A Comparative Study of Two New Innovative Techniques for Solving the Transportation Problems and its Application in Real Life Engineering

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Abstract : In this paper the two new innovative approaches named NMD Method and ASM Method are used in solving a real life engineering transportation problem and have been compared on the basis of their respective optimality and iterations required. Numerical examples are used for comparison of these methods by comparing the iterations used and optimality of the obtained results.

1. INTRODUCTION

A Transportation problem is one of the earliest and most important applications of linear programming problem. Now a day's transportation problem has become a standard application for industrial organizations having several manufacturing units, warehouses and distribution centres. In a transportation problem certain amount of homogeneous commodity is available at number of sources and a fixed amount is required to meet the demand at each number of destination and a balanced condition (*i.e.* Total demand is equal to total supply) is assumed. Then finding an optimal schedule of shipment of the commodity with the satisfaction of demands at each destination is the main goal of the problem.

In 1941 Hitchcock [2] developed the basic transportation problem along with the constructive method of solution and later in 1949 Koopmans [8] discussed the problem in detail. Again in 1951 Dantzig [3] formulated the transportation problem as linear programming problem and also provided the solution method. The Simplex method is not suitable for the Transportation Problem especially for large Scale transportation problem due to its special Structure of the model. In 1954 Charnes and Cooper was developed Stepping Stone method for the efficiency reason.

For obtaining an optimal solution for transportation problems it was required to solve the problem into two stages. In first stage the initial basic feasible solution (IBFS) was obtained by opting any of the available methods such as "North West Corner", "Matrix Minima", "Least Cost Method", "Row Minima ", "Column Minima" and "Vogel's Approximation Method " etc. Then in the next and last stage MODI (Modified Distribution) method was adopted to get an optimal solution. Charnes and Cooper [1] also developed a method for finding an optimal solution from IBFS named as "Stepping Stone Method".

In this paper we are presenting two new approaches to solve the transportation problem. Above conventional methods need more iteration to arrive an optimal solution but these methods provide direct optimal solution with lesser number of iterations and its degeneracy. Hence, these two new methods have been compared and their application has been shown in the real life engineering problems.

ASM-Method

Step 1: Construct the transportation table from given transportation problem.
Step 2: Subtract each row entries of the transportation table from the respective row minimum and then subtract each column entries of the resulting transportation table from respective column minimum.
Step 3: Now there will be at least one zero in each row and in each column in the reduced cost matrix. Select the first zero (row-wise) occurring in the cost matrix. Suppose $(i, j)^{th}$ zero is selected, count the total number of zeros (excluding the selected one) in the i^{th} row and j^{th} column. Now select the next zero and count the total number of zeros in the corresponding row and column in the same manner. Continue it for all zeros in the cost matrix.
Step 4: Now choose a zero for which the number of zeros counted in step 3 is minimum and supply maximum possible amount to that cell. If tie occurs for some zeros in step 3 then choose a $(k,l)^{th}$ zero breaking tie such that the total sum of all the elements in the k^{th} row and l^{th} column is maximum. Allocate maximum possible amount to that cell.
Step 5: After performing step 4, delete the row or column for further calculation where the supply from a given source is depleted or the demand for a given destination is satisfied.
Step 6: Check whether the resultant matrix possesses at least one zero in each row and in each column. If not, repeat step 2, otherwise go to step 7.
Step 7: Repeat step 3 to step 6 until and unless all the demands are satisfied and all the supplies are exhausted.

NMD Method

Step I : Construct the Transportation matrix from given transportation problem

Step II : Select minimum odd cost from all cost in the matrix

Step III : Subtract selected least odd cost only from odd cost in matrix. Now there will be at least one zero and remaining all cost become even

Step IV : Multiply by $\frac{1}{2}$ each column (i.e. $\frac{1}{2}C_{ij}$) or To get minimum cost 1 in any column , if possible by dividing cost in that column.

Step V : Again select minimum odd cost in the remaining column except zeros in the column.

Step VI : Go to Step III. Now there will be at least one zero and remaining all cost will become even.

Step VII : Repeat step IV and V , for remaining sources and destinations till (m + n - 1) cells are allocated.

Step VIII : Start the allocation from minimum of supply and demand. Allocate this minimum of supply/demand at the place of 0 first and then 1.

Step IX : Finally total minimum cost is calculated as sum of the product of cost and corresponding allocated value of supply/ demand i.e.

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

2. APPLICATION IN REAL LIFE ENGINEERING

a) Railroad blocking problem

Railroads carry millions of shipments annually from their origins to their respective destinations. Shipment could be composed of a set of individual cars that all share a common origin and destination. To reduce the intermediate handling of shipments as they travel over the railroad network, a set of shipments is classified (or grouped) together to create a *block*.

The blocking problem is to identify this classification plan for all shipments in this network, called a blocking plan, so that the total shipment cost is minimum. A blocking plan significantly affects the shipment cost.

However, the blocking problem is a very large-scale optimization problem, and its complexity and sheer size have not allowed this problem to be solved to optimality or near-optimality satisfying all the practical considerations required for an implementable plan.

