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Comparison of Performance of VAM and its Modifications in Case of Transportation and Trans-Shipment Problems

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Abstract: ***This research paper is about the comparison of performance of Vogel's Approximation method over its modifications using three key measures which are average iteration, number of best solutions, and computational time. The greater the performance of improved VAM technique, more effective the method will become to find out the optimum cost in case of transportation and trans-shipment problems. The characteristics of both IVAM and VAM methods varies with the size of the problem. The average iteration for a bigger sized problem effects the computational time. The use of total opportunity cost matrix and its effect on the computational time is shown in this paper. The appropriate method based on the problem size is also predicted in this paper.***

Keywords: IVAM, Trans-shipment, Total opportunity cost matrix, Computational time

1. Introduction

The transportation and trans-shipment problems are mainly concerned with the optimal way in terms of transportation cost in which utilities or products or raw material produced at different plants which are known as supply origins are transported to a number of warehouses or plants or customers which are known as demand destinations. The main objective in case of transportation problem is to fully satisfy the requirement at demand destinations within the maximum operating production capacity constraints at the minimum possible unit cost. This minimisation is generally done by finding the shortest path using network methods. Travel choice theory also plays a vital role in transportation problems. This is because of the reason that the travel behaviour varies from one person to another. Also the waiting time is overestimated which leads to inefficient operational process. Route time, travel time, and cost are the main factors which are needed to consider while designing any transportation model for any industry, plant, city or country.

Transhipment problem consists of shipment of products or goods or containers to an intermediate destination, and then from that intermediate destination to yet another destination with or without changing the media of transportation. Some of the possible reasons for this kind of transportation may be to change the means of transport during the journey known as transloading or when there is no direct air, land, or sea link between the source and destination or where the intended port of entry is blocked or to hide the identity of the origin of source. Another reason is to combine small shipments into a large shipment (consolidation), dividing the large shipment at the other end (deconsolidation). Trans-shipment usually takes place in transport hubs. Much international trans-shipment also takes place in designated customs areas, thus avoiding the need for customs checks or duties, otherwise a major hindrance for efficient transport [4].

The Vogel's Approximation Method or VAM is an iterative procedure calculated to find out the initial feasible solution of the transportation problem. Here the shipping cost is taken into consideration, but in a relative sense. Vogel's Approximation Method is also called as Penalty Method because the difference costs chosen are nothing but the penalties of not choosing the least cost routes. The Vogel's Approximation method is conventionally used in the transportation industry for cost effective transportations and trans-shipments. Every industry is facing new transportation and trans-shipment problems with the increase in the size of cost matrix due to increase in the cost and size of demand and requirement lots. That is why we need an appropriate approach to solve these kinds of problems. For solving such problems there are few important factors that are required to be taken into consideration before designing any kind of flow chart or algorithm or iterative procedure. These important factors are least average iterations, number of best solutions which are showing the accuracy of the method, and the CPU time for processing the problem so that the operation processing require least RAM memory and least configuration of processor for processing. These requirements are the base for performance measurements. Two authors Serdar Korukoglu and Serkan Balli [5] have been contributed in the performance evaluation of the improved VAM by considering above mentioned requirements. S. K.Goyal [1] has modified the VAM for unbalanced transportation problem by suggesting that the cost of transportation to and from a dummy should be assumed equal to the largest unit transportation cost before applying VAM. C.S. Ramakrishnan [2] has modified the Goyal's method by introducing some new iterative/calculation steps for initial reduction of the cost matrix before applying VAM. Daniel, Shimshak, James alan kaslik and Thomas Barclay [3] has modified the VAM using heuristics.

But our objective is to achieve an ideal Modified VAM method which can yield best- solutions not only for small sized but also for large lot sized transportation and trans-shipment problems along with the fulfillment of above discussed three important requirements. With the development in the technology and advancement in the field of computational sciences, this kind of improvement is a must. As use of MATLAB is increasing, there must be an algorithm whose time complexity should be as low as possible and which can predict upto n number of best solutions based on their ranks from first best solution to nth best solution. So that if it is not feasible by any reason to take path one for transportation of goods then the manager could choose from available "n" next options to complete the transportation of goods. This can decrease the ideal time for rework and decision making process and can hence increase the efficiency of the respective plant/industry.

