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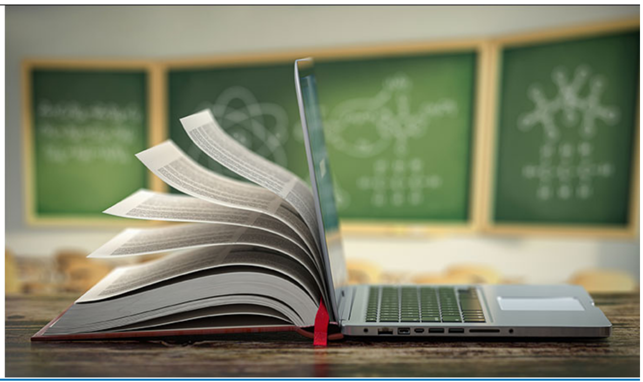

New Technique for Finding the Maximization to Transportation Problems

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Abstract. Transportation problems (TP) are one of the important problems in linear programming problems (LPP) that generally address the problems of transporting and distributing goods with the aim of achieving the largest profit or the lowest cost depending on the type of problem addressed. In this research study, a new technique was proposed to solve transportation problems with an objective function of the type of maximization that is used to achieve the highest possible profit. This technique was obtained by relying on a published research paper that deals with the same problem but with an objective function of the miniaturization type. The efficiency of this new technique was tested in terms of the type of results obtained when it was used to solve many transportation problems in life, and some of them were mentioned in this paper. After that, the solution results were compared using the proposed technique with the use of the three well-known classical methods which are NWCM, LCM, and VAM. Whereas, the results using the new technique were the required results that represent the optimal solution or close to the optimal solution.

Keywords. Operations Research, Optimization Problems, Transportation Model, Maximization of Transportation Problems, IBFS, VAM.

1. Introduction

In this fast-moving world the need for commodities increases day by day. Accordingly, the importance of transportation plays a big role in society. The profits and fortunes of firms that move goods from one place to another are determined by transportation. The transportation problem model is one of the well-known models in operations research that is concerned with finding the number of products transferred from a group of distributors to a group of warehouses through the road network so that the demand in the warehouses is met, but with the largest possible profit or the lowest possible cost depending on the type of problem. TP was first proposed by Frank L. Hitchcock (1875-1957) in 1941 in his paper “The distribution of a product from several sources to numerous localities”. In 1947, Tjalling C. Koopmans presented his paper entitled "Optimum utilization of the transportation system". The two aforementioned studies are the main achievements in developing various approaches to solving transportation problems [1- 2]. Transportation models focus mainly on the optimal method that achieves the maximum profit or the lowest cost according to the type of problem with which the homogeneous goods are to be transported from many factories (supply centers) to many warehouses (destinations). In this problem, the main goal is to find the optimal schedule for shipping the commodity while meeting the constraints of both supply and demand. In this study, transportation problems with an objective function of the type of maximization were addressed, and based on a detailed study of what researchers have done to develop solutions to this problem, a new technique has been proposed to solve these balanced and unbalanced problems [3- 4]. The proposed new technique through which the initial solution (and sometimes even gives the optimal solution) can be found, through which the optimal solution is easily reached. In recent years several methods have been proposed to find IBFS for a transportation model [5- 9]. After testing the new technique proposed in this paper it may be used to solve many transportation problems in public life, its efficiency had been proven by giving the required results that are better or equal to the results obtained by using the three well-known classical methods: NWCM, LCM and VAM. What distinguishes the new technique is that it includes clear and easy solution steps that can save a lot of time and effort when using it to solve various transportation problems. The authors introduced many articles to find the solutions in variant fields such as transportation problems, reliability, optimization, and so on. For examples, to find the optimal solution of nonlinear systems and optimization problems we used the trust region techniques [10- 13], conjugate gradient techniques [14- 18], line search techniques [19- 22], and projection technique [23- 25], and some article in reliability [26- 31], but in this work we introduce a new technique to finding the maximization to transportation problems

2. The Steps of the New Technique

The following solution steps are specific to the technique suggested in this paper:

Step 1) Building TP schedule.

