

Optimization Cost of Transportation by Applying Linear Programming

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Abstract: Optimization means using resources and existing technology in the best possible way. Better planning and its execution results in cost optimization of many problems can give the company advantages either to minimize the cost or maximize the profit. Mathematical tools such as linear programming allow for better results. By using modern computing equipment and applying the linear programming, the objectives of optimization can be achieved. Nowadays, every company needs to utilize any possible opportunity to gain a competitive advantage over other companies. Among many possible activities, the transportation problem is one of the opportunities that the company can focus on. In this research, a real-world application of a transportation problem that involves transporting the product A from company's warehouse to distributor's warehouse is modeled using linear programming, in order to find the optimal transportation cost. Excel solver has been used to model and solve this problem and the result will determine the nearest distributor's warehouse product A to be shipped.

Keywords: Linear Programming, Transportation Problem, Excel Solver

1. Introduction

Companies must seek the highest efficiency in all of their activities in order to be successful in the highly competitive markets of today and use all possibilities to obtain a competitive advantage over other companies. Minimizing the cost of transportation is recognized as one of the primary areas offering tremendous opportunity among numerous alternative actions. There are several factors to consider to get the optimum cost of transportation cost which are the distance, shipping cost and shipments. Implementing optimization techniques for this transportation problem to ship the product A from three different company's warehouses which is in Johor, Selangor and Pulau Pinang to seven distributor's warehouses which is in Johor Bahru, Seremban, Melaka, Shah Alam, Butterworth, Ipoh and Alor Star is a possible way to make improvements over the total cost of logistics. In this research, the applications of a transportation problem are modeled using linear programming and solved by using

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Microsoft Excel Solver to get the optimum transportation cost. Linear programming is a mathematical method for determining the best way to achieve the best result in the context of a mathematical model for a collection or requirements by linear relationships, such as maximizing profit or minimizing cost. Solver is a Microsoft Excel add-in program to find an optimal, maximum or minimum value for a small in one cell [1-6].

2. Methodology

All the data for this research such as shipping cost, stock capacity, and requirement, has been used by the previous researcher but the value is changed. The value of the shipping cost table is changed according to the distance of each company’s warehouse to seven different distributor’s warehouses since we only focused on how to get optimum transportation cost instead of data collection.

Table 2.1: Shipping Cost

	Johor	Selangor	Pulau Pinang
Johor Bahru	45	200	265
Shah Alam	180	40	185
Seremban	135	95	195
Melaka	100	135	210
Butterworth	300	190	55
Alor Star	265	155	95
Ipoh	215	100	115

*All units are in Ringgit Malaysia

Table 2.2: Stock capacity

Johor	3980
Selangor	1785
Pulau Pinang	4856

*All units are in cartons

Table 2.3: Requirement

Johor Bahru	1168
Shah Alam	1560
Seremban	1439
Melaka	986
Butterworth	1658
Alor Star	2035
Ipoh	1159

*All units are in cartons

2.1 Linear Programming

For the given problem, we formulate a mathematical description called a mathematical model to represent the situation. The model consists of Decision variables, Objective function and constraints.

Decision variables represent unknown quantities. In this problem three warehouses will be symbolized as:

$$\begin{aligned} \text{Johor} &= A_1 \\ \text{Selangor} &= A_2 \\ \text{Pulau Pinang} &= A_3 \end{aligned}$$

And seven distributor’s warehouses will be symbolized as:

$$\text{Johor Bahru} = B_1$$

- Shah Alam = B_2
- Seremban = B_3
- Melaka = B_4
- Butterworth = B_5
- Alor Star = B_6
- Ipoh = B_7

Objective function of the problem is expressed as a mathematical expression in a decision variable. The objective function contains costs associated with each of the variables. It is minimization problem.

Let C_{ij} be the cost of shipping for Product A from A_j to B_j
 Let X_{ij} be the number of Product A shipped from A_j to B_j

$$\text{Minimize } Z = \sum_{i=1}^m \sum_{j=1}^n X_{ij} C_{ij}$$

Constraints are the conditions that force supply and demand needs to be satisfied. There are three constraints for this problem.

