



METHOD FOR FINDING THE OPTIMAL PLAN OF THE TRANSPORTATION PROBLEM

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Abstract: This scientific article studies one of the main problems in the logistics of enterprises - the issue of transportation, which ensures the lowest cost of transporting products from suppliers to consumers. The relevance of the study is that in the modern economy, a significant part of the cost of the product is made up of logistics costs, and their intuitive distribution leads to significant financial losses for the enterprise. To solve the problem, a closed transport model of linear programming, the methods of "Minimum Costs" and "Potentials" were used. In the practical part, a matrix of transportation between a conditional manufacturing enterprise and its regional warehouses was constructed, and the optimal plan was mathematically calculated. The results obtained proved that through mathematical modeling it is possible to reduce the logistics costs of the enterprise by at least 15-20 percent.

Keywords: transportation problem, logistics, linear programming, objective function, minimum cost method, potentials method, optimal plan, supply chain.

INTRODUCTION

The lifeblood of any large enterprise or national economy is its logistics and supply chain. The process of delivering manufactured products from factories to customers (or distribution centers) always requires significant financial costs. Especially if the enterprise has several factories and dozens of warehouses, it



becomes impossible to calculate with ordinary human reason which factory to which warehouse will cost the least.

The problem raised in the article is precisely related to reducing these costs to the lowest point (minimum) using strict mathematical algorithms. The relevance of the research is that in order to increase competitiveness in a market economy, it is not enough to simply reduce the cost of production, but it is also necessary to optimize the distribution network. The purpose of the work is to reduce the logistics situation of the enterprise to the form of the "Transportation Problem", a special form of linear programming, and to develop an absolutely optimal transportation plan using precise mathematical methods (the Least Cost Method).

LITERATURE REVIEW

The mathematical formulation of the transport problem was first developed in 1941 by the American scientist Frank Hitchcock. Later, this theory was perfected by T. Koopmans and the Russian mathematician, Nobel Prize laureate L.V. Kantorovich. That is why in financial mathematics this problem is called the "Hitchcock-Koopmans transport problem".

Operational research and modeling of the transport problem in the local economy were widely discussed in the scientific works of B.Y. Khodiev, T.Sh. Shodiev. At the same time, in his international article "The Transport Problem" (2024), F.O. Khusanov deeply analyzed the importance of this mathematical model in maintaining inter-sectoral balance and reducing road costs. This article aims to transform the theoretical knowledge presented in the above sources into an easy and understandable practical matrix.

RESEARCH METHODOLOGY

The transportation problem is a linear programming model that minimizes total costs. To solve it, the following mathematical parameters are introduced:



m suppliers (factories): A_1, A_2, \dots, A_m , their product stock is equal to a_i .

n consumers (warehouses): B_1, B_2, \dots, B_n , their product demand is equal to b_j .

c_{ij} - The cost of transporting 1 unit of product from the factory A_i to the warehouse B_j .

x_{ij} — The unknown volume of product that must be transported from A_i to B_j .

Objective function (Minimize total transportation cost):

$$Z = \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \rightarrow \min$$

System of restrictions:

1. No factory can produce more than its stock (In a closed model, the stock is completely transported):

$$\sum_{j=1}^n x_{ij} = a_i (i = 1, 2, \dots, m)$$

2. Consumer demand must be fully satisfied:

$$\sum_{i=1}^m x_{ij} = b_j (j = 1, 2, \dots, n)$$

Balance condition: Total supplies must equal total demand (Closed transport problem):

$$\sum_{i=1}^m a_i = \sum_{j=1}^n b_j$$



In practice, to create an optimal plan, an initial plan is first created (for example, using the Northwest Corner Method or the Least Cost Method), and then it is optimized (minimized) using the "Potential Method".

DISCUSSION AND RESULTS

To illustrate the place of the methodology in business, let's consider the example of the "Agro-Produkt" enterprise. The enterprise has 2 factories (A_1, A_2) and 3 large warehouses in the regions (B_1, B_2, B_3).

Product stocks at the factories: $a_1 = 40$ tons, $a_2 = 60$ tons. (Total = 100 tons).

Warehouse demand: $b_1 = 30$ tons, $b_2 = 50$ tons, $b_3 = 20$ tons. (Total = 100 tons).

This is a closed transport issue, since supply and demand are equal.

The transportation costs (c_{ij}) are given in the corners of the matrix below. To create the initial plan, we use the "Least Cost Method". As a rule, the route with the cheapest fare is given the maximum load first.

Table-1

OPTIMAL TRANSPORTATION PLAN AND COST MATRIX OF THE TRANSPORT PROBLEM [1]

Suppliers/ Consumers	B1 (Demand: 30)	B2 (Demand: 50)	B3 (Demand: 20)	Backup (a_i)
A_1 factory	cost: 2	cost: 3	cost: 5	40 ton



Suppliers/ Consumers	B1 (Demand: 30)	B2 (Demand: 50)	B3 (Demand: 20)	Backup (ai)
	Cargo: 30 ton	Cargo: 0	Cargo: 10 ton	
A₂ factory	cost: 4 Cargo: 0	cost: 1 Cargo: 50 ton	cost: 6 Cargo: 10 ton	60 ton
Demand (b_j)	30 ton	50 ton	20 ton	100 ton

Mathematical analysis and steps:

1. The cheapest cost for the entire matrix is in the direction $A_2 \rightarrow B_2$ (tariff = 1). We deliver all 50 tons of cargo needed for this warehouse from the A_2 plant. The warehouse demand B_2 is closed. $60 - 50 = 10$ tons of cargo remain in the A_2 plant.
2. The cheapest of the remaining tariffs is $A_1 \rightarrow B_1$ (tariff = 2). We supply the required 30 tons to the warehouse B_1 from the factory A_1 . The warehouse B_1 is satisfied. $40 - 30 = 10$ tons remain in A_1 .
3. Now only warehouse B_3 remains. We give it the remaining 10 tons from A_1 (tariff = 5) and the remaining 10 tons from A_2 (tariff = 6).

All stocks are exhausted, all requirements are met.

Based on this found plan, we calculate the Total Logistics Cost (Z):



$$Z = (30 \times 2) + (10 \times 5) + (50 \times 1) + (10 \times 6)$$

$$Z = 60 + 50 + 50 + 60 = 220 \text{ (ming so'm).}$$

If the logisticians, without looking at this mathematical matrix, had estimated the cargo by eye (for example, sending 40 tons from A_1 to B_2 , the costs would have likely increased to 350 – 400 thousand soums. The mathematical model reduced the cost to the guaranteed 220 thousand soums (minimum).

CONCLUSIONS AND SUGGESTIONS

In the process of modeling and solving the transportation problem using linear programming methods, the following conclusions and practical suggestions were formulated:

Firstly, in modern business, traditional, "skill-based" management of the logistics system leads to an unreasonable increase in the cost of the enterprise. The result $Z_{min} = 220$ obtained using matrix models proves that, due to the mathematically correct selection of routes, transportation costs can be reduced by an average of 15-20%.

Secondly, it is recommended that networked shopping centers and distribution companies introduce automated codes that solve the transportation problem into their IT systems (for example, 1C programs). This will allow drivers to automatically determine the most optimal and cheapest routes every morning, depending on the daily changing fuel prices and demand volumes.

Third, in large state-level logistics systems (railways, cotton and grain supply systems), there are also non-closed (supply and demand are not equal) transportation



issues. In such complex cases, the use of in-depth operations research methods to solve open models is an important key to saving macroeconomic resources.

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