2. Goyal's Modification of VAM

S.K. Goyal has modified the VAM method for unbalanced transportation problems which exists when demand and supply is not equal. And initially the unbalanced transportation problems were solved by inserting dummy rows or columns for balancing the demand and supply. But, S.K. Goyal pointed out that the cost of transporting products or goods to demand destinations from source in the dummy row/column is assumed to be zero which results into higher initial basic feasible solution in terms of optimal cost because goods or products are allocated to and from the dummy origin in the earlier stages of computations in case of VAM method. So to improve this mistake the author has suggested that the cost of transportation to and from a dummy should be assumed equal to the largest unit transportation cost before applying VAM so that the optimal cost can be reduced [1].

The problem considered for verification of S.K. Goyal's Method is shown in table1.

Table 1: Example for the verification of S.K. Goyal's Method

To 'j' / From 'i'	1	2	3	Supply
A	7	9	12	60
B	10	16	20	60
C	16	11	15	60
Demand	40	50	65	

The conventional solution obtained using VAM is as: -

Table 2: Example for the verification of S.K. Goyal's Method using VAM

To 'j' / From 'i'	1	2	3	Dummy	Supply
A	7	9	12 (60)	0	60
B	10 (40)	16	20	0	60
C	16	11(35)	15	0 (25)	60
Demand	40	50	65	25	180

Total cost of supplying the demand using VAM method is calculated as:
[(12*60)+(10*40)+(16*15)+(20*5)+(11*35)+(0*25)] =1,845.
Now, Initial solution by S.K. Goyal's Suggested Approach: -

Table 3: S.K. Goyal's Example solved using S.K. Goyal's approach

To 'j' / From 'i'	1	2	3	Dummy	Available
A	7	9	12 (60)	20	60
B	10 (40)	16	20	20(20)	60
C	16	11 (50)	15 (5)	20(5)	60
Required	40	50	65	25	180

Total cost of supplying the requirement = 2,245.

On comparing both the costs we get an increase of 400 unit cost. So, this example is showing the drawbacks of S.K. Goyal's method which are further modified by C.S. Ramakrishnan and is discussed in next section in detail.

3. C. S. Ramakrishnan Modification on Goyal's VAM technique

The author C.S. Ramakrishnan has suggested following approach as modification of Goyal's VAM technique:

The first step is to subtract the column from each column of the original cost matrix. Then in the second step replace the dummy cost cells row/column by the largest unit transportation cost in the reduced matrix obtained after applying step one[2]. Table 4 is showing the result obtained after applying first two steps on the considered example.

Table 4: S.K. Goyal's Cost Matrix

	1	2	3	4
A	0	0	0	9
B	3	7	8	9
C	9	2	3	9

In the third step subtract row minima and in fourth step subtract column minima for the dummy column which yields table 5.

Table 5: C.S. Ramakrishnan Modification

	1	2	3	4
A	0	0	0	9(3)
B	0	4	5	6(0)
C	7	0	1	7(1)

Now apply VAM to the reduced matrix which is yielding table 6.

Table 6: VAM procedure applied in C.S. Ramakrishnan Modification

To 'j' / From 'i'	1	2	3	Dummy	Supply
A	0 (5)	0	0 (55)	3	60
B	0 (35)	4	5	0 (25)	60
C	7	0 (50)	1 (10)	1	60
Demand	40	50	65	25	180

The optimal solution (zero cost cells only used):
A to 1(5), A to 3(55), B to 1(35), B to 4(25), C to 2(50), C to 3 (10).

Inserting objective function value in place of source to destinations format is yielding following optimal solution for total transportation cost =

[(7*5)+(12*55)+(10*35)+(0*25)+(11*50)+(15*10)] =1,745.

On Comparing C.S. Ramakrishnan's modification with S.K. Goyal's modification for the considered example we can predict that C.S. Ramakrishnan approach is way much better than S.K. Goyal's technique. But the number of iterations that we need to perform in C.S. Ramakrishnan's techniques are more as compare to that in case of S.K. Goyal's technique.

4. Improved Vogel Approximation Method using Total Opportunity Cost matrix

IVAM is widely used for large sized transportation problems. It is a good approach which is offering accuracy along with alternative solutions. IVAM use a special type of matrix called Total opportunity cost for solving balanced as well as unbalanced transportation problems.

Row opportunity cost matrix can be obtained by subtracting smallest cost of selected row from each element of the same row and for each row respectively.

Table 7: Row opportunity cost matrix

	1	2	3	4
A	7	9	12	0
B	10	16	20	0
C	16	11	15	0

Column opportunity cost matrix can be obtained by subtracting smallest cost of selected column from each element of the same column and for each column respectively.

