Operations Research

Application of the Vogel Approximation Method to Reduce Transport-logistics Processes

Submitted in partial fulfillment of the Operations Research Course – VIth semester by:

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ABSTRACT

In the last decade or so, much research has been done in the direction of Vogel's Approximation Method (VAM). In particular, some researchers have focused on the use of VAM or modified VAM in the domain of transport and logistics. The VAM is a technique of finding a highly optimized initial basic feasible solution to an allocation problem. The VAM is regarded as one of the best methods to solve any allocation problem ahead of Several existing algorithms such as the North West Corner Rule (NWC) and the Least Cost Method (LCM). In this report, we thoroughly dissect 3 recent and relevant papers that discuss the use of VAM or a modified version of VAM for solving transport/transshipment/logistics problems. *It is important to note that there is a paper with the same title as our topic. However, we are not using that paper as the basis of this report. We have summarized that paper in another report.*

Introduction

Logistics has undergone a major change in recent decades. Unlike in previous years, today it deals with the flow of material, information and financial resources in all areas of a company. This implies that logistics does not only deal with material flow in individual businesses, but also assesses individual influences from time, place and space point of view to satisfy customers and achieve optimal costs associated with these activities. It is a comprehensive science which improves corporate processes and enables the company to respond more quickly to market and customer demands. Nowadays, the emphasis is placed on the quality and high level of services provided; thus, the use of logistics is a necessity.

In any increasing competitive environment and even in companies, we must adopt an optimized transport logistic management system with the objective to increase the overall gain by minimizing the transportation costs. Along with economic improvement comes the shortening of travel routes, which is also associated with a reduction in the time required to carry out activities. Currently, there are many ways to optimize processes in a company. The most commonly used are those using operational research methods or graphical representations.

Methodology

In this report, we thoroughly review four papers that employ VAM (or its modified version) to solve transport-logistic problem.

The three papers chosen are as follows:

1) Improved Vogel's Approximation Method to Solve Fuzzy Transshipment Problem

2) An Improved Vogel's Approximation Method for the Transportation Problem

3) Logical Development of Vogel's Approximation Method (LD-VAM): An Approach to Find Basic Feasible Solution of Transportation Problem

It deals with determining a cost plan for transporting a single commodity from several sources to several destinations. The principal objective is to minimize the cost of shipping goods from one location to another so that the needs of each arrival area are met while ensuring that every shipping location operates within its capacity. In simpler terms, it aims to find the best way to fulfill the demand of n demand points using the capacities of m supply points. As one can imagine, transportation models like these play an important role in logistics and supply chains.

Vogel's Approximation Method (VAM)

VAM is based on the concept of penalty cost or regret. A penalty cost is a difference between the largest and next largest cell cost in a row or column. VAM allocates as much as possible to the minimum cost cell in the row or column with the highest penalty cost. The steps involved in the VAM are as follows:

Step 1: Balance the given transportation problem if either (total supply>total demand) or (total supply<total demand).

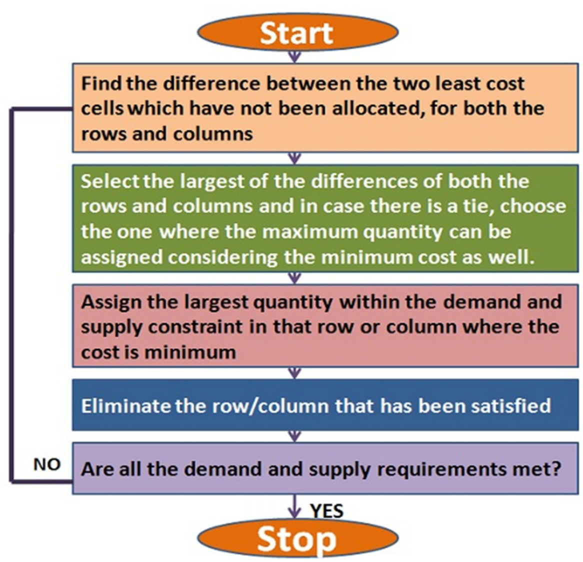
Step 2: Determine the penalty cost for each row and column by subtracting the lowest cell cost in the row or column from the next lowest cell cost in the same row or column.

Step 3: Select the row or column with the highest penalty cost (breaking ties arbitrarily or choosing the lowest-cost cell).

