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The method of minimum corner for a transportation problem

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Abstract
The movement of goods is a topic of interest, both nationally and internationally. In addition to the fact that freight transport directly contributes to economic growth, ultimately all delivered goods and merchandise end up on businessmen's shelves and in people's households. Thus, it can be said that the way in which the entire freight transport process is carried out also affects the quality of people's lives. The transportation problem concerns the optimization of the distribution of a given substance or resource from a set of origin points (sources) to a set of destination points (destinations) such that the transportation cost or time is minimized. This is a classic optimization problem, often modeled by transportation networks. The minimum cost method, also known as the northwest corner method, is a technique used in transportation and logistics to determine an optimal initial solution to a transportation problem. The goal is to minimize the initial transportation costs by efficiently allocating resources.

Keywords: Transportation problem, Optimal solution, Minimum cost.

1. Introduction

Essentially, the problem is to find the optimal quantities to transport from each source to each destination, so that the demands at the destinations are satisfied and the total costs are minimized. These costs can include actual transportation costs, but also logistics, storage, or other costs. A simple example would be the transportation of goods from factories to stores. Each factory has a production capacity, and each store has a demand. The transportation problem would consist of determining the quantities of goods that must be sent from each factory to each store, so that the demands of the stores are satisfied and the total transportation costs are minimized. This problem can be extended to other situations, such as the transportation of human resources, energy, or information. Advantages: Easy to understand and implement, Provides a quick initial solution. Disadvantages: Does not always guarantee the optimal solution. May lead to higher costs than other methods.

2. Materials and methods

The solution algorithm for the minimum line cost method contains the following steps:

- It is checked whether the problem is balanced;
- It is checked on any line which is the lowest cost and the corner method is applied
- We will repeat this process if there are still costs on the chosen line.
- The same process is repeated, step by step, until we finish the lines of the transportation problem matrix;
- We check if the solution is non-degenerate (we continue with the optimal solution) or if it is degenerate and we stop
- We write the solution and the value of the objective function

3. Results & Discussion

Example 1: Using the minimum line cost method, determine a solution to the transportation problem given by the table:

	C_1	C_2	C_3	
D_1	2	3	1	20
D_2	1	4	2	15
D_3	3	1	2	15
	10	20	20	

- We have three centers, C_1, C_2, C_3 , which represent market demand.
- We have three warehouses, D_1, D_2, D_3 which represent the market supply.
- We define "demand": 10+20+20=50
- We define "offer": 20+15+15=50
- We choose the third line, the costs being 1, 2, 3 we will choose the minimum of these numbers.
- It will result that $c_{32} = 1$ is the minimum:

$$\begin{cases} x_{32} = \min(15,20) = 15 \\ 20 - 15 = 5 \qquad \rightarrow x_{31} = 0, x_{33} = 0 \\ 15 - 15 = 0 \end{cases}$$

- We choose the second line, the lowest cost is : $c_{21} = 1$.

$$\begin{cases} x_{21} = \min(10,15) = 10 \\ 15 - 10 = 5 \qquad \rightarrow x_{11} = 0 \\ 10 - 10 = 0 \end{cases}$$

- We still remain on line two, $c_{23} = 2$.

$$\begin{cases} x_{23} = \min(5,20) = 5 \\ 20 - 5 = 15 \qquad \rightarrow x_{22} = 0 \\ 5 - 5 = 0 \end{cases}$$

- We choose the first line; the lowest cost is : $c_{13} = 1$.

$$\begin{cases} x_{13} = \min(15,20) = 15 \\ 20 - 15 = 5 \qquad \rightarrow x_{13} = 15 \\ 15 - 15 = 0 \end{cases}$$

- We choose the first line, the only remaining cost is $c_{12} = 3$.
- We choose: min(5,5)=5 $\rightarrow x_{12} = 5$
- The solution and the value found is :

$$\begin{cases} x_0 = (0,5,15,10,0,5,0,15,0) \in R^{10} \\ f(x_0) = 5 \cdot 3 + 15 \cdot 1 + 10 \cdot 1 + 5 \cdot 2 + 15 \cdot 1 = 65 \end{cases}$$

- The solution is non-degenerate because it has five non-zero basic variables.

