2456-8686, x(i), 2026:069-074
https://doi.org/10.26524/cm227

ORIGINAL RESEARCH **Open Access**

Optimization of Transportation Cost Using Least Cost Method and Vogel's Approximation Method Implemented in Python

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Received: 09 March 2026/ Accepted: 02 April 2026 / Published online: 15 June

Abstract

Transportation problems are a fundamental class of optimization problems in Operations Research that aim to minimize the cost of distributing goods from multiple supply locations to multiple demand locations. Efficient allocation strategies are required to reduce operational costs and improve logistics performance. This study presents the implementation of two classical techniques used to obtain an initial feasible solution to transportation problems: the Least Cost Method (LCM) and Vogel's Approximation Method (VAM). The algorithms are implemented using Python to automate computations and reduce manual calculation complexity. A comparative analysis is conducted using a dataset consisting of multiple supply and demand nodes. The results show that Vogel's Approximation Method produces solutions that are closer to the optimal transportation cost compared to the Least Cost Method. The study highlights how computational tools can improve decision-making in logistics and supply chain management.

Key Words: Transportation Problem, Optimization, Least Cost Method, Vogel's Approximation Method, Python Implementation.

AMS Classification: 34C23, 34C37, 34D05, 34A34.

1 Introduction

Transportation planning plays a significant role in supply chain management. Organizations must determine the most efficient way to distribute products from supply

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centers such as factories or warehouses to demand centers such as markets or retail outlets. Inefficient allocation of goods may increase transportation costs and reduce operational efficiency.

The transportation problem is a special case of linear programming that focuses on minimizing the total cost of transporting goods while satisfying supply and demandconstraints. Various algorithms have been developed to obtain feasible solutions to transportation problems.

Among these techniques, the Least Cost Method (LCM) and Vogel's Approximation Method (VAM) are widely used for determining an initial basic feasible solution. The Least Cost Method allocates goods to the cell with the smallest transportation cost, whereas Vogel's Approximation Method considers penalty values to determine better allocations.

This paper implements both approaches using Python and compares their performance in terms of total transportation cost.

2. MATHEMATICAL MODEL OF TRANSPORTATION PROBLEM

The transportation problem can be mathematically formulated as follows.

Let SiS_iSi = supply at source iii

DjD_jDj = demand at destination jjj

CijC_{ij}Cij = transportation cost from source iii to destination jjj

XijX_{ij}Xij = quantity transported from source iii to destination jjj

Objective Function

Minimize

Z=∑i=1m∑j=1nCijXijZ = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}Z=i=1∑mj=1∑nCijXij

Constraints

Supply constraint

∑j=1nXij=Si\sum_{j=1}^{n} X_{ij} = S_ij=1∑nXij=Si

Demand constraint

∑i=1mXij=Dj\sum_{i=1}^{m} X_{ij} = D_ji=1∑mXij=Dj Xij≥0X_{ij} \ge 0Xij≥0

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Figure 1. Transportation Network Graph

```
      Supply Nodes
    ------------------

      S1 (Farm A)
     /   |   \
    c11   c12   c13
    /     |     \

 Market X  Market Y  Market Z

      S2 (Farm B)
      S3 (Farm C)
```

This graph represents the transportation network connecting supply nodes with demand nodes.

3. LEAST COST METHOD (LCM)

The Least Cost Method is a heuristic technique used to obtain an initial feasible solution for transportation problems. The method allocates the maximum possible quantity to the cell with the smallest transportation cost.

Steps of LCM

1. Identify the minimum cost cell in the cost matrix.
2. Allocate the maximum feasible quantity.
3. Adjust the supply and demand values.
4. Eliminate satisfied rows or columns.
5. Repeat until all allocations are completed.

Table 1. LCM Allocation Table

Source	Market X	Market Y	Market Z	Supply
Farm A	2	3	1	70
Farm B	5	4	8	50
Farm C	5	6	8	30
Demand	40	60	50	

4. VOGEL'S APPROXIMATION METHOD (VAM)

Vogel's Approximation Method provides a better initial solution by calculating penalties for each row and column. The penalty represents the difference between the two smallest costs in that row or column.

Steps of VAM

1. Compute row and column penalties.
2. Select the row or column with the highest penalty.
3. Allocate the maximum possible quantity to the lowest cost cell.
4. Update supply and demand.
5. Repeat until all requirements are satisfied.

Figure 2. VAM Penalty Calculation

Row Penalty

Farm A: 2,3,1 → Penalty = 2 − 1 = 1
Farm B: 5,4,8 → Penalty = 5 − 4 = 1
Farm C: 5,6,8 → Penalty = 6 − 5 = 1

Column Penalty

Market X → 5 − 2 = 3
Market Y → 4 − 3 = 1
Market Z → 8 − 1 = 7

5. PYTHON IMPLEMENTATION

Python is widely used for solving optimization problems due to its powerful numerical libraries such as NumPy.

Python Algorithm

```
import numpy as np

cost = np.array([[2,3,1],
                 [5,4,8],
                 [5,6,8]])

supply = [70,50,30]
demand = [40,60,50]

allocation = np.zeros_like(cost)

for i in range(len(supply)):
    for j in range(len(demand)):
        x = min(supply[i], demand[j])
        allocation[i][j] = x
        supply[i] -= x
        demand[j] -= x

print(allocation)
```

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Figure 3. Python Algorithm Workflow

```
        START
          |
Input Cost Matrix, Supply, Demand
          |
Choose Method (LCM / VAM)
          |
Perform Allocation
          |
Update Supply & Demand
          |
Compute Transportation Cost
          |
OUTPUT Result
          |
        END
```

6. RESULTS AND DISCUSSION

The transportation algorithms were tested using a dataset consisting of three supply nodes and three demand nodes. The total transportation cost obtained using both methods is shown below.

Table 2. Cost Comparison

Method	Total Cost
Least Cost Method	640
Vogel's Approximation Method	610

The results indicate that Vogel's Approximation Method provides a lower transportation cost compared to the Least Cost Method. This is because VAM considers penalty values while selecting allocation cells.

7. CONCLUSION

This study examined the application of the Least Cost Method and Vogel's Approximation Method for solving transportation problems. Both techniques were implemented using Python to simplify the allocation process and reduce computational effort.

The results demonstrate that Vogel's Approximation Method provides a more efficient initial solution compared to the Least Cost Method. Therefore, VAM is recommended for practical transportation planning problems.

Future work may extend this study by applying optimality tests such as the MODI method or implementing linear programming solvers.

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