Step 4: Allocate as much as possible to the viable cell with the lowest transportation cost in the row or column with the highest penalty cost.

Step 5: Repeat steps 2, 3, and 4 until all requirements have been met.

Step 6: Compute total transportation cost for the feasible allocations.



Improved Vogel's Approximation Method to Solve Fuzzy Transshipment Problem

Introduction

Following the convention of traditional transportation problems, the authors in this paper have defined a supply point to be a point that can send goods to another point but cannot receive goods from any other point. Similarly, a demand point has been defined as a point that can receive goods from other points but cannot send goods to any other point. However, unlike trivial transportation problems that consider shipments to happen only between supply and demand points, this paper takes into account the "transshipment points," which are points that can both receive goods from other points and send goods to other points. This paper essentially models a fuzzy transshipment numerical problem and focuses on obtaining an optimal solution for it. The authors have used both the traditional VAM and an improved VAM (IVAM) approach for solving the numerical. Their results show that IVAM achieves a better solution than the traditional VAM.

Applying IVAM

VAM was improved by using total opportunity cost (TOC) matrix and regarding alternative allocation costs. The TOC matrix is obtained by adding the row opportunity cost matrix and column opportunity cost matrix.

Row opportunity cost matrix

For each row, the smallest cost of that row is subtracted from each element of the same row.

Column opportunity cost matrix

For each column of the original transshipment cost matrix the smallest cost of that column is subtracted from each element of the same column.

Following this, the steps applied are same as that of the standard VAM.

SIDENOTE – PAPER 1

CITATION

Gani, A. N., Baskaran, R., & Assarudeen, S. M. (2014). Improved vogel's approximation method to solve fuzzy transshipment problem. Intern. J. Fuzzy Mathematical Archive, 4(2), 80-87.

RESULTS

The results show that the initial basic feasible solution for their numerical calculated using IVAM (2475) is more optimized than the one calculated using VAM (2481.66).

Kindly refer to Appendix 1 (a separate docx file) for the mathematics used in solving the numerical.

An Improved Vogel's Approximation Method for the Transportation Problem

Introduction

The basic idea behind the study done in this paper was to get better initial solutions for the transportation problem. Several heuristic methods, as we know, are already available to get an initial basic feasible solution. However, there is a dichotomy associated with them. Although some heuristics can find an initial feasible solution very quickly, the solution they find is often not very good in terms of minimizing total cost. On the other hand, some heuristics may not find an initial solution quickly, but the solution they find is often excellent in terms of minimizing total cost. In this paper, VAM was improved by using total opportunity cost and regarding alternative allocation costs, applying VAM on the total opportunity cost matrix. In addition to this method, improved VAM (IVAM) considers the highest three penalty costs and calculates alternative allocation costs in the VAM procedure. Then it selects the minimum one out of them.

Applying IVAM

The authors improve the traditional VAM by using total opportunity cost (TOC) matrix and regarding alternative allocation costs. The TOC matrix is obtained by adding the "row opportunity cost matrix" and "cost opportunity cost matrix" (as discussed in the previous section). The proposed algorithm is applied to the TOC matrix, which considers the highest three penalty costs and calculates alternative allocation costs in the VAM procedure. Then it selects the least one of them, that is, the minimum. For better understanding, here are the steps of IVAM:

Step 1: Balance the given transportation problem if either (total supply>total demand) or (total supply<total demand).

Step 2: Obtain the TOC matrix.

Step 3: Determine the penalty cost for each row and column by subtracting the lowest cell cost in the row or column from the next lowest cell cost in the same row or column.

Step 4: Select the rows or columns with the highest three penalty costs (breaking ties arbitrarily or choosing the lowest-cost cell).

Step 5: Compute three transportation costs for selected three rows or columns in step 4 by allocating as much as possible to the feasible cell with the lowest transportation cost.

SIDENOTE – PAPER 2

CITATION

Korukoğlu, S., & Ballı, S. (2011). A Improved Vogel's Approximatio Method for the Transportation Problem. Mathematical and Computational Applications, 16(2), 370-381.

Kindly refer to Appendix 2 (a separate docx file) for the mathematics used in solving the numerical as well as for the graphs related to results.

Step 6: Select the minimum transportation cost of three allocations in step 5 (breaking ties arbitrarily or choosing the lowest-cost cell).
Step 7: Repeat steps 3-6 until all requirements have been met.
Step 8: Compute total transportation cost for the feasible allocations using the original balanced-transportation cost matrix.