	C_1	C_2	C_3	
D_1	0^2	5^3	15^1	20

D_2	10^{1}	0^{4}	5^{2}	15
D_3	0^{3}	15^{1}	0^{2}	15
	10	20	20	

The solution algorithm for the minimum corner method contains the following steps:

- Check whether the problem is balanced;
- Check which is the lowest cost in the transportation problem matrix and apply the corner method;
- The same process is repeated, step by step, until we finish all the costs of the transportation problem matrix
- We check if the solution is non-degenerate (we continue with the optimal solution) or if it is degenerate and we stop;
- We write the solution and the value of the objective function.

Example 2: Using the minimum cost method, determine a solution to the transportation problem given by the following table:

	C_1	C_2	C_3	
D_1	2	3	3	20
D_2	4	3	2	20
D_3	1	5	2	30
	15	35	20	

- We have three centers, C_1, C_2, C_3 , which represent market demand.
- We have three warehouses D_1, D_2, D_3, which represent the market supply.
- We define "demand" : 15+35+20=70.
- We define "offer" : 20+20+30=70.
- We are looking for the lowest cost in the entire table ($c_{31} = 1$).
- We note that we will choose : $c_{31} = 1$.

$$\begin{cases} \min(15,30) = 15 \\ 30 - 15 = 15 \\ 15 - 15 = 0 \end{cases} \rightarrow x_{31} = 15, x_{11} = 0, x_{21} = 0$$

- We are looking for the lowest cost in the remaining table : ($c_{33} = c_{23} = 2$).
- We note that we will choose : $c_{33} = 2$.

$$\begin{cases} \min(15,20) = 15 \\ 20 - 15 = 5 \\ 15 - 15 = 0 \end{cases} \rightarrow x_{33} = 15, x_{32} = 0$$

- We are looking for the lowest cost in the remaining table : ($c_{23} = 2$).
- We note that we will choose *:* $c_{23} = 2$.

$$\begin{cases} \min(5,20) = 5 \\ 20 - 5 = 15 \\ 5 - 5 = 0 \end{cases} \rightarrow x_{23} = 5, x_{13} = 0$$

- We are looking for the lowest cost in the remaining table ($c_{12} = c_{22} = 3$).
- We note that we will choose : $c_{22} = 3$.

$$\begin{cases} \min(15,35) = 15 \\ 35 - 15 = 20 \\ 15 - 15 = 0 \end{cases} \rightarrow x_{22} = 15$$

- We are looking for the lowest cost in the remaining table ($c_{12} = 3$).
- We note that we will choose : $c_{12} = 3$.

$$\begin{cases} \min(20,20) = 20 \\ 20 - 20 = 0 \\ 20 - 20 = 0 \end{cases} \rightarrow x_{122} = 20, x_{32} = 0$$

- The solution and the value of the objective function found is:

$$\begin{cases} x_0 = (0,20,0,0,15,5,15,0,15) \in R^9 \\ f(x_0) = 20 \cdot 3 + 15 \cdot 3 + 5 \cdot 2 + 15 \cdot 1 + 15 \cdot 2 = 160 \end{cases}$$

- It is observed that the solution is non-degenerate and we can apply the optimality criterion to it.

	C_1	C_2	C_3	
D_1	0^2	20^3	0^1	15
D_2	0^1	15^4	5^2	15
D_3	15^3	0^1	15^2	15
	10	15	20	

4. Conclusions

The classical transportation problem is part of the much larger class of problems modeled by transportation networks. A transportation network models an economic situation in which, from a certain number of points, called sources, a quantity of a certain substance must be transported to another number of points, called destinations. The extremely general situation above can then be concretized in a particularly large number of ways, specifying whether or not there are intermediate points between sources and destinations, the way in which the transportation is done (which are the possible routes, the cost of transportation, minimum and/or maximum limits for the quantity transported on each route, the time required for transportation), the goals pursued. The goal of the problem is to find the quantities that must be transported on each route so as to ensure the needs of each destination, within the limits of the quantities available at the sources, at the minimum possible cost.

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5. References

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