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A NEW PROPOSED METHOD FOR SOLVING TRANSPORTATION PROBLEMS

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ABSTRACT
Transportation problems is a form of linear programming problem in which commodities are carried from a set of sources to a set of destinations based on the supply and demand of the source and destination, respectively, with the goal of minimizing overall transportation cost. Finding an initial basic feasible solution (IBFS) is required in the solution phase of a transportation problem in order to reach the optimal answer. Optimality provides us with the best route that prompts or has the lowest aggregate cost, whatever is desired. The Least-Cost Method and North-West Corner Method are two well-known current approaches that are compared to the proposed method and it is discovered that the latter produces superior outcomes. The researcher found the most feasible solution using the proposed method is the same as the optimal solution in some numerical examples.
KEY WORDS: ***Transportation problem, Initial Basic Feasible Solution, Supply and Demand, Optimal Solution***

1. INTRODUCTION

In the discipline of Applied Mathematics and Operation Research, Transportation Problem is a subset of Linear Programming Problem. Linear programming is an important mathematical method for dealing with the optimal use of limited resources. The term programming refers to the prediction of cost, utilization of resources, time, and profit, among other things. These are known as optimum problems.

The transportation problem is a type of linear programming problem that can be addressed using a reduced form of the simplex technique. The basic goal in such situations is to minimize the overall cost of moving a commodity (single product) from one or more origins (sources, suppliers, or capacity of the Centre) to different destinations (sinks, demand or requirement of Centre).

Transportation problem can be expressed mathematical as

$$\text{Minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} x_{ij} \ \text{(Total Transpiration Cost)}$$

$$\text{Subject to } \sum_{j=1}^{n} x_{ij} = a_i , \quad i = 1, 2, 3, \dots \dots . m \text{ (Supply from sources)}$$

$$\sum_{i=1}^{m} x_{ij} = b_j, \quad j = 1,2,3, \dots \dots n \text{ (Demand from destinations)}$$

$$x_{ij} \geq 0 , \quad \text{for all i and j}$$

$$\text{Supply} \left(\sum_{i=1}^{m} a_i \right) = \text{Demand} \left(\sum_{i=1}^{n} b_j \right)$$

Where Z : Total Transportation cost to be minimized.

C_{ij} : Unit Transportation cost of commodity from each source i to destination j.

x_{ij} : Number of units of commodity sent from source i to destination j.

a_i: Level of supply at each source i.

b_j : Level of demand at each destination j.

Tabular representation of Transportation problem

Source	**Destination**					**Total Supply**
	$\mathbf{D_1}$	$\mathbf{D_2}$	$\mathbf{D_3}$	----	$\mathbf{D_n}$	
S_1	$X_{11}(C_{11})$	$X_{12}(C_{11})$	$X_{13}(C_{11})$	----	$X_{1n}(C_{11})$	a_1
S_2	$X_{21}(C_{11})$	$X_{22}(C_{11})$	$X_{23}(C_{11})$	----	$X_{2n}(C_{11})$	a_2
S_3	$X_{31}(C_{11})$	$X_{32}(C_{11})$	$X_{33}(C_{11})$	----	$X_{3n}(C_{11})$	a_3
----	----	----	----	----	----	----
S_m	$X_{m1}(C_{11})$	$X_{m2}(C_{11})$	$X_{m3}(C_{11})$	----	$X_{mn}(C_{11})$	a_m
Total Demand	b_1	b_2	b_3	----	b_n	$\left(\sum_{i=1}^{m} a_i\right) = \left(\sum_{i=1}^{n} b_j\right)$

2. LITERATURE REVIEW

Sharma, S., & Nazki, H. (2020) the goal of this research is to find an ideal solution to a transportation problem by comparing the North West Corner Method, Least Cost Method, Vogel's Approximation Method, Stepping Stone Method, ASM Method, and ATM Method. Six strategies were used by the researcher in this work to find the initial basic feasible solution. The study discovered that the ASM technique produces a comparatively better outcome than other methods since it delivers an optimal answer directly, with fewer iteration. Furthermore, the ASM method takes less time and is simple enough for even a layperson to grasp and execute.

Kaur, L., Rakshit, M., & Singh, S. (2019) the research's purpose is to develop a better optimal solution to the transportation problem. The goal of this study is to find the initial basic feasible solution using VAM, MDM, and KCM methodologies and the ARPD (Average relative percentage deviation) technique. The researcher discovered that the KCM method is a better and more effective initial fundamental feasible solution, and the proposed technology is very simple to use and takes less time to compute.

