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# OPERATIONS RESEARCH OF MANUFACTURING AND TRANSPORTATION COST IN THE TEXTILE INDUSTRY

[1]Krishna Somani, [2]Disha Mansinghka, [3]Ayushi Garg,
[4]Aarushi Laddha, [5]Tanmay Pareek

NMIMS University, Indore, India

***Abstract:*** The cost incurred in manufacturing and transportation has a huge impact on the overall profit of the firm. This research paper uses Operation Research Techniques to experiment with ways to reduce manufacturing and logistics costs for textile industries from supply-to-demand destinations. This aim is achieved through the use of mathematical modeling techniques like Linear Programming, the North West Corner Method, Vogel's Approximation Method, etc to find feasible costs and solve transportation-related issues with help of Excel Solver. This technique is useful for guiding quantitative decisions in industrial engineering. We also aimed at finding an optimal mix from a range of products. The objective is to reduce the cost incurred and find the optimal amount of 2 variants of a product by considering the various costs involved so as to maximize the profit of the firm with given resources with the help of the Simplex Method of LPP technique .

***Index Terms***: Textile Industry, Cost Reduction, Transportation, Linear programming, Simplex, Profit Maximization

## I. INTRODUCTION

The design, manufacture, and distribution of garments is one of the main concerns of the textile industry. Natural or synthetic raw materials made with the use of chemical industry products are both acceptable. It is engaged in the activities of yarn production, weaving, processing as well as embroidery. One of India's top sectors, contributing significantly to GDP, is the textile and apparel sector. The Indian textile and apparel sector is significant not just in the domestic market but also has high standing and a well-known presence abroad. Ever-increasing customer expectations and fierce competition in global markets force manufacturing companies to continuously enhance competitiveness through the increase in the efficiency and adaptability of new technical textile goods. Thus, the simplification of the production process to produce such goods boost the rate of new products while also successfully closing a niche market, meeting new societal needs, and providing textile companies with possibilities to add value. (Juan Jose Bullon) Professionals continuously seek approaches and tools that help them to make better decisions. Operations research (OR) covers a wide variety of techniques, each with its strengths, limitations, success stories, and advocates. There is little research aimed at increasing the understanding of the applicability of Operation Research (OR) techniques in optimizing manufacturing & transportation cost. There is a paucity of literature providing details about the situations in which the techniques work well.

## II. LITERATURE REVIEW

Textile manufacturing is a typical traditional manufacturing industry that heavily leaned on small and medium enterprises with limited capacity for investing in advanced engineering technologies. It relies on product customization and short manufacturing cycles as distributors and consumers are increasingly looking for variety and personalization. (Zhenglei He) The present day's contribution is about 14% of industrial production and 4% of India's GDP. This paper deals with a supply chain strategic decision problem in the textile industry. The supply chain studied is composed of several production locations in the three process stages. Several suppliers provide raw materials in the given production location for the first stage. Depending on strategic decisions, the time to market can vary, or the service level can be significantly impacted. Several structural, operational, and overall performance variances exist in their supply chain. Material consumption has a huge impact on the overall cost of the manufactured product. Thus, planning cost-effective cutting lays and processing cutting orders is required to decrease the overall material consumption

and improve the effectiveness of the cutting processes. (Ismail WR Taifa) In the strive to attain the best level of quality, there is a significant increase in the overall cost of quality. (Muhammad Rehan Yasin) A major burden falls on transportation. This cost must be reduced to the minimum to save time and monetary resources depending on various factors like production and inventory locations. This is also motivated by a desire and needs to move towards a more sustainable and ecological supply chain. (Alice Berthier) With this paper, we aspire to experiment with ways to reduce manufacturing and logistics costs from textile industries to customers. This aim can be achieved through the use of mathematical modelling techniques like Linear Programming which is a linear function that can be maximized or minimized when subjected to various constraints. This technique is useful for guiding quantitative decisions in industrial engineering. There are other methods like the North West Corner Method, Vogel's Approximation Method to find feasible costs and solve transportation-related issues with help of Excel Solver. It is difficult to develop an exact mathematical model due to the complex relationships between various textile process parameters and performance properties, therefore, to assist the decision-makers to find the optimal solutions to the process. Manufacturing processes for all industries are expected to be more efficient with quick reactivity to the market and adaptation to the big data environment. In this situation, intelligent techniques are regarded as the key indicator in maximizing efficiency. (Zhenglei He) Even though the textile industry is dominating the global market, its structure in India is quite diverse, with numerous infrastructure problems and various player configurations at every level. The textile industry has a strong correlation with each factor relating to the process. A change in the transportation cost must be evaluated with the given impacts and effects.

