IJITCE

International Journal of
Information Technology & Computer Engineering

www.ijitce.com

Using linear programming, transportation cost optimization

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Abstract:

Transportation plays a vital role in every manufacturing industry as it is one of the major activities that binds the whole supply chain and accounts for customer satisfaction with the right delivery time. Hence, bringing in an optimized transport routing on the grounds of time taken and cost of transportation is very important. In this paper, a cost optimization model for transportation of goods of a flavors and fragrance company is presented. The problem was a linear programming problem and was solved using an EXCEL solver. A savings of Rs. 765,000 per annum was estimated comparing the cost of transportation in the new model to that of the previous model.

INTRODUCTION

The transportation services and techniques used by a business are very significant in the development of a bigger client base, and if a successful logistics or transportation model is developed, the firm may generate a substantial amount of revenue. According to Jonsson [1, a logistics and supply chain specialist], improving the direct cost portion of the logistics department may generate 10–30 percent of turnover or profit. In this current environment, where the world's population is growing at an alarming rate and the world is becoming a global village, it is critical for a company to have a cost-effective and time-efficient transportation system that strives to provide its services to customers in every corner of the globe. Because transportation is such a crucial critical part in the success of a firm, many logistics and supply chain professionals have conducted extensive study into different aspects of the transportation system. Ronald and colleagues [2] have developed a genetic algorithm that takes into account the geographic information system (GIS), and this method is used to address issues with transportation routes. According to Dorer and Calisti [3,] the idea of adaptive transportation networks, which automatically optimises the current transportation system in accordance with changing conditions, has been developed. The authors of [4] have explored a variety of linear programming techniques and aspects, as well as their applications.

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Chandrakantha has presented an example of an optimization issue solution utilising the EXCELsolver option in [5]. Jonsson [1] has studied logistics and supply chain management, and the section on direct costing in logistics was particularly beneficial in terms of optimising the transportation system and lowering its costs. Caris et al. [6] have investigated intermodal freight transportation systems and have proposed solutions that take routes into consideration.

The weather conditions, as well as traffic parameters Working on a firm's transportation model with the use of linear programming, the authors of [7] have mostly focused on generating profits for the company in question. They worked on a transportation model in which mosquito coils were to be delivered from a warehouse to distributors, and they developed a cost-effective transportation model utilising the EXCEL solver function to accomplish their goal. Using genetic algorithms on the reverse supply chain, Tatavarthy and Sampangi [9] have developed a better transportation model, which they attribute to the use of genetic algorithms on the reverse supply chain. Public transportation fares were the focus of the authors' research in [10], and they came up with a solution for this problem via the use of a simulation that boosted the operator's profit while also benefiting public transportation passengers. A solution for fuzzy transportation issues was presented by the authors of [11], who concentrated on problems involving fuzzy transportations in which the demand for a number of products is unknown. They devised an algorithm to solve fuzzy transportation problems. Martnez-López and colleagues [12] concentrated on offering a motorway system of transportation for shipping businesses while taking environmental factors into consideration. Mathur and colleagues [13] have been working on offering a solution for fuzzy transportation challenges by producing algorithmic solutions to the difficulties. They have worked on public transportation networks and developed a transportation model or design that is based on the idea of integrated optimization and has resulted in an increase in urban mobility. Sharma and Tatavarthy [15] have concentrated their efforts on a disaster management challenge on how to optimise the supply chain of essentials during a crisis, and they were able to do this by conducting a review of several articles. Mangala and colleagues [16] have spoken about the need of operational excellence in a sustainable supply chain. Additionally, they have said that the integration of multiple technologies such as blockchain, big data, and so on, might aid in the creation of a more efficient supply chain system. It was attempted to minimise the cost of transportation to its lowest possible level by using the cheapest transportation model possible while taking all of the limitations into account throughout the process of building the model in this research. It was necessary to optimise a model of a flavours and fragrance firm that comprised of three plants, three warehouses, and nine marketplaces, and the optimization of the transportation model was accomplished via the use of the EXCEL solver function

Problem

The network was made up of three production units, often known as factories, three warehouses, and nine marketplaces in total. The product flow was set up such that it was made at the facilities and then

sent to the warehouses, after which it was shipped to the market. The cost of transportation did not stay the same for every kind of transportation circumstance, though. The current model at the firm was estimated to have cost around Rs. 3,800,000, and the company was looking for an upgraded model. The most cost-effective transportation route with the most ideal amounts to be delivered was chosen out of all available combinations since it would be profitable for the firm, and this was the case.
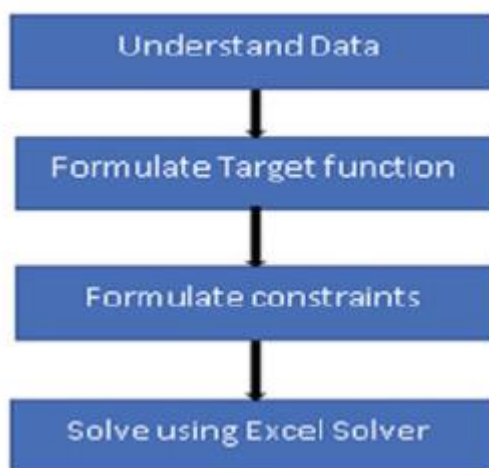

Fig. 1 Methodologyflowchar

Methodology

In the beginning, the transportation expenses associated with each of the instances were gathered and tallied. In the next step, the cost function or the goal function was developed for the given situation. In the next step, the target function was reduced using the EXCEL solver once all of the existing constraints had been written out. The methods used to solve the issue is shown in Figure 1, which is a straightforward flowchart.