V.T, L., & M., U. (2018) the primary goal of this researcher paper is to calculate the minimum transportation cost by comparing the initial basic feasible solution of a transportation problem using the North West Corner Rule (NWCR), Least Cost Method (LCM), Vogel's Approximation Method (VAM), Modified Vogel's Approximation Method (MVAM), and ASM Method. The researcher discovered that Vogel's Approximation Method (VAM), Modified Vogel's Approximation Method (MVAM), and ASM Method produced the same initial basic feasible solution for balanced transportation problem with minimum transportation cost as the remaining two methods, namely North West Corner Rule (NWCR) and Least Cost Method (LCM).

Raigar, S., & Modi, G. (2017) the objective of this study is to discover the best solution to a transportation problem while minimizing costs using the offered methods, North West Corner Rule (NWCR), Least Cost Method (LCM), Vogel's Approximation Method (VAM), and Modified Distribution Method (MODI). The study discovered that the proposed approach is an appealing way since it is very basic, easy to grasp, and produces results that are identical or even less than the VAM method. The researcher also compared the results of the Vogel's Approximation Method (VAM), Modified Distribution Method (MODI), and the suggested Method.

3. MATERIALS AND METHODS

The basic initial feasible solution methods to solve transportation problems are

3.1. North-West Corner Method (NWCM): The North-West Corner Method is an easy method for determining an initial feasible answer. The steps are as follows:
Begin at the transportation table's upper left (North-West) corner.

In the current row and column, compare the supply and demand values. Assign units to the lower supply or demand figure. If the demand in the column is met, proceed to the next column's right square. If the row's supply is depleted, proceed to the square in the following row. If both demand and supply are met, proceed to the diagonal square in the following column and row. Steps 2 and 3 must be repeated until all supply and demand needs are satisfied.

3.2 Least Cost Method (LCM): The Least Cost Method prioritizes cells with the lowest transportation costs. The steps are as follows:
Calculate the cost of transportation and choose the square with the lowest cost. In the event of a tie, choose an arbitrary choice. Based on supply and demand, allocate the most available units to the square at the lowest possible cost. Delete the row, column, or both that the allocation satisfied. Steps 1–3 must be repeated with the decreased transportation table until all supply and demand conditions are satisfied.

3.3. Vogel's Approximation Method (VAM): Vogel's Approximation Method seeks to optimally balance supply and demand by taking into account differences in transportation costs. The steps are as follows:
Determine the difference between the two lowest transportation costs for each row and column.

Choose the row or column with the greatest difference. Allocate the most units to the square at the lowest cost in the given row or column. Cross out the row or column that the assignment has satisfied.
Recalculate the row and column differences for each row and column except the ones that have been filled in and crossed out. Steps 2 through 5 should be repeated until all assignments are completed.

In this study, the researcher constructed a new technique to resolving transportation issues. The goal in these situations is to reduce the cost of carrying commodities from sources to destinations.

3.4. Proposed Method

Step-1: Determine the Penalty In the first approximation, calculate the penalty for each row and column by taking the absolute difference between the lowest cost ($C_{12)}$ and the next lowest cost (C_{11}) in each row, and between the lowest cost (C_{21}) and the next lowest cost (C_{11}) in each column. This helps it discover potential points for change.

Step-2: Determine the greatest and smallest differences. In this phase, find the greatest difference in column penalties ($Max(b_j)$) and the lowest difference in row penalties ($Min(a_i)$). This helps it decide which row and column to work on next. It generally chooses the cell (a_i, b_j) with the largest difference in column penalties and the smallest difference in row penalties.

Step-3: Find the least cost (x_{ij}) in the transportation table using the second approximation, assuming that a_i represents the smallest cost in the row and b_j represents the minimum cost in the column. This will help it populate the transportation table with values.

Step-4: Determine the first and second best approximations. Alternatively, it may be necessary to move back and forth between the first and second estimates until it achieves desired least cost. In each iteration, modify the transportation table by accounting for differences in penalties and computing the first and second estimates as needed. This procedure is continued until an optimal solution is found.

Step-5: Reduce Total Cost the transportation problem's ultimate goal is to reduce total cost of transportation. It should have an optimal solution that minimizes overall transportation costs while meeting the limitations of supply and demand after a few repeats of steps 1-4.

4. RESULTS AND DISCUSSION

Researcher has hypothetical example for proving the objective of the research

NUMERICAL ILLUSTRATION

In this paper, consider four different-size cost minimizing transportation problems, selected form literature. The researcher also use these examples to perform a comparative study of proposed algorithm with northwest corner and least cost methods. The researcher solve example 2 step-by-step continuous.

