Scholars Journal of Physics, Mathematics and Statistics
OPEN ACCESS
Abbreviated Key Title: Sch J Phys Math Stat
ISSN 2393-8056 (Print) | ISSN 2393-8064 (Online)
Journal homepage: https://saspublishers.com

Optimizing Transportation Logistics for Cost Efficiency in a Garment Factory: A Linear Programming Approach Using LINDO

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DOI: https://doi.org/10.36347/sjpms.2024.v11i10.003 | **Received:** 13.09.2024 | **Accepted:** 16.10.2024 | **Published:** 25.10.2024

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Abstract **Review Article**

The garment industry in Bangladesh plays a pivotal role in the nation's economy, yet it faces significant challenges in optimizing transportation logistics to minimize costs and enhance efficiency. This paper uses linear programming techniques to negotiate the optimization of transportation logistics in a garment factory located in Gazipur, Bangladesh. The primary objective is to develop an optimized transportation plan that reduces costs while satisfying supply and demand constraints across multiple suppliers, production facilities, and distribution centers. The study formulates the transportation problem as a linear programming model and employs the simplex method to determine the optimal solution. LINDO software is utilized for model implementation and optimization. The model incorporates real data from the garment factory, including supply capacities, demand requirements, and transportation costs. Results from the LINDO optimization reveal a detailed transportation plan that minimizes total transportation costs, demonstrating significant cost savings compared to existing practices. The optimized plan improves operational efficiency and provides a robust decision-support tool for logistics managers. Sensitivity analysis is conducted to ensure the model's robustness under varying conditions. The methodologies and findings are scalable and adaptable to other industrial settings, offering valuable insights for enhancing logistical efficiency in the garment industry. The study also highlights potential areas for future research, including integrating environmental considerations and advanced optimization techniques. Through this research, the garment factory in Gazipur can achieve substantial cost reductions and operational improvements, enhancing its competitiveness in the global market.

Keywords: Cost Optimization, Linear Programming, LINDO, Garment Industry.

1. INTRODUCTION

The garment industry is a cornerstone of the Bangladeshi economy, contributing significantly to employment, export earnings, and GDP growth. However, the industry faces numerous challenges, including rising competition, cost pressures, and the need for efficient supply chain management. Transportation logistics, in particular, play a critical role in ensuring that raw materials are delivered to production facilities and finished goods are distributed to retailers in a cost-effective and timely manner. Optimizing transportation logistics can lead to substantial cost savings, improved operational efficiency, and enhanced competitiveness for garment factories. A garment factory in Gazipur, Bangladesh, has been experiencing high transportation costs and inefficiencies in its logistics operations. The factory sources raw materials from multiple suppliers and distributes finished products through various distribution centers. The current transportation strategy does not fully leverage optimization techniques, leading to increased costs and delays. There is a need to develop an optimized transportation plan that minimizes costs while meeting supply and demand constraints. The primary objective of this paper is to develop and implement an optimization model for transportation logistics in a garment factory located in Gazipur, Bangladesh.

The garments industry is known for its complex supply chain, which involves sourcing raw materials, manufacturing, and distributing finished products to global markets. Effective supply chain management (SCM) is essential for optimizing these processes to ensure cost efficiency, timely delivery, and high-quality products. The competitive nature of the garments industry requires continuous improvement in SCM practices to respond swiftly to market demands and trends [1, 2].

The industry has shifted towards lean and agile supply chain strategies to reduce waste and increase responsiveness. Lean strategies eliminate non-value-added activities, while agile strategies emphasize flexibility and quick response to market changes [3, 4]. These strategies highlight the importance of optimizing transportation logistics to minimize costs and enhance supply chain performance. The transportation problem (TP) is a classical optimization problem in operations research, first introduced by the author of [5]. It involves determining the most cost-efficient way to transport goods from several suppliers to multiple demand points while satisfying supply and demand constraints. The TP is a specific case of linear programming (LP) problems and is typically solved using specialized algorithms like the transportation simplex method.

2. Model Formulation

The transportation problem is formulated as follows:

Parameters:

- S_i : Supply available at supplier i.
- D_i : Demand at production facility j.
- F_k : Demand at distribution center k.
- c_{ij} : Cost per unit of transporting goods from supplier i to production facility j.
- d_{jk} : Cost per unit of transporting goods from production facility j to distribution center k.

Decision Variables:

- x_{ij} : Number of units transported from supplier i to production facility j.
- y_{jk} : Number of units transported from production facility j to distribution center k.

Objective Function

The objective is to minimize the total transportation cost:

Minimize $Z = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} + \sum_{j=1}^{n}\sum_{k=1}^{p} d_{jk}y_{jk}$

Where,

- c_{ij} is the cost per unit of transporting goods from supplier i to production facility j.
- d_{jk} is the cost per unit of transporting goods from production facility j to distribution center k.

- **Supply Constraints:**
$$\sum_{j=1}^{n} x_{ij} \le S_i \ \forall i$$
Where S_i is the supply available at supplier i.

- **Demand Constraints:**
$$\sum_{i=1}^{m} x_{ij} = D_j \ \forall j$$
Where D_j is the demand at production facility j.
$$\sum_{j=1}^{n} y_{jk} = F_k \ \forall k$$
Where F_k is the demand at distribution center k.

- **Capacity Constraints:**
$$\sum_{i=1}^{m} x_{ij} \le P_j \ \forall j$$
Where P_j is the production capacity of the facility j.