Step 2) Transform the problem from *max* into *min* by subtracting every value from the largest value in TP schedule.

Step 3) Convert the unbalanced TP to balanced TP.

Step 4) At every row define the two minimum values and output the difference between these two values (called the penalty). And at every column define the two maximum values and output the difference between these two values (called the penalty).

Step 5) Determine which row or column corresponds to the largest difference obtained in Step 4.

Step 6) Assign the largest possible amount of demand and supply units to the cell with the lowest value in the specific row or column chosen in Step 5. If the highest differences are repeated, then the cell with the lowest value in the row or column corresponding to the largest difference is chosen. When there is a redundancy in the minimum cells, the cell that takes the maximum possible amount of allocation is chosen. If a repeat occurs in the maximum allotted quantity in the minimum cells, the cell corresponding to the largest is chosen from among the demand or supply.

Step 7) After allocating the maximum possible quantity for the selected cell, the row (or column) in which the supply (or demand) was consumed is removed.

Step 8) Repeat the solution steps from Step 4 until all supply and demand have been exhausted.

Step 9) Put the values of the decision variables x_{ij} into the TP schedule in Step 1.

Step 10) Apply the objective function to find the solution to the problem.

3. Numerical Examples

Example 1. There are three factories in different locations A, B and C. These factories supply shipments to three different warehouses I, II and III. Table 1 below shows the net profits for each product unit, along with the availability of companies and warehouse requirements. Find the appropriate allocation to maximize the overall return.

TABLE 1 The TP matrix of example 1

Origin	**Destination**			**Supply**
	I	**II**	**III**	
A	**24**	**28**	**21**	**65**
B	**27**	**25**	**26**	**110**
C	**23**	**22**	**29**	**75**
Demand	**100**	**70**	**80**	**250**

Solution: The mathematical model for Example 1 is:

Objective Function: $Z = \sum_{i=1}^{3} \sum_{j=1}^{3} c_{ij}\, x_{ij}$

Restrictions:

Supply Restrictions	Demand Restrictions
$x_{11} + x_{12} + x_{13} = 65$	$x_{11} + x_{21} + x_{31} = 100$
$x_{21} + x_{22} + x_{23} = 110$	$x_{12} + x_{22} + x_{32} = 70$
$x_{31} + x_{32} + x_{33} = 75$	$x_{13} + x_{23} + x_{33} = 80$

The above TP table is balanced because total supply = total demand = 250, and it must be converted into a miniaturization problem table as in the following Table 2:

TABLE 2 The TP matrix of example 1 converted into a miniaturization problem

Origin	**Destination**			**Supply**
	I	**II**	**III**	
A	**5**	**1**	**8**	**65**
B	**2**	**4**	**3**	**110**
C	**6**	**7**	**0**	**75**
Demand	**100**	**70**	**80**	**250**

According to the algorithm of the new technique, the following Table 3 is obtained:

TABLE 3 The TP matrix of example 1 according to the new technique

Origin	**Destination**						**Supply**	**Penalty**		
	I		**II**		**III**					
A	**0**	**5**	**65**	**1**	**0**	**8**	**65**	**4**	**4**	**4**
B	**100**	**2**	**5**	**4**	**5**	**3**	**110**	**1**	**1**	**2**
C	**0**	**6**	**0**	**7**	**75**	**0**	**75**	**6**	**-**	**-**
Demand	**100**		**70**		**80**		**250**			

Penalty	**1**	**3**	**5**		
	3	**3**	**5**		
	3	**3**	**-**		

$\therefore Z = (65 \times 28) + (100 \times 27) + (5 \times 25) + (5 \times 26) + (75 \times 29) \; = \; 6950$

Example 2. What is the appropriate allocation to maximize TP profit in following Table 4?

