In this paper, a transportation problem in which costs, supplies and demands represented by the quantities transported from Aramco to Saudi Electricity Company has been studied. These are the main determinants of the cost of transporting oil. We discussed how to minimize the cost of the amount of consignment been transported from various origins to different destinations at the minimum cost without violating the availability and requirement constraints by the ideal utilization of linear programming and transportation problem.

From the previous data analysis in chapter four, we observed that my hypothesis of this research has been clarified and executed as follows:

Hypothesis -1: H1a: Changing the paths of transporting oil from supplier points to receives points will have an impact on the transportation cost.

Based on the data analysis and the results of using Vogel Approximation Method and MODI Method, it was observed that the total transportation cost of oil from Aramco to Saudi Electricity Company has been impacted by changing transporting paths.

This means that the hypothesis of "changing paths impacts the transporting cost" it has been failed to reject by the study as there are some paths has been changed and impacted the total transportation cost such as the paths to Tihama has been changed by transporting all its demand from Aramco – Yanbou instead of transporting 446,403,073.48 L from Aramco - Southern Jeddah to Tihama, transporting 74,39,127.87 L from Aramco – Southern Riyadh to Tihama and transporting 31,692,593.95 L from Aramco – Yanbu to Tihama.

Hypothesis -2: H2a: Using transportation problem of linear programming will lead to find the minimum cost of transporting oil from suppliers points to receivers points.

As per the data analysis, it was noted that using one of transportation problem techniques which is Vogel

Approximation Method and MODI leads to find the minimum cost of transporting oil from Aramco sources to Saudi Electricity Company destinations. This means the hypothesis of "transportation problem of linear programming will lead to find the minimum cost of transporting oil" has been failed to reject by the study where after using Vogel and MODI methods the total transportation costs became the minimum cost and changed from 105,390,942 SR. to 104,615,691.48 SR.

B Conclusion

The transportation problem approach we have used in this study helps solve not only the case of transporting oil from Aramco to Saudi Electricity Company but the most of the real-life transportation problems with multi objective and imprecise and precise parameters through an interactive decision-making process. This work aims to present an interactive possibilistic linear programming problem approach for solving multi objective transportation problems with imprecise cost, demand, and supply. By this approach, at the same time the most probable value of the imprecise total costs is minimized, opportunity of getting lower total cost is maximized and the risk of getting higher total cost are minimized. (Wang, R. C., & Liang, T. F. ,2005)

C Managerial Relevance

As aforementioned previously, the result of this research are of huge concern from the managerial spot as it identifies and analyses the a variety of factors that have a significant role in deciding the success of the organization.

Because the study has adhered the constraints of Aramco which are the number of sources and the supply capacity of each source and has adhered the constraints of Saudi Electricity Company which are the number of destinations and the demand capacity of each and the total transportation costs using data of a small period and a specific region became the minimum cost and changed from 105,390,942 SR to 104,615,691.48 SR.

So, these findings are holding immense importance with respect to the contract of transporting oil from Aramco to Saudi Electricity Company, as Saudi Electricity Company can take a decision to make new contract with the third party contractor upon the knowledge of these factors or edits the current with the third party contractors.

E Scientific Implications

As aforementioned previously in chapter one, the transportation problem is scientifically related to mathematical modeling techniques, in which linear functions are maximized or minimized when subject to various constraints called linear programming. This technique is very useful for guiding quantitative decision-making in business planning, industrial engineering, and (to a lesser extent) the social sciences and physical sciences. (Dantzig, G. B., & Thapa, M. N. ,2006).

The findings of this study came from using one of the three methods of transportation problem that find the basic feasible solution which is Vogel approximation Methods because the result of this method mostly is near to the optimum result. But the result of this method in this study is not better than result used by Saudi Electricity Company, so the Vogel approximation Method was not the optimum in this study.

After that to find the optimum result of our case we use Modified Distribution Method (MODI) or Steppingstone method. In this study we have used Modified Distribution Method (MODI) and we have found the optimum result which us better than the result used by Saudi Electricity Company.

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