## III. PROBLEM EXPRESSION

FCs and VCs are expenses for the garment sector. While the variable costs rise proportionately to the whole amount of made clothing, FCs are unaffected by order quantities (number of produced garments). For the garment sector, examples of FCs include machine and rental expenses, whereas VCs include the costs of raw materials and other apparel-related accessories. Therefore, reducing VCs rather than FCs should be the goal of material consumption analysis and cost-cutting strategies.

Pre-costing and final costing methods are part of the costing process. Early in the development process, pre-costing, also known as predictive cost estimation, pre-production costing, or sample costing, entails calculating all expenses.

The internal wastage, such as marker fallout, as well as the external wastage, which includes splice losses, width losses, and end losses, make up the total fabric losses.

Since up to 75% of manufacturing apparel can be due to material costs, thus by critically analyzing and optimizing the raw materials costs can increase profits.

Businesses can increase their profitability by carefully analyzing and lowering the costs of raw materials, which can make up to 75% of the cost of producing garments.

Different means of transport are used between destinations. Each storehouse has a limited capacity for each mode of transport. Products stored in storage are transported to guests by rail and/ or road. Also, destinations have a limited cargo capacity for each mode of transport.

The following information is added Possible transport connections between storage and guests are defined, including transport styles. Transport companies deal with transport between storage and guests, using different modes of transport. This part begins with a description of the problem's breadth because the optimization model that will be created is anticipated to apply to a variety of situations. This is followed by assumed that client product demand and product delivery must do contemporaneous.

The problem is followed by an extended description of the problem through a case study.The system used for the Transportation Problem is Excel Solver which is also Vogel's Method Solution. A transportation problem is a special kind of direct programming problem, calculating the cost of transporting a particular commodity from a set of sources or origins (manufactories, manufacturing installations, etc.) to a set of destinations (storages, businesses, etc.) is the thing. Minimize. Each source has a finite force (that is, the maximum number of products that can be packed from it), but each destination has a demand that must be met (that is, the minimal number of products that must be packed). Shipping costs from origin to destination are directly commensurable to the number of units packed.

| TO | BENGALURU | MUMBAI | DELHI | KOLKATA | | SUPPLY |
|---|---|---|---|---|---|---|
| FROM | | | | | | |
| CHENNAI | 5 | 4 | 6 | 8 | | 4750 |
| AHMEDABAD | 7 | 6 | 8 | 5 | | 3250 |
| JAIPUR | 9 | 5 | 4 | 8 | | 1500 |
| | | | | | | |
| DEMAND | 2250 | 2750 | 3500 | 1000 | | |

The given are 3 different plants or supply locations - $S_1$, $S_2$ & $S_3$

With $X_{ij}$ as the estimated or required units (Volume) to be moved from source to destination.

Using the transport costs shown in the table, we can write the following equations:

**Cost minimization function**

We add all the values from the table, by multiplying the cost ( minimum cost of road transportation to any textile industrialist or supplier) & the volume. (V Prifti, I Dervishi, K Dhoska, I Markja and A Pramono)

$Z = 5X_{11} + 4X_{12} + 6X_{13} + 8X_{14} + 7X_{21} + 6X_{22} + 8X_{23} + 5X_{24} + 9X_{31} + 5X_{32} + 4X_{33} + 8X_{34}$

**Force / Supply constraints**

First row: $X_{11} + X_{12} + X_{13} + X_{14} \leq 4750$

Second row: $X_{21} + X_{22} + X_{23} + X_{24} \leq 3250$
Third row: $X_{31} + X_{32} + X_{33} + X_{34} \leq 1500$

**Demand constraints**
$X_{11} + X_{21} + X_{31} = 2250$
$X_{12} + X_{22} + X_{32} = 2750$
$X_{13} + X_{23} + X_{33} = 3500$
$X_{14} + X_{24} + X_{34} = 1000$
Where $X_{ij}$ is more than 0 for each i and j