Results and Discussions

Because it is vital to comprehend the real product flow, a network diagram, as seen in Fig. 2, was created. The cost of distribution for different scenarios may be seen in the first row of Table 1. The three plants are represented by the letters P1, P2, and P3, the three warehouses are represented by the letters W1, W2, and W3, and the nine marketplaces are represented by the letters M1 to M9. Transport costs per unit are represented by two cells: one representing a plant and one representing a warehouse; the other representing a market and one representing the transportation costs per unit are represented by two cells: one representing a plant and one representing a warehouse; the other representing a market and one representing a warehouse. It has already been noted that this information was obtained from the flavour and fragrance production business. Table 2 shows the factors that need to be determined, such as the number of units that need to be carried. For example, the number of units to be carried from the plant 1 to the warehouse 1 is represented by x(P1, W1), while the number of units to be transported from the warehouse 3 to the market 8 is represented by x(W3, M8). In addition, the cost function was derived and defined. The overall transportation cost is represented by the cost function or the goal function. When it comes to this instance, it is nothing more than a total of the products of the relevant cells in Tables 1 and 2, which is

$$\{6 \times x(P1, W1) + 5 \times x(P2, W1) + \cdots + 3 \times x(W$$
$$+ 3 \times x(P1, W2) + 4 \times x(P2, W2) + \cdots + 4 \times$$
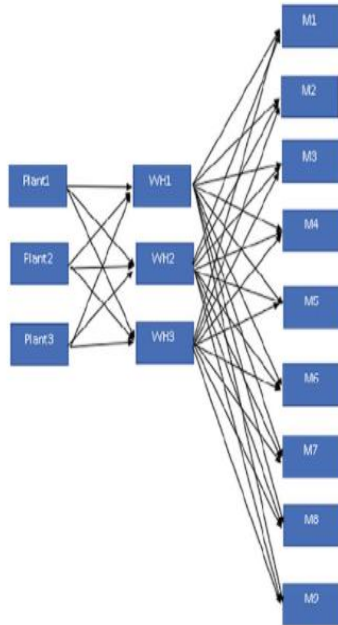
Fig. 2 Network diagram of the product

plants, it is well known that the sum of all the amounts produced by the plant must be less than or equal to the plant's total capacity (or capacity). As a result, the formulation in Eqs. may be interpreted as follows: (1a)–(1c)

$$x(P1, W1) + x(P1, W2) + x(P1, W3) \leq 800,000$$

$$x(P2, W1) + x(P2, W2) + x(P2, W3) \leq 100,000$$

$$x(P3, W1) + x(P3, W2) + x(P3, W3) \leq 150,000$$

When it comes to the markets, the total of all the quantities that reach the market must match the projected values in Table 3 in order for the market to function properly. There are nine equations in all, one for each market, as shown in Eqs. (2a)–(9a), which are as follows: (2i).

Table 1 Distribution cost of the product (per unit) in Rs

Distribution costs per unit (Rs)

	P1	P2	P3	M1	M2
W1	6	5	1	3	8
W2	3	4	5	6	6
W3	4	3	2	5	8

$$x(W1, M1) + x(W2, M1) + x(W3, M1) = 50,000 \quad (2a)$$

$$x(W1, M2) + x(W2, M2) + x(W3, M2) = 40,000 \quad (2b)$$

$$+ 4 \times x(P1, W3) + 3 \times x(P2, W3) + \cdots + 4$$
$$+ 6 \times x(W3, M9)\} = F(x)$$

$$x(W1, M3) + x(W2, M3) + x(W3, M3) = 100,000 \quad (2c)$$

$$x(W1, M4) + x(W2, M4) + x(W2, M4) = 80,000 \quad (2d)$$

Table 3 Demand forecast values for the markets per annum

Forecast values
M1
M2
M3
M4
M5
M6
M7
M8
M9

$$x(W1, M5) + x(W2, M5) + x(W3, M5) = 30,000 \quad (2e)$$

$$x(W1, M6) + x(W2, M6) + x(W3, M5) = 35,000 \quad (2f)$$

$$x(W1, M7) + x(W2, M7) + x(W2, M7) = 45,000$$

$$x(W1, M8) + x(W2, M8) + x(W3, M8) = 70,000$$

$$x(W1, M9) + x(W2, M9) + x(W3, M9) = 65,000$$

Because it is a large factory, plant 1 has the capacity to produce up to 800,000 units each year. For the sake of simplicity, it is also assumed that the number of units arriving at the warehouse will match the number of units leaving the warehouse and going to the market. When it comes to