Table 8: Column opportunity cost matrix

	1	2	3	4
A	0	0	0	0
B	3	7	8	0
C	9	2	3	0

Total opportunity cost matrix is sum of Row opportunity cost matrix and column opportunity cost matrix.

Table 9: Total opportunity cost matrix (TOC)

	1	2	3	4
A	7	9	12	0
B	13	23	28	0
C	25	13	18	0

The important point to note down regarding TOC matrix is that it considers highest three penalty costs and calculates alternative allocation costs in VAM procedure and then it selects minimum one of them. The total transportation cost for the feasible allocations using the original balanced-transportation cost matrix for the considered example is given in Table 10.

Table 10: Result of IVAM applied on considered example

To 'j' / From 'i'	1	2	3	Dummy	Supply
A	7	9	12 (60)	0	60
B	13 (40)	23 (15)	28 (5)	0	60
C	25	13 (35)	18	0 (25)	60
Demand	40	50	65	25	180

Total cost of supplying the demand using VAM method is calculated as:
[(0*25)+(13*40)+(23*15)+(13*35)+(12*60)+(28*5)] =2,180.

On comparing this result with S.K. Goyal's method we can observe an improvement of 65 unit cost. Hence we can conclude that IVAM approach is better than S.K. Goyal's technique irrespective of its time complexity for such a smaller matrix size problem. If we directly compare this method with VAM method then we can see that VAM method is providing us better solution for optimal transportation cost. VAM method is showing an advantage of 335 unit cost over IVAM. Hence for smaller sized problems as given by [5] VAM is better than IVAM. Also, the approach by C.S. Ramakrishnan is better than IVAM for solving small matrix size transportation as well as trans-shipment problems.

5. Methodology suggested for the Performance Evaluation

The methodology that can be followed for developing an efficient approach and predicting best fir method for particular type and particular size of problem is as follows:

Average Iteration (AI): Mean of number of iterations to obtain optimal solutions using initial solutions of VAM , S.K. Goyal's modified VAM, C.S. Ramakrishnan's modified VAM, and IVAM over different matrix sized (small to large) transportation and trans-shipment problems.

Number of best solutions (BS): A frequency which indicates the number of instances VAM, S.K. Goyal's modified VAM, C.S. Ramakrishnan's modified VAM and IVAM yielded optimal solution with lower iteration over the total of problem instances. NBS does not contain case of equal iteration between VAM S.K. Goyal's modified VAM, C.S. Ramakrishnan's modified VAM and IVAM.

Computation Time: The computational time is represented by three time variables:

1) Initial basic feasible solution computational time: the time to reach initial solution.
2) Optimal solution computational time: is the time to reach optimal solution from initial basic feasible solution to optimal solution.
3) Computational Total Time: is the total time from the beginning that is sum of initial basic feasible solution computational time and optimal solution computational time.

These parameters are responsible for the processing time of problem irrespective of its size. Average iteration is responsible for the determination of problem size and best suitable method for its solution whether it is VAM or IVAM because according to the literature provided by Serdar Korukoglu and Serkan Balli: VAM is best fit for small matrix sized problems and IVAM is best fit for Larger matrix sized problems. Number of best solutions are responsible for choosing alternative routes for transportation. It can provide us a better choices based on our priorities for selection of route. Cost is the key factor while choosing the routes. Computation time is decided by the time complexity of the algorithm. The method should be accurate but at the same time its time complexity must be as minimum as possible.

6. Conclusion

After reviewing all the literature it is found that for smaller sized problems the best fit method is C.S. Ramakrishnan's modified VAM followed by VAM but for larger sized problems the best fit method is IVAM. The main disadvantage of IVAM is its time complexity for smaller sized problem which is greater than the required. And the advantage here is its accuracy. But for processing trans-shipment problems we don't have a suitable approach. Based on the approach followed for transportation problems we can develop an algorithm for the processing of trans-shipment problems. Because in Industry we have several factors to consider but in cross countries transportation environmental hazards or conditions , suitable mode of transportation and privacy of origin of source is also an issue which needs to be considered and requires a lot more research and better approach for solving the trans-shipment problem. Routing process is also a key factor. Multiple routing can increase the complexity of activities inside a plant. Hence there is a need of algorithm which can provide us 'n' best possible routes considering all the factors including transportation cost respectively. So that the decision maker can make decision faster. This can improve the efficiency of plant at a desired optimal cost.

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