THE PROBLEM OF DELIVERY OF COTTON RAW FLOWS THROUGH MINIMUM COST TRANSPORTATION

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https://doi.org/10.5281/zenodo.7812868

Abstract: In the article, the formulation, model, real distribution of the problem of transportation of raw cotton through the optimal road network and their optimal solution are considered. Also, the supply flow of cotton raw materials in the cotton ginning industry was analyzed.
Key words: Transportation problem, radial directions, optimization, freight transportation.

Agriculture of the Republic of Uzbekistan is specialized in the cultivation of raw cotton. Due to this, there is a need to determine the shortest length of low-cost road schemes for the transportation of raw cotton streams. This is because the flow of material delivered along the shortest path network is cost-effective and brings high efficiency.

Combinatorics methods were used to transport cotton raw materials from cotton receiving points to cotton factories in radial directions [1].

Cases observed in the application of radial directions in the transportation of goods [3, 5] were studied in scientific works, and the issue of reducing the costs of motor transport enterprises and increasing the quality of service was considered.

The problem of optimization of cotton raw material flows is formulated as follows.

The set of numbers of cotton raw material sending places is $I = \{1, 2, ..., i, ... m\}$ and the set of cotton raw material receiving points is $J = \{1, 2, ..., j, ..., n\}$. The distances between all i-numbered cotton processing facilities (CPF) and j-digital cotton receiving points (DCRP) are known by the l_{ij} matrix $\|l_{ij}\|_{IJ}$. In addition, each shipper's i-numbered CPF cotton raw material shipment volume a_i and j-numbered DCRP's raw material processing requirement b_j values are given. The mathematical model of the cotton raw material flow optimization problem is expressed as follows.

It is necessary to determine such positive values of raw cotton flow between each i and j, i.e

$$X_{ij} \geq 0, \quad i \in I, \quad j \in J, \qquad (1)$$

where the flow of cotton raw materials transported from each i CPF to all $j \in J$ DCRPs $\sum_j X_{ij}$ does not exceed its shipping capacity a_i

$$\sum_{j \in J} X_{ij} \leq a_i, \quad i \in I, \qquad (2)$$

the flow of cotton raw materials transported to each j DCRP $\sum_i X_{ij}$ should not exceed its raw material processing capacity b_j

$$\sum_{i\in J} X_{ij} \le b_j, \quad j \in J \qquad (3)$$

The volume of transport work in carrying out cotton raw material transportation flows between the sending and receiving addresses should be at least $\sum_i \sum_j X_{ij} l_{ij}$

$$\sum_{i\in I} \sum_{j\in J} X_{ij} l_{ij} \to MIN \qquad (4)$$

In the above model of the transport problem, the limiting conditions (1, 3) are in the form of inequality or equality, and if $\sum_i a_i = \sum_j b_j$ equality exists, such models are called closed models. In order to determine the quantitative solutions of the above-mentioned problems, it is necessary to transform them into a model consisting only of equations in their open form, that is, limiting conditions. For this, an artificial Y_{ij} is introduced to the right-hand side of conditions 2 and 3, and these expressions are converted into equations, i.e.

$$\sum_{i\in I} (X_{ij} + Y_{ij}) = a_i; \qquad (2^1)$$

$$\sum_{j\in J} (X_{ij} + Y_{ij}) = b_j; \qquad (3^1)$$

$$\sum_{i\in I} \sum_{j\in J} (X_{ij} + Y_{ij}) l_{ij} \to MIN; \qquad (4^1)$$

The flow of cotton raw materials is sent from cotton processing facilities to cotton receiving points. It takes into account the division of the regional territory into districts, that is, the attachment of cotton processing centers to cotton receiving points is carried out taking into account the administrative division of the regions. As a result, the average freight transportation distance and the total volume of completed transport work, measured in ton km, will increase. Optimizing the flow of cotton raw material that needs to be transported allows you to determine a plan that provides a minimum of transportation work.

In general, the process of transporting raw cotton to cotton gins consists of the following stages:

1) transportation of cotton raw materials from cotton fields to cotton processing facilities;
2) transportation of raw material from cotton processing facilities to cotton ginning plants;
3) transportation of raw materials from cotton fields to cotton gins.

The optimization problem of cotton raw material flows is formally expressed in the form of a linear programming transport model. We formulate the transport problem necessary to optimize cotton raw material flows (Table 1).