TABLE 4 The TP matrix of example 2

Origin	**Destination**			**Supply**
	I	**II**	**III**	
A	**4**	**10**	**7**	**40**
B	**11**	**12**	**16**	**35**
C	**18**	**3**	**14**	**51**
D	**11**	**15**	**6**	**37**
Demand	**54**	**61**	**48**	**163**

Solution: The mathematical model for Example 2 is:

Objective Function: $Z = \sum_{i=1}^{4} \sum_{j=1}^{3} c_{ij}\, x_{ij}$

Restrictions:

Supply Restrictions	Demand Restrictions
$x_{11} + x_{12} + x_{13} + x_{14} = 40$	$x_{11} + x_{21} + x_{31} + x_{41} = 54$
$x_{21} + x_{22} + x_{23} + x_{24} = 35$	$x_{12} + x_{22} + x_{32} + x_{42} = 61$
$x_{31} + x_{32} + x_{33} + x_{34} = 51$	$x_{13} + x_{23} + x_{33} + x_{43} = 48$
$x_{41} + x_{42} + x_{43} + x_{44} = 37$	

The above TP table is balanced because total supply = total demand = 91, and it must be converted into a miniaturization problem table as in the following Table 5:

TABLE 5 The TP matrix of example 2 converted into a miniaturization problem

Origin	**Destination**			**Supply**
	I	**II**	**III**	
A	**14**	**8**	**11**	**40**
B	**7**	**6**	**2**	**35**
C	**0**	**15**	**4**	**51**
D	**7**	**3**	**12**	**37**

Demand	54	61	48	163

According to the algorithm of the new technique, the following Table 6 is obtained:

TABLE 6 The TP matrix of example 2 according to the new technique

Origin	Destination I		Destination II		Destination III		Supply	Penalty			
A	0	14	27	8	13	11	40	3	3	3	3
B	0	7	0	6	35	2	35	4	4	4	4
C	51	0	0	15	0	4	51	4	-	-	-
D	3	7	34	3	0	12	37	4	4	9	-
Demand	54		61		48		163				
Penalty	7		7		1						
	7		2		1						
	-		2		1						
	-		2		9						

$$\therefore Z = (27 \times 10) + (13 \times 7) + (35 \times 16) + (51 \times 18) + (3 \times 11) + (34 \times 15) = 2382$$

4. Comparison the Results

The methods that used to find the optimal solution of TP differ mainly in terms of preference the solutions at the beginning. A good solution that has a beginning will produce the value of the objective function greater because the type of objective function in this problem covered in this study is of the type of maximization. The results of solving the examples presented in this paper have been compared to demonstrate the efficiency of the new technique. The results obtained were compared with the results of the three classic solution methods, namely NWCM, LCM and VAM. We can see from table 7 that the optimal solution obtained by the new technique is equal to other three methods regarding to example 1, but it better than NWCM and LCM but it also equal to VAM regarding to example 2. It should be noted that VAM is the best method of the classic methods for finding a solution, but it is characterized by the difficulty and complexity of its steps to find the solution. What distinguishes the new method is the simplicity and ease of its steps compared to VAM. In other words, we reached the same solution that obtained by VAM, but in fewer and easier steps, which leads to less effort and time to get the solution, and that is indicated the efficiency and goodness of the new technique.

TABLE 7 Comparison of the new technique with NWCM, LCM, and VAM

Name	NWCM	LCM	VAM	The New Technique
Ex 1	6560	6950	6950	6950
Ex 2	1062	2376	2382	2382

4. Conclusion

In this work, a new technique is proposed to find a solution to the TP with an objective function of maximization. By comparing the results of the new technique with the results of the three classic methods (NWCM, LCM, VAM), table (7) shows that the new technique gives better results or equal to the results of the other three methods. Note that we employed the new proposed technique to solve many balanced and unbalanced TP examples in the case of maximization and in most cases the desired results were obtained compared with the classical methods. It can be concluded that the new technique gives favorable and appropriate results and has easy solution steps in terms of understanding and application and thus a lot of time and effort is saved to obtain the optimal solution or near of it.

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