TRANSPORTATION COST MINIMIZATION USING LINEAR PROGRAMMING FOR A UK RETAIL DISTRIBUTION NETWORK

1. Overview

Client:

A UK-based national retail chain managing inventory distribution from 3 central warehouses to 18 regional retail hubs across England, Scotland, and Wales

Objective:

To apply linear programming in designing an optimized transportation plan that minimizes overall shipping costs while ensuring each hub receives its weekly inventory requirements.

2. Background

The logistics team relied on a rule-of-thumb dispatch model which resulted in inconsistent loading, underutilized routes, and redundant short-haul trips. Rising fuel costs and missed delivery windows prompted the company to seek a mathematically driven optimization approach. Our task was to formulate and solve a transportation model using LP principles to improve cost efficiency and route utilization.

3. Problem Definition

Business Goal:

Minimize total weekly transportation costs from warehouses to retail hubs, subject to capacity and demand constraints.

Constraints:

- Each warehouse has a maximum weekly dispatch capacity

- Each retail hub has a fixed demand that must be met

- Transport cost varies per route depending on distance, weight, and carrier availability

- Goods are standardized by weight for modeling simplicity

4. Data Summary

Warehouse	Weekly Supply (tons)
W1	1200
W2	900
W3	1100

Hub	Weekly Demand (tons)
H1–H18	Varies (50–150 tons)

Cost Matrix (per ton): A 3×18 matrix representing the cost of shipping from each warehouse to each hub, derived from carrier pricing and fuel-adjusted distance.

5. Methodology

Software Used:

- Excel Solver (Simplex LP)
- Python (validation using scipy.optimize.linprog)
- Final report and charts created in Word and Excel

Model Formulation:

Decision Variables:

Let x_{ij} be the tons shipped from warehouse i to hub j

Objective Function:

$$\text{Minimize} \sum_{i=1}^{3} \sum_{j=1}^{18} c\_ij * x\_ij$$

Where c_{ij} is the cost per ton from warehouse i to hub j

Subject to:

- **Supply constraints (per warehouse):**

$$\sum_{j=1}^{18} x_{ij} \leq \text{Supply}_i$$

- **Demand constraints (per hub):**

$$\sum_{i=1}^{3} x_{ij} = \text{Demand}_j$$

- **Non-negativity:**

$$x_{ij} \geq 0$$

6. Solution and Interpretation

- Excel Solver produced a feasible, cost-minimizing shipment plan meeting all 18 hub demands

- Resulting fleet mileage was reduced by prioritizing longer hauls from low-cost distribution points

- All hubs were served within a 1% deviation of historical average delivery time

Total Cost Savings (Weekly):

£18,200 saved compared to prior model **Fleet mileage reduced by 22% Truckload efficiency improved by 16%**

7. Visual Outputs (Generated for Client)

- Sankey diagram: Flow of goods from warehouses to hubs

- Heatmap of cost-per-ton across all routes

- Comparison bar chart: Baseline vs. optimized transportation costs

- Route utilization matrix (Excel table with optimal values)

8. Deliverables Provided

- Excel model with editable cost matrix and Solver preloaded

- Python script for advanced users to replicate/extend the model

- 15-page report including:

    o LP formulation

    o Sensitivity insights

    o Assumptions and limitations

o   Recommendations for operational adoption

9. Results & Operational Impact

Metric	Before (Manual Planning)	After LP-Based Optimization	Change
Weekly Distribution Cost	£82,700	£64,500	↓ 22%
Avg. Truckload Utilization	68%	84%	↑ 16%
Missed Delivery Windows (Monthly)	12+	2 (exceptional cases only)	↓ 83%

10. Recommendations

- Integrate LP model with weekly ERP-generated demand forecasts
- Use optimized outputs to guide external logistics contract negotiations
- Explore route clustering techniques (heuristics) for mixed-load constraints
- Review model assumptions quarterly (fuel costs, road conditions, carrier availability)

11. Strategic Value Delivered

- Shifted the transportation planning team to a **data-validated routing system**
- Established a scalable LP-based template that can evolve with expansion or warehouse restructuring
- Improved environmental footprint through better route planning and load maximization