In this regard, it should be remembered that the number of quantities entering and leaving the warehouse is equal to the number of quantities entering and exiting. In this case, there are three warehouses,
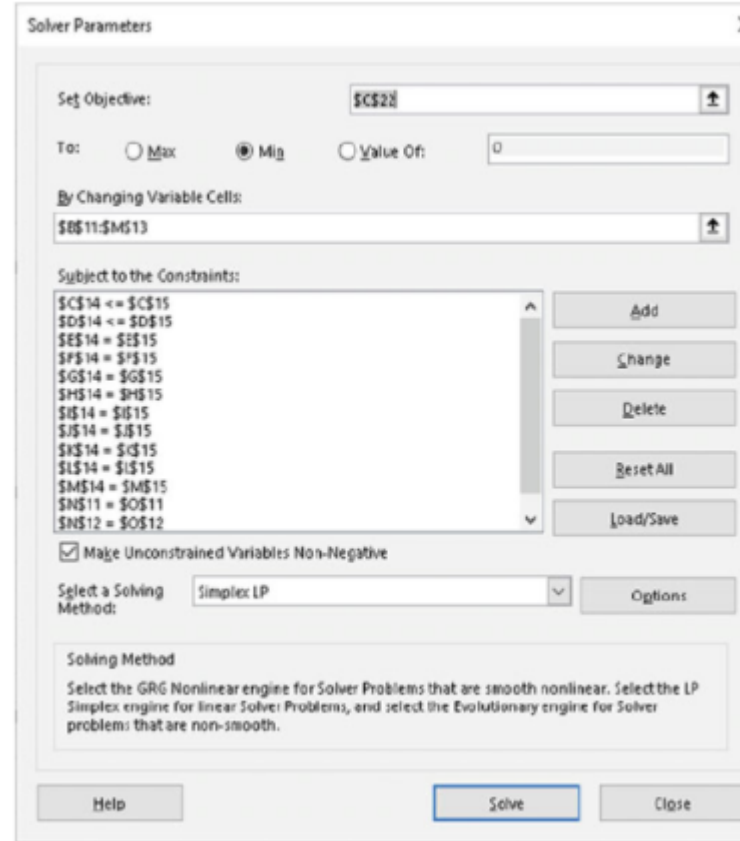
and three equations are constructed for the same, as shown in Eqs. 1 through 3. (3a)–(3c)

$$x(P1, W1) + x(P2, W1) + x(P3, W1) = \{x$$
$$+ x$$
$$+ x$$
$$+ x$$
$$+ x$$

$$x(P1, W2) + x(P2, W2) + x(P3, W2) = \{x$$
$$+ x$$
$$+ x$$
$$+ x$$
$$+ x$$

$$x(P1, W3) + x(P2, W3) + x(P3, W3) = \{x$$
$$+ x$$
$$+ x$$
$$+ x$$
$$+ x$$

18 A. Vamsikrishna et al.Fig. 3 Solver parameter dialog box for solving the LPP

Following the definition of all of the restrictions and goal functions, they were computed in the EXCEL spreadsheet using existing functions such as SUM, AVERAGE, and so forth. Furthermore, these equations were solved using the EXCEL solver once all of the relevant inputs were defined. The dialogue window for the EXCEL solver is seen in Figure 3. The goal should be set to the cell that corresponds to the target function in the target function matrix. Because this is a cost function that has to be reduced, the radio button labelled 'Min' was chosen on the computer. As previously stated, the LPP is subject to a large number of restrictions. In the 'Subject to Limitations' box, you must provide the constraints that you want to apply. The 'Simplex LP' approach of problem solving should be used. After completing all of these steps, the solution button was pressed.

The ideal distribution quantity for transportation from each plant to each warehouse, and from each warehouse to each market, is obtained as indicated in Table 4 once the solutions have been shown to converge. 18 A. Vamsikrishna et al. Transportation costs were estimated to be Rs. 3,035,000 for the above-mentioned situation. According to the corporation, the cost was around Rs. 3,800,000 at the time of purchase. As a result, it was predicted that the new transportation model would result in annual savings of around Rs. 765,000.

Conclusion

It was decided to construct a transportation optimization model. A total of three factories, three warehouses, and nine marketplaces were included in this study, and the transportation model was

optimised using the EXCEL solver tool to construct the transportation network. By using linear programming, the transportation costs were minimised to the greatest extent feasible. The total amount of money spent was Rs. 3,035,000. A savings of around Rs. 765,000 per year was projected when the cost of new vs used vehicles was compared.

a transportation concept similar to the one used before This article also paves the way for future research into the design of transportation models and the solution of these models using the linear programming approach, which makes the cost optimization strategy more straightforward. However, the scope of the study expands to include multivariable problems and the use of the EXCEL solver to evaluate various optimization strategies to address a variety of transportation issues.

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