The quantity of product A sent from A_i is $\sum_{j=1}^7 X(i, j)$ and since the quantity of product A available at A_i is a_i ,

$$\sum_{j=1}^7 X(i, j) \leq a(i), \text{ where } i = 1, 2 \text{ and } 3$$

The product A sent to B_j is $\sum_{i=1}^3 X(i, j)$ and since the quantity of product A required at B_j is b_j ,

$$\sum_{i=1}^3 X(i, j) \geq b(j), \text{ where } j = 1, 2, 3, 4, 5, 6 \text{ and } 7$$

Non-negativity,

$$X_{ij} \geq 0, \text{ for all values of } i \text{ and } j$$

2.2 Modelling Problem using Excel Solver

This section will demonstrate how to use Excel Solver to find the optimum transportation cost. Excel’s formula language is capable of expressing a wide range of mathematical connections and offers both interactive and user-programmable techniques to describe mathematical programming problems [7-9].

Step 1: Construct a Shipping Cost in excel that will contain the average cost between each destination as Figure 2.1

1	Shipping Cost							
2								
3		Johor Bahru	Shah Alam	Seremban	Melaka	Butterworth	Alor Star	Ipoh
4	Johor	45	180	135	100	300	265	215
5	Selangor	200	40	95	135	190	155	100
6	Pulau pinang	265	185	195	210	55	95	115

Figure 2.1: Shipping Cost table in Excel

Step 2: Construct a Shipments table in excel that will contain shipments, stock, requirement, total in and total out. In this table the value for the shipments, total in and total out are set as 0, as Figure 2.2.

Shipments									
	Johor Bahru	Shah Alam	Seremban	Melaka	Butterworth	Alor Star	Ipoh	total out	Stock
Johor	0	0	0	0	0	0	0	0	3980
Selangor	0	0	0	0	0	0	0	0	1785
Pulau pinang	0	0	0	0	0	0	0	0	4856
total in	0	0	0	0	0	0	0		
Requirement	1168	1560	1439	986	1658	2035	1159		
Total Minimum Cost	0								

Figure 2.2: Shipments table in Excel

Total in referring to product A shipped to that particular distributor’s warehouse from the company’s three warehouse. And total out refer to quantity of product A shipped from that particular warehouse to distributor’s seven warehouses. To find the value for the total minimum cost, we use =SUMPRODUCT(B4:H6*B11:H13). We drag the value of shipping cost from Johor to Johor Bahru (B4) until Pulau Pinang to Ipoh (H6) and multiply the value of shipments from Johor to Johor Bahru (B11) until Pulau Pinang to Ipoh (H13).

Step 3: use Solver Parameters to get the total minimum cost of this transportation problem as Figure 2.3