## IV. ANALYSIS & FINDINGS FOR OPITIMAL TRANSPORTATION COST

VOGEL'S APPROXIMATION METHOD (VAM)

For cloth, we've taken 3 different cities- Chennai, Ahmedabad & Jaipur which are geographically distinct suppliers of the Indian cloth market, and for the end product to be reached to the guests, there are 4 different destination metropolises Bengaluru, Mumbai, Delhi, Kolkata (the requests where guests interact with cloth product). The transportation problem formed with the cells act as rudiments that define pre-unit transportation cost from Supplier To Destination where demand is to be fulfilled with optimized transportation cost. (Khan)
Also, the force is the capacity of cloth goods which is lower than equal to constraint and the demand is the gains of the business which is equal to constraint (demand must be matched)

**M1**

| | D1 | D2 | D3 | D4 | SUPPLY |
|---|---|---|---|---|---|
| S1 | 5 | 4 | 6 | 8 | 4750 |
| S2 | 7 | 6 | 8 | 5 | 3250 |
| S3 | 9 | 5 | 4 | 8 | 1500 |
| DEMAND | 2250 | 2750 | 3500 | 1000 | |

M1 would be the original matrix of per unit cost and M2 gives the optimized cost using specific transportation channels and therefore the optimal result can be attained with given variables & constraints.

**M2**

| | D1 | D2 | D3 | D4 | | Assigned | = | Supply |
|---|---|---|---|---|---|---|---|---|
| S1 | 0 | 2750 | 2000 | 0 | | 4750 | | 4750 |
| S2 | 2250 | 0 | 0 | 1000 | | 3250 | | 3250 |
| S3 | 0 | 0 | 1500 | 0 | | 1500 | | 1500 |
| | | | | | | | | |
| Assigned | 2250 | 2750 | 3500 | 1000 | | | | |
| = | | | | | | | | |
| Demand | 2250 | 2750 | 3500 | 1000 | | | | |

| | |
|---|---|
| OPTIMAL | 49750 |

The optimal solution can be analyzed as 2250 units & 1000 units to be transported from Ahmedabad to Bengaluru & Kolkata respectively, 2750 units & 2000 units from Chennai to Mumbai & Delhi respectively and 1500 units from Jaipur to Delhi. With these units, Only Rs.49750 would be the total cost of logistics for the textile industry or the supplier or the company with optimal values of volumes ($X_{ij}$)

NORTH-WEST CORNER METHOD

| | First table using North - West Method | | | | |
|---|---|---|---|---|---|
| To | Bengaluru | Mumbai | Delhi | Kolkata | Supply |
| From | | | | | |
| Chennai | 5 | 4 | 6 | 8 | 4750 |
| | 2250 | | | | |
| Ahemdaba | 7 | 6 | 8 | 5 | 3250 |
| Jaipur | 9 | 5 | 4 | 8 | 1500 |
| Demand | 2250 | 2750 | 3500 | 1000 | 9500 |

Select the upper-left cell, i.e., the northwest corner cell of the transportation framework, and appoint the minimum of supply or demand.
Deduct the above least value from Oi and Di of the related line and segment.

| | Final Table using North -West Method | | | | |
|---|---|---|---|---|---|
| To | Bengaluru | Mumbai | Delhi | Kolkata | Supply |
| From | | | | | |
| Chennai | 5 | 4 | 6 | 8 | 4750 |
| | 2250 | 2500 | | | |
| Ahemdabad | 7 | 6 | 8 | 5 | 3250 |
| | | 250 | 3000 | | |
| Jaipur | 9 | 5 | 4 | 8 | 1500 |
| | | | 500 | 1000 | |
| Demand | 2250 | 2750 | 3500 | 1000 | 9500 |

This was a balanced problem, and the minimal cost attained by using the northwest corner system was Rs 56,750 with given constraints.

