Optimising Transportation Costs in a Multi-Warehouse Retail Supply Chain using Linear Programming in R

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1. Executive Summary

This project demonstrates how Linear Programming (LP) can be used to optimise transportation costs in a retail supply chain. Using R and the lpSolve package, we modelled the distribution of goods from two distribution centres (DCs) to three stores, aiming to minimise total transportation costs while satisfying all demand and capacity constraints. The model was solved successfully, with clear cost savings and practical business insights.

2. Problem Description

A retail company operates two distribution centres and supplies goods to three retail stores. Each store has specific monthly demand, and each DC has a limited supply capacity. Transportation costs differ between DCs and stores. The goal is to find the optimal shipping quantities from each DC to each store to minimise total costs while meeting all constraints.

3. Dataset Overview

From / To | Store A | Store B | Store C | DC Capacity

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DC1 | $5.5 | $6.5 | $7.5 | 1200 units

DC2 | $8.2 | $5.2 | $6.2 | 1500 units

Store | Demand (units)

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A | 800

B | 500

C | 1000

4. LP Model Formulation

Decision Variables:

x1: DC1 to Store A

x2: DC1 to Store B

x3: DC1 to Store C

x4: DC2 to Store A

x5: DC2 to Store B

x6: DC2 to Store C

Objective Function:

Minimise total cost = 5.5x1 + 6.5x2 + 7.5x3 + 8.2x4 + 5.2x5 + 6.2x6

Subject to Constraints:

- x1 + x4 = 800 (Store A demand)

- x2 + x5 = 500 (Store B demand)

- x3 + x6 = 1000 (Store C demand)

- x1 + x2 + x3 <= 1200 (DC1 supply limit)

- x4 + x5 + x6 <= 1500 (DC2 supply limit)

- All x >= 0

5. R Code Implementation

library(lpSolve)

costs <- c(5.5, 6.5, 7.5, 8.2, 5.2, 6.2)

constraints <- matrix(c(

1, 0, 0, 1, 0, 0,

0, 1, 0, 0, 1, 0,

0, 0, 1, 0, 0, 1,

1, 1, 1, 0, 0, 0,

0, 0, 0, 1, 1, 1

), nrow = 5, byrow = TRUE)

rhs <- c(800, 500, 1000, 1200, 1500)

directions <- c('=', '=', '=', '<=', '<=')

solution <- lp(direction = 'min', objective.in = costs, const.mat = constraints, const.dir = directions, const.rhs = rhs)

print(solution$solution)

print(solution$objval)

6. Results

Route | Units | Cost per Unit | Total Cost

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DC1 → Store A | 800 | $5.5 | $4,400

DC2 → Store B | 500 | $5.2 | $2,600

DC2 → Store C | 1000 | $6.2 | $6,200

| | | $13,200

7. Business Insights

- The model suggests allocating all of Store A's demand to DC1, fully utilising its low-cost route.

- Store B and C are best served from DC2, leveraging lower transportation costs from that centre.

- DC1 is operating at full capacity, while DC2 still has spare capacity, enabling future demand flexibility.

8. Conclusion

Linear Programming provides a practical and efficient method for solving real-world supply chain problems. By implementing an LP model in R, the company can reduce transportation costs while ensuring supply chain reliability. This approach is scalable to larger networks and adaptable to changing constraints.

9. Appendix (Code Output)

[1] 800 0 0 0 500 1000

[1] 13200