Example

Considering three number of trains started from a certain location and these carry fixed numbers of goods i.e. Cars from source station (Lucknow) to different destinations. Let the different trains and their destinations are:

Train name
i) First Train - T1
ii) Second Train - T2
iii) Third train - T3

Destination
a) Mumbai - D1
b) Nasik - D2
c) Nagpur - D3

ASM Method

The cost associated while carrying goods/ cars via different trains from source station to destination have summarised in a matrix and the maximum number of cars which a train could carry and the number of trains to be unloaded at the desired destinations are its constraints. The matrix for the same is as under:-

	D1	**D2**	**D3**	
T1	34	41	33	**63**
T2	37	32	45	**54**
T3	48	39	28	**58**
	72	**48**	**55**	

Step 1
Applying row minimisation in the above matrix

	D1	**D2**	**D3**	
T1	1	8	0	**63**
T2	5	0	13	**54**
T3	20	11	0	**58**
	72	**48**	**55**	

Step 2
Applying column minimisation in the above matrix

	D1	D2	D3	
T1	0	8	0	**63**
T2	4	$0_{(48)}$	13	**54/6**
T3	19	11	0	**58**
	72	**48/0**	**55**	

Step 3
On deleting column D2as the total number activities required at that destination has been fulfilled

	D1	D3	
T1	0	0	**63**
T2	4	13	**6**
T3	19	$0_{(55)}$	**58/3**
	72	**55/0**	

Step 4
On deleting column D3as the total number activities required at that destination has been fulfilled

	D1	
T1	$0_{(63)}$	**63**
T2	$4_{(6)}$	**6**
T3	$19_{(3)}$	**3**
	72	

Calculating the total cost associated after allocating to the above assignments

T2D2	=	48X32	=	1536
T3D3	=	55X28	=	1540
T1D1	=	63X34	=	2142
T2D1	=	6X37	=	222
T3D1	=	3X48	=	144

Total Minimum Cost = 5584

Using NMD Method

	D1	D2	D3	
T1	34	41	33	**63**
T2	37	32	45	**54**
T3	48	39	28	**58**
	72	**48**	**55**	

Step 1
Subtracting minimum odd cost (i.e. 33) from all other odd cost in the above matrix

	D1	D2	D3	
T1	34	8	$0_{(55)}$	**63/8**
T2	4	32	12	**54**
T3	48	6	28	**58**
	72	**48**	**55/0**	

Step 2
On deleting column D3as the total number activities required at that destination has been fulfilled

	D1	D2	
T1	34	8	**8**
T2	4	32	**54**
T3	48	6	**58**
	72	**48**	

Step 3
Multiplying each cost of remaining matrix by ½ we get:-

	D1	D2	
T1	17	4	**8**
T2	2	16	**54**
T3	24	3	**58**
	72	**48**	

Step 4
Subtracting minimum odd cost (i.e. 3) from all other odd cost in the above matrix:-

	D1	D2	
T1	14	4	**8**
T2	2	16	**54**
T3	24	0**(48)**	**58/10**
	72	**48/0**	

Step 5
On deleting column D2as the total number activities required at that destination has been fulfilled

	D1	
T1	14	**8**
T2	2	**54**
T3	24	**10**
	72	

Calculating the total cost associated after allocating to the above assignments

T1D3	=	55X33	=	1815
T3D2	=	48X39	=	1872
T1D1	=	8X34	=	272
T2D1	=	54X37	=	1998

T3D1 = 10X48 = 480

Total Minimum cost = 6437

b) Industrial Resource shipment problem

The three manufacturing industries HPCL (Mumbai), IOCL (Paradip), BPCL (Vishakhapatnam) delivering their oil tankers to their consumers which are as follows:

a) Tata chemicals (at Nanded)
b) Reliance yarn plant (at Nagpur)
c) Jindal Polyfilms (at Nasik)

The cost incurred while transferring their oil tankers to different destinations shown in the matrix given below.

	TATA	**RELIANCE**	**JINDAL**	
BPCL	116	168	34	**18**
IOCL	352	182	316	**25**
HPCL	166	348	258	**32**
	22	**26**	**27**	**75**

On solving the above problem we obtain, Total cost associated after allocating to the above assignments by

- **ASM Method**
  Total Minimum cost = 11484

- **NMD Method**
  Total Minimum cost = 13500

Comparison of the above approaches with the VAM method

	Example 1			**Example 2**		
	ASM Method	**NMD Method**	**VAM**	**ASM Metho**	**NMD Method**	**VA M**

				d		
Assignment cost	5584	6437	5584	11484	13500	114 84
Number of Iterations	4	6	5	3	7	5

3. CONCLUSION

From the above two processes used for solving a real life engineering problem through assignment, it has been found that ASM method could be used while implementing in real life engineering problems which although may also provide similar optimal result as through VAM but the number of iterations have been significantly reduced which ultimately reduce time, also it is more easier to perform.

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