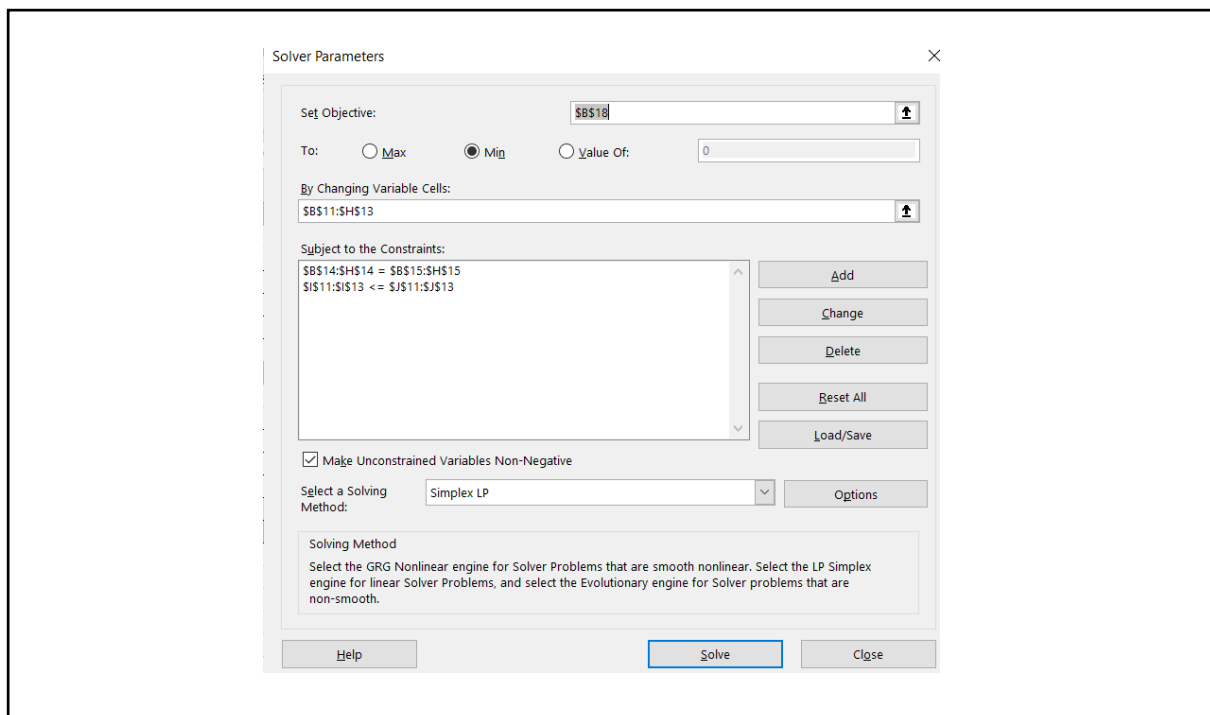


Figure 2.3: Solver Parameters

By referring the Figure 2.3, we set the objective to Min. Next, we drag the value of shipments from Johor to Johor Bahru until Pulau Pinang to Ipoh to fill in the ‘By Changing Variable Cells’ in Solver Parameters. For the first constraint, drag the value of total out from Johor to Pulau Pinang and set the constraint to less than and equal and drag the value of Stock from Johor to Pulau Pinang. Next, add a constraint, drag the value of total in from Johor Bahru to Ipoh and set the constraint to equal and drag the value of Requirement from Johor Bahru to Ipoh. For the last constraint, just tick at the box ‘Make

Unconstrained Variables Non-Negative' and click 'Solve'. Then, the result will automatically show in the Excel.

3. Results and Discussion

After clicking the 'Solve' in Solver Parameters, the Excel Solver will automatically show the optimum value for the shipments and optimum cost.

8	Shipments									
9										
10		Johor Bahru	Shah Alam	Seremban	Melaka	Butterworth	Alor Star	Ipoh	total out	Stock
11	Johor	1168	0	1214	986	0	0	0	3368	3980
12	Selangor	0	1560	225	0	0	0	0	1785	1785
13	Pulau Pinang	0	0	0	0	1658	2035	1159	4852	4856
14	total in	1168	1560	1439	986	1658	2035	1159		
15	Requirement	1168	1560	1439	986	1658	2035	1159		
16										
17		Total Minimum Cost								
18		RM816.63								
19										
20										
21										
22										

Figure 3.1: Final Result

Based on the Figure 3.1, the Solver solve the transportation problem and find the total minimum cost for the product A to be ship from company's warehouse to distributor's warehouse. The new value for the shipments, total in and total out are shown. The three company's warehouses were given each of the nearest distributor's warehouses to ship product A. The Company's warehouse in Johor only needs to ship product A to three distributor's warehouses which are in Johor Bahru, Seremban, and Melaka. While company's warehouse in Selangor only needs to ship product A to two distributor's warehouses in Shah Alam and Seremban. Next, company's warehouse in Pulau Pinang only needs to ship product A to three distributor's warehouses in Butterworth, Alor Star and Ipoh. Linear programming really helps the company to choose where the nearest location product A to be shipped.

4. Conclusion

In conclusion, Excel Solver is a good software to determine the optimum answer, especially linear programming [10]. If the company applies the solution of transportation problem for delivery product A, that will be given the company a big advantage to minimizing the cost. Also, linear programming can determine which distributor's warehouse that product A should be delivered from company's warehouse. For example, the company's warehouse in Johor only needs to ship product A at three from seven distributor's warehouses while Selangor only needs to ship product A at two distributor's warehouses and lastly for Pulau Pinang, only need to ship at three distributor's warehouses. Excel Solver chooses the location itself by considering the average shipping cost and the distance from company's warehouse to each distributor's warehouse. Indirectly, the company can save time for delivery the product A.

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