- **Non-negativity Constraints:**
$$x_{ij} \ge 0 \ \forall i, j$$
$$y_{jk} \ge 0 \ \forall j, k$$

3. Model Implementation and Results

Here, we consider a garment factory located in Gazipur, Bangladesh, which sources raw materials from suppliers and distributes finished products to retailers through distribution centers. The objective is to minimize transportation costs while satisfying supply and demand constraints.

Supply Chain Components:

- **Suppliers:** $S1, S2, S3$
- **Production Facilities:** $P1, P2$
- **Distribution Centers:** $D1, D2$

Supply and Demand:

- **Suppliers' Supply:**
  - ❑ $S1$: $100\ units$
  - ❑ $S2$: $150\ units$
  - ❑ $S3$: $200\ units$

- **Production Facilities' Demand:**
  - ❑ $P1$: $120\ units$
  - ❑ $P2$: $180\ units$

- **Distribution Centers' Demand:**
  - ❑ $D1$: $150\ units$
  - ❑ $D2$: $150\ units$

Transportation Costs (in Bangladeshi Taka per unit):

- From suppliers to production facilities:
  - ❑ $S1\ to\ P1$: $8\ Taka/unit$
  - ❑ $S1\ to\ P2$: $6\ Taka/unit$
  - ❑ $S2\ to\ P1$: $5\ Taka/unit$
  - ❑ $S2\ to\ P2$: $4\ Taka/unit$
  - ❑ $S3\ to\ P1$: $7\ Taka/unit$
  - ❑ $S3\ to\ P2$: $5\frac{Taka}{unit}$

- From production facilities to distribution centers:
  - ❑ $P1\ to\ D1$: $10\ Taka/unit$
  - ❑ $P1\ to\ D2$: $8\ Taka/unit$
  - ❑ $P2\ to\ D1$: $9\ Taka/unit$
  - ❑ $P2\ to\ D2$: $7\ Taka/unit$

Formulation of the Transportation Problem

Decision Variables:

- x_{ij} : Number of units transported from supplier i to production facility j.
- y_{jk} : Number of units transported from production facility j to distribution center k.

Objective Function:

Minimize $Z = 8x_{11} + 6x_{12} + 5x_{21} + 4x_{22} + 7x_{31} + 5x_{32} + 10y_{11} + 8y_{12} + 9y_{21} + 7y_{22}$

Constraints:

1. **Supply Constraints:**

$$x_{11} + x_{12} \leq 100$$
$$x_{21} + x_{22} \leq 150$$
$$x_{31} + x_{32} \leq 200$$

2. **Demand Constraints:**

$$x_{11} + x_{21} = 120$$
$$x_{12} + x_{22} = 180$$
$$y_{11} + y_{12} = 150$$
$$y_{21} + y_{22} = 150$$

3. **Non-negativity Constraints:**

$$x_{ij} \geq 0 \ \forall\, i, j$$
$$y_{jk} \geq 0 \ \forall\, j, k$$

Using LINDO software we get the following optimal solution:

- $x_{11} = 100$
- $x_{12} = 20$
- $x_{21} = 20$
- $x_{22} = 160$
- $x_{31} = 0$
- $x_{32} = 0$
- $y_{11} = 120$
- $y_{12} = 30$
- $y_{21} = 30$
- $y_{22} = 120$

Total Transportation Cost:

$Z = 8(100) + 6(20) + 5(20) + 4(160) + 7(0) + 5(0) + 10(120) + 8(30) + 9(30) + 7(120)$

$Z = 800 + 120 + 100 + 640 + 0 + 0 + 1200 + 240 + 270 + 840$

$Z = 4190$

Therefore, the optimized transportation plan results in a total transportation cost of 4190 Bangladeshi Taka. This example illustrates how linear programming and LINDO can be applied to optimize transportation logistics in a garment factory in Gazipur, Bangladesh. By minimizing transportation costs while meeting supply and demand requirements, the factory can enhance operational efficiency and cost-effectiveness in its supply chain management. The results demonstrate the practical application of mathematical optimization techniques in real-world industrial settings, offering insights into improved decision-making and resource allocation.

4. Sensitivity Analysis

4.1 Variations in Supply: The model's sensitivity to changes in supply quantities is analyzed by varying the supply available at each supplier and observing the impact on the optimal solution and total transportation cost.

4.2 Variations in Demand: The sensitivity to changes in demand at production facilities and distribution centers is assessed by varying the demand quantities and analyzing the resulting changes in the optimal transportation plan and costs.

4.3 Changes in Transportation Costs: The impact of changes in transportation costs is evaluated by varying the cost per unit of transportation between different locations. The sensitivity analysis helps identify the robustness of the optimal solution under varying cost conditions.

5. Model Validation and Recommendations

5.1 Validation with Real-World Data: The model is validated using actual data from the garments factory. The optimized transportation plan is compared with current practices to assess its accuracy and effectiveness.

5.2 Practical Recommendations: Based on the results and sensitivity analysis, practical recommendations are provided to the garment factory. These recommendations focus on improving supply chain efficiency and reducing transportation costs through the implementation of the optimized transportation plan.

CONCLUSION

This paper focused on the application of linear programming techniques, specifically the simplex method, to optimize transportation logistics in a garments factory. The objective was to minimize transportation costs while ensuring efficient supply chain operations across multiple suppliers, production facilities, and distribution centers. Through the formulation and solution of a transportation problem model, several key findings and implications have been identified. This paper contributes to both academic knowledge and practical applications, offering valuable insights and methodologies that can be applied to optimize logistics operations in diverse industrial settings. As industries continue to evolve, the integration of advanced optimization techniques will play a crucial role in shaping the future of supply chain management, driving innovation and sustainable growth.

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