Table 1

Distribution of cargo flows between the consignee and the consignor

Table 1

Distribution of cargo flows between the consignee and the consignor

Shipper (i) \ Consignor (j)	v \ u	1st cotton point	2nd cotton point	3rd cotton point	a_i tons
1 farm		12 120	8	21	120
2 farm		20	13 60	7	60
3 farm		8 55	19 20	12	75
4 farm		11	7	22 55	55
5 farm		15	14 80	6	80
6 farm		17	10 40	14 45	85
7 farm		9	15	10 75	75
b_j tons		175	200	175	550

We get 3 cotton receiving points (DCRP) and 7 cotton processing facilities (CPF) as consumer destinations. We determine the distances between each DCRP and CPF based on the current road network. These distances in Table 1 are written in the upper right corner of the corresponding ij cells of the matrix. We determine the current transportation volume X_{ij} and write it in the appropriate ij cells of Table 1. We define X_{ij} as the sum of the b_j volume in the matrix cells by columns, and a_i by rows (Table 1).

Now we calculate the value of the load cycle in tkm according to the distribution of load flows in Table 1.

$$P_{амал} = X_{11}\cdot\ell_{11} + X_{22}\cdot\ell_{22} + X_{31}\cdot\ell_{31} + X_{32}\cdot\ell_{32} + X_{43}\cdot\ell_{43} + X_{52}\cdot\ell_{52} + X_{62}\cdot\ell_{62} + \\ + X_{63}\cdot\ell_{63} + X_{73}\cdot\ell_{73} = 120\cdot12 + 60\cdot13 + 55\cdot8 + 20\cdot19 + 55\cdot22 + 80\cdot14 + 40\cdot10 + \\ + 45\cdot14 + 75\cdot10 = 7150\,ткм$$

We calculate the average 1 t freight distance ($l_{амал}^{ўр}$) corresponding to the actual distribution of cargo flows:

$$l_{амал}^{ўр} = \frac{P_{амал}}{Q_{амал}} = \frac{7150}{550} = 13\,км$$

Solving the transport issue consists of two stages:

1) creating an initial base plan;
2) optimization of the initial plan.

Table 2

Optimal distribution of cargo flows between the consignee and the consignor

Shipper (i) \ Consignor (j)	v \ u	1 cot. point	2 cot. point	3 cot. point	a_i tons
		0	4	0	
1 farm	12	25 (12)	95 (8)	(21)	120
2 farm	7	(20)	(13)	60 (7)	60
3 farm	8	75 (8)	(19)	(12)	75
4 farm	11	(11)	55 (7)	(22)	55
5 farm	6	(15)	(14)	80 (6)	80
6 farm	14	(17)	50 (10)	35 (14)	85
7 farm	9	75 (9)	(15)	(10)	75
b_j tons		175	200	175	550

Now let's calculate the transportation work (P_{onm}) and average transportation distance of 1 ton for the found optimal plan of cargo flows (Table 2).

$$P_{амал} = X_{11}\cdot\ell_{11} + X_{12}\cdot\ell_{12} + +X_{23}\cdot\ell_{23} + X_{13}\cdot\ell_{13} + X_{42}\cdot\ell_{42} + +X_{53}\cdot\ell_{53} + X_{63}\cdot\ell_{63} +$$
$$+ X_{62}\cdot\ell_{62} + X_{71}\cdot\ell_{71} == 25\cdot12+60\cdot7+75\cdot8+55\cdot7++50\cdot10+80\cdot6+35\cdot14+$$
$$+45\cdot14+95\cdot8 = 4610\,ткм$$

Average shipping distance corresponding to the optimal plan of cargo flows ($l^{ўр}_{оптим}$)

$$l^{ўр}_{оптим} = \frac{P_{опт}}{Q_{амал}} = \frac{4610}{550} = 8{,}38\,км$$

The reduction of the applied load currents in relation to the average transport distance $\Delta l_{ўр}$ is defined as follows:

$$\Delta l_{ўр} = l^{ўр}_{амал} - l^{ўр}_{оптим} = 13 - 8{,}38 = 4{,}62\,км$$

The load cycle reduction ΔP is determined as follows:

$$\Delta P = P_{амал} - P_{опт} = 7150 - 4610 = 2540\,ткм$$

Reduced excess transportation costs ΔC is found as:

$$\Delta C = \Delta P\cdot S_{ткм} = 2540\cdot 42000 = 106680000\,сўм.$$

Thus, according to the results of our considered example of optimization of cotton raw material flows, it was determined that the average transportation distance of 1 t of cargo will be 4.62 km, the cargo turnover will be 2540 tkm, and the transportation costs will be reduced by 106680000 soums. This, in turn, in the conditions of current market competition, meeting the needs of consumers for transportation using the most effective technologies increases the competitiveness of enterprises.

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