## V. ANALYSIS & FINDINGS FOR COST REDUCTION IN TEXTILE MANUFACTURING

The aim is to maximize the profit in textile manufacturing this can be done by using linear programming.
There can be many scenarios in the manufacturing of the textile industry. Here we aim at finding an optimal mix from a range of products. The objective is to find the optimal amount of 2 types of products by considering the various costs involved that can be produced to maximize the profit of the firm.
The quantitative data that has been presented here is collected on a primary basis from the firm which is situated in Indore (Madhya Pradesh), While we can take as many ranges of products as we want the information here is just focused on 2 types of kurtas. Using the information that has been provided by the firm a linear programming problem (LPP) can be formed. A simplex method of LPP is being performed on the data to identify the ideal quantity of the types of kurtas produced by the company.
The data relating to the costing is provided below-

**TABLE 1. DIRECT EXPENSES OF KURTA**

| | Type 1 | type 2 |
|---|---|---|
| **Cloth** | Rs 15/meter | Rs 12/meter |
| **Printing charges** | Rs 8/meter | Rs 10/meter |

| | | |
|---|---|---|
| **Meters per unit** | 6 | 6 |
| **Cost per unit** | 138 | 132 |

**TABLE 2. INDIRECT EXPENSES OF KURTAS**

| | Type 1 (in Rs) | Type 2 (in Rs) |
|---|---|---|
| **Cutting** | 1 | 1 |
| **Wastage** | 4 | 5 |
| **Steam Press** | 2 | 2 |
| **Packing** | 5 | 5 |

**TABLE 3. FINAL TABLE**

| | Type 1 (in Rs) | type 2 (in Rs) |
|---|---|---|
| **Total cost** | 150 | 145 |
| **Selling price** | 200 | 180 |
| **Demand units** | 2000 | 4500 |
| **Supply** | 2000 | 4500 |

From the above data, we have come up with 3 constraints that will help in identifying the total units allocated to both types of kurtas. The constraints are-

1. Cloth costing
2. Printing costing
3. Additional costing

**CONSTRAINT 1 (CLOTH)**

| | | | |
|---|---|---|---|
| **MONTHLY COST OF CLOTH** | TYPE 1 | TYPE 2 | TOTAL |
| **TOTAL COST OF CLOTH** | 90 | 84 | |
| **SUPPLY UNITS** | 2000 | 4500 | |
| | 180000 | 378000 | 558000 |
| **90X1+84X2 = 558000** | | | |

**CONSTRAINT 2 (PRINTING)**

| | | | |
|---|---|---|---|
| | TYPE 1 | TYPE 2 | TOTAL |
| **PRINTING COST** | (8*6) = 48 | (10*6) = 60 | |
| **SUPPLY UNITS** | 2000 | 4500 | |
| | 96000 | 270000 | 366000 |
| **48X1+60X2=366000** | | | |

**CONSTRAINT 3 (ADDITIONAL COST)**

| | | | |
|---|---|---|---|
| **TOTAL ADDITIONAL COST** | TYPE 1 | TYPE 2 | TOTAL |
| **PER UNIT COST** | 12 | 13 | |
| **SUPPLY UNITS** | 2000 | 4500 | |
| | 24000 | 58500 | 82500 |

| | | | |
|---|---|---|---|
| **12X1+13X2=82500** | | | |

**LPP MODEL**
**Simplex Method (Maximization)**

**Objective function**
The objective of the firm is to minimize the cost of different types of kurtas
Profit per unit of Type 1 kurta = Rs 50
Profit per unit of Type 2 kurta = Rs 35
**MAX Z= $50_{X1}+35_{X2}$**

**SUBJECT TO CONSTRAINTS**

| |
|---|
| **$90_{X1}+84_{X2} \leq 558000$** |
| **$48_{X1}+60_{X2} \leq 366000$** |
| **$12_{X1}+13_{X2} \leq 82500$** |
| **Such that** |
| **$X_1 \geq 0$** |
| **$X_2 \geq 0$** |

**DATA AND CONSTRAINTS**

| Variable constraints | X | Y | Optimal solution | 310000 | |
|---|---|---|---|---|---|
| | | | | | |
| Optimal value | 6200 | 0 | | | |
| MAX Z | 50 | 35 | | | |
| | | | | | |
| Subject to constraints | | | | | |
| | 90 | 84 | 558000 | ≥ 558000 | |
| | 48 | 60 | 297600 | ≥ 366000 | |
| | 12 | 13 | 74400 | ≥ 82500 | |

The simplex method is being solved using Excel Solver. The optimal solution discovered here is Rs 310000.