Table: 1

	Destination Source	D1	D2	D3	D4	D5	Supply	
Eaxmple-1	S1	4	1	2	4	4	60	273
	S2	2	3	2	2	2	35	
	S3	3	5	2	4	4	40	
	Demand	22	45	20	18	30	∑ 135	
Example-2	**Destination Source**	**D1**	**D2**	**D3**			**Supply**	143
	S1	6	8	4			14	
	S2	4	9	8			12	
	S3	1	2	6			5	
	Demand	6	10	15			∑ 31	
Example-3	**Destination Source**	**D1**	**D2**	**D3**	**D4**		**Supply**	415
	S1	7	5	9	11		30	
	S2	4	3	8	6		25	
	S3	3	8	10	5		20	
	S4	2	6	7	3		15	
	Demand	30	30	20	10		∑ 90	
Example-4	**Destination Source**	**D1**	**D2**	**D3**	**D4**		**Supply**	2850
	S1	3	1	7	4		300	
	S2	2	6	5	9		400	
	S3	8	3	3	2		500	
	Demand	250	350	400	200		∑ 1200	
Example-5	**Destination Source**	**D1**	**D2**	**D3**			**Supply**	555
	S1	6	4	1			50	
	S2	3	8	7			40	
	S3	4	4	2			60	
	Demand	20	95	35			∑ 150	

4.1 Example illustration

The researcher present here the step-wise solution of one of these problems for better understanding of the reader. Considering this, step by step allocations in various cost cells are explained below only for Ex-2 from Table 1

Table: 2

Destination Source	D1	D2	D3	Supply
S1	6	8	4	14
S2	4	9	8	12
S3	1	2	6	5
Demand	6	10	15	∑ 31

STEP-1: Calculate the penalty by taking the difference between lowest and next lowest cost in each row or columns

Table: 2.1

Destination Source	D_1	D_2	D_3	Supply	Row penalty
S1	6	8	4	14	2
S2	4	9	8	12	4
S3	1	5 2	6	0	1
Demand	6	5	15	∑ 31	
Column penalty	3	6	2		

STEP-2: Using Table 2.1, Taking smallest difference in row is min{2,4,1}=1 and largest difference in columns max{3,6,2}=6, x_{32}=min{5,10}=5 then delete the S3 row because its zero supply. $|D_2-S_3|=|10-5|=5$ is reaming demand

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Table: 2.2

Destination Source	D1	D2	D3	Supply
S1	6	8	4	14
S2	4	9	8	12
Demand	6	5	15	∑ 26

STEP-3: Now the researcher computing approximation the smallest cost in the transportation Table 2.2 is 4.

Table: 2.3

Destination Source	D1	D2	D3	Supply
S1	6	8	14 4	0
S2	4	9	8	12
Demand	6	5	1	∑ 12

X_{13}= min{14, 15}=14 then delete the S1 row because its zero supply |D3-S1|=|15-14|=1 is reaming demand

Table: 2.4

Destination Source	D1	D2	D3	Supply	Row penalty
S2	4	9	1 8	12-1	4
Demand	6	5	0	∑ 11	
Colum penalty	2	4	7		

STEP-4: Similarly repeat the above steps, Using Table 2.4 taking the smallest and next smallest penalty in each row{4} and each column {2,4,7} now taking minimum penalty in row is 4 and maximum penalty in column is 7 x23=min{12,1}=1 then delete D3 column.

Table: 2.5

Destination Source	D1	D2	Supply
S2	6 4	9	11-6=5
Demand	0	5	∑ 5

Now the researcher compute minimum cost in transportation Table 2.5 is 4, x21= min{6,11}= 6 then delete the D1colums because its zero demand |11-6|=5 is remand supply.

Table: 2.6

Destination Source	D2	Supply
S2	9 5	5-5=0
Demand	0	∑ 0

In last cell same penalty row and column, x22 =min{5, 5} = 5 then delete the whole matrix because its zero supply and demand

.

STEP-5: Using Table2 Total allocates the point for obtained minimize cost

Destination Source	D1	D2	D3	Supply
S1	6	1 8	14 4	14
S2	6 4	5 9	1 8	12
S3	1	5 2	6	5
Demand	6	10	15	∑ 31

Total Minimum Cost = 4*14+4*6+9*5+8*1+2*5=143

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The researcher compares the performance of the suggested approach to NWCM and LCM using five different-size examples. Table-3 shows that in instances 1, 2, 4, and 5, the result obtained through the proposed method is the same as the best result, while in case 3 it is near to the perfect answer. It is clear that this proposed method improves the current methods NWCM and LCM in terms of effectiveness.

Table 3

No: of example	Type of problem	Result of NWCM	Result of LCM	Result of proposed Method	Optimal Solution
Example-1	3*5	363	278	273	273
Example-2	3*3	228	163	143	143
Example-3	4*4	540	435	415	410
Example-4	3*4	4400	2900	2850	2850
Example-5	3*3	730	555	555	555

5. CONCLUSION

The researcher has created a recommended strategy for identifying the initial basic feasible solution of transportation challenges in this research study. The proposed method has been optimized as well. The Proposed method is compared to the Least Cost approach and the North West Corner Method after the researcher analyzed and compared the five numerical example. In comparison to standard methods, the proposed method provides more accurate results.

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