Simulations

The main goal of the experiment was to evaluate the effectiveness of the initial solutions obtained by VAM and IVAM by comparing them with optimal solutions. Effectiveness indicates the degree of closeness between the initial solution and the optimal solution. The performances of VAM and IVAM are compared by the authors using the following measures:

Average Iteration (AI): Mean of iteration numbers to obtain optimal solutions using the initial solutions of VAM and IVAM over various sized problem instances.

The number of best solutions (BS): A frequency that indicates the number of instances VAM and IVAM yielded optimal solutions with lower iteration over the total of problem instances. NBS does not contain cases of equal iteration between VAM and IVAM.

Computation Time: The CPU time is represented by three variables: T1, T2, and T3. T1 is the time to reach an initial solution. T2 is the time to reach the optimal solution from the initial solution, and T3 is the total time from the beginning to the end (sum of T1 and T2).

Results show that the IVAM has better stats in all three metrics.

Logical Development of Vogel's Approximation Method (LD-VAM): An Approach to Find Basic Feasible Solution of Transportation Problem

Introduction

The authors aim to overcome existing limitations of the VAM by proposing a new algorithm - Logical Development of Vogel's Approximation Method (LD-VAM. Their results show that their proposed approach performs better than the traditional VAM algorithm for transportation problem.

Limitation of Existing VAM

In the VAM algorithm, select such row or column which contains the largest penalty to ensure the least cost in the current iteration and avoiding the chance of taking higher cost in the next iteration. If the highest penalty cost appears in two or more row or column, the VAM algorithm selects any one of them (or select the most top row or extreme left column).

However, it is not necessarily true that the largest penalty always ensures the lowest cost because the difference between the two pairs of numbers can be equal when one of the pair is smaller than another pair.

For example, differences between 11 and 6 and between 8 and 3 are equal, but the lowest numbers exist in the second pair. For that reason, we can say that in the VAM algorithm, if the lower pair does not appear in the topmost or extreme left position, then the lowest cost will not be selected in the current iteration. Therefore, the total transportation cost in the initial basic feasible solution may not be minimized.

Steps Involved in the Proposed Algorithm: Logical Development of Vogel's Approximation Method (LD-VAM):

Step 1: If $s<0$ and $d<0$, then Stop.
Step 2: If supply and demand are unbalanced, then balance the transportation problem by adding dummy demand or supply.

SIDENOTE – PAPER 3

CITATION

Das, U. K., Babu, M. A., Khan, A. R., Helal, M. A., & Uddin, M. S. (2014). Logical development of Vogel's approximation method (LD-VAM): an approach to find basic feasible solution of transportation problem. International Journal of Scientific & Technology Research (IJSTR), 3(2), 42-48.

Kindly refer to Appendix 3 (a separate docx file) for the mathematics used in solving the numerical.

Step 3: Calculate the penalty like in the traditional VAM.
Step 4: Select the lowest cost of that row or column, which has the largest penalty. If more than one row or column has the same penalty metric, select that row or column, which contains the least cost among them.
Step 5: Allocate the maximum possible amount x_{ij}. If the lowest cost appears in two or more cells in that row or column, choose the extreme left or the most top cell with the lowest cost. If a tie occurs in the largest penalties in some rows or columns, select that row or column containing the least cost among them.
Step 6: Adjust the supply and demand and cross out the satisfied row or column. If row and column are satisfied simultaneously, then crossed out one of them and set zero supply or demand in the remaining row or column.
Step 7:

a) If exactly one row or one column with zero-sum has (remaining) zero supply or demand remains uncrossed out, Stop.
b) If only one row or column with positive supply or demand remains uncrossed out, determine the basic variables in the row or column by the Least-Cost Method.
c) If all uncrossed out rows or column variables by the Least-Cost Method. Stop.
d) Otherwise, go to Step-3.

Advantage of the LD-VAM over the VAM

The LD-VAM resolved the problem of the VAM i.e., when the largest penalty appears in two or more rows or columns; then, it selects that row or column, which contains the least cost and gives the maximum possible allocation thereby providing the lowest feasible solution.

Analysis & Results

By solving a numerical using both ways, the authors prove that the LD-VAM provides a lower feasible solution than the VAM which is very often close to the optimal solution and sometimes even equal to optimal solution. For further results, see appendix 3.