## VI. RESULTS & DISCUSSION

Transportation debit also known as functional analysis for its wide operation in the real world. This is frequently a special nicely debit to optimize transport price in cloth trade during which product area unit transported from a collection of supplies to a collection of destinations subject to the vacuity and demand of the source and destination, severally, specified the overall price of transportation is dropped. Principally, the answer procedure for the transportation debit consists of the following phases:

- Phase 1- Mathematical expression of the transportation equation.
- Phase 2- Chancing an original doable result.
- Phase 3- Optimize the original doable result that's attained in part two.

The paper study about a true debit of applied mathematics well by taking the debit of transport reduction in the cloth trade. The problem of minimizing transportation costs was answered by working with 2 techniques:
• The North West Corner Method
• Vogel's Approximation system.

The calculations showed that predicated on the demand for the cloth, we have taken 3 different destinations that are Chennai, Ahmedabad & Jaipur which are geographically distinct suppliers of cloth, and for the end product to be reached the guests, there are 4 different destinations cosmopolises Bengaluru, Mumbai, Delhi, Kolkata.
From the calculations, it's set up that by the northwest corner the amount of transportation is rupees 56,750 whereas transportation cost by VAM is rupees 49,750.
In the unborn, we can continue to apply another way of transportation styles to contemporize and optimize the result. Also, we can continue the disquisition by with experimenting different styles of functional disquisition like simplex system, etc., and try to maximize the profit in an artificial enterprise.
In the moment's largely competitive request, various associations want to deliver products to the guests in a cost-effective way, so that the request becomes competitive. To meet this challenge, the transportation model provides an important frame to determine the swish ways to deliver goods to the customer at optimal cost.

Different means of transport are used between destinations. Each store has a limited capacity for each mode of transport. Products stored in warehouses are transported to guests by rail and/ or road. Also, destinations have a limited weight capacity for each mode of transport.

In the textile industry, there are no limits on the monthly supply. The firm has to increase supply by as many units of the product as the demand arises, the production here is 2000 units of type 1 and 4500 units of type 2. This has been taken on an average basis as production varies according to the seasons.

In the case of manufacturing in the textile industry, the optimal solution is discovered by reducing cost and allocating units that generate maximum profit. (Charles J.McCallum)

The optimal solution to maximize profit is to produce 6200 units of Type 1 kurtas only and not produce any units of type 2 kurtas. When the firm produces 2000 units of type 1 kurta and 4500 units of type 2 kurta, the profit is Rs 257500. but if it produces 6200 units of type 1 kurta only, the profit is Rs 310000.

Since the optimization model that will be developed is anticipated to apply to different cases, this section starts with depicting the compass of the problem which is followed by an extended description of the problem through a case study. The system used in Transportation Problems using Excel Solver which is also Vogel's approximation method. LPP has been solved by using the simplex method on the excel solver.

## VII. RECOMMENDATIONS

1. They can increase the flexibility and speed of innovative technical textile product creation. They can also specifically decentralize the control systems that allow for new advances in efficiency through more flexibility and adaptability.
2. Future industrial applications must be created quickly to match the agility needed by contemporary organizations.
3. In the future, regular monitoring and application at other steps of transportation methods can be used to update and optimize the solution.
4. Individuals or organizations can pursue research by experimenting with different research activities with artificial intelligence and try to maximize profits in an industrial enterprise.
5. As we continue to update and optimize the solution, in the future we can continue to use the other transportation method steps. Additionally, we can carry on the investigation by experimenting with other operational research methodologies to maximize profit in an industrial firm.

## VIII. LIMITATIONS

1. In this illustration taken above, we have assumed that supply is the same as demand. But in reality, supply shortages or excess may exist.
2. The cost of freight to be shipped (transportation cost) may vary for different companies or entities depending on economies of scale, an external environment like economic factors, legal considerations, etc.
3. There are bound to be some real constraints that we can't deal with in any model. In this case, the company or production unit will have to rely on our intuition and directness to ensure timely decision-making.

## IX. CONCLUSION

The above case can be used to help textile manufacturers to minimize transportation costs with limited capacity and resources as it can also work for short-term production cycles. The manufacturer or the company can solve the problem of supply chain management with an efficient system of deciding on the suppliers and respective quantities.

LPP for maximizing profit with constraints like raw material cost, wastage, cutting, packing & other parameters, and North West Corner Method and VAM for feasible logistics cost are some of the methods of operations research equipped to reduce cost not only to manufacturers but also to the customers and build a data-based approach for the high demand country like India and help manufacturer save some resources and invest them in modern technologies.

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