Muhamediyeva Dilnoz Tulkunovna
Doctor of Technical Sciences, Professor
National Research University «Tashkent Institute of Irrigation
and Agricultural Mechanization Engineers», Republic of Uzbekistan

Abdusalomov Shahzodbek
Master
National University of the Republic of Uzbekistan

SOLUTION OF A FUZZY TRANSPORTATION PROBLEM

Transport models are widely used in logistics and supply chains to reduce costs. When the coefficients of costs and quantities of supply and demand are known accurately, many algorithms have been developed to solve the transport problem. But in the real world, in many cases, the ratios of costs and quantities of supply and demand are fuzzy values. The problem of fuzzy transportation is a transportation problem in which transportation costs, volumes of supply and demand are fuzzy values [1-2].

Definition 1. A triangular fuzzy number A is a fuzzy number completely defined by tuples of 3 (a, b, c) such that a <b <c, with a membership function defined as [1]

$$\mu_{\tilde{A}}(x)=\begin{cases}0 & if \quad x\le a,\\ \dfrac{x-a}{b-a} & if \quad a\le x\le b,\\ \dfrac{x-c}{c-b} & if \quad b\le x\le c,\\ 0 & if \quad x\ge c.\end{cases}$$

Definition 2. Harmonic mean *H* positive real numbers $x_1, x_2 \ldots, x_n$ is defined as [7]

$$H=\frac{n}{\frac{1}{x_1}+\frac{1}{x_2}+\ldots+\frac{1}{x_n}}=\frac{n}{\sum_{i=1}^{n}\frac{1}{x_i}}.$$

Mathematically fuzzy transport problem can be formulated as follows [2-6]:

Minimize

$$z = \sum_{i=1}^{m}\sum_{j=1}^{n}\tilde{c}_{ij}x_{ij}.$$

Subject to limitations

$$\sum_{j=1}^{n} x_{ij} = \tilde{a}_i, \qquad j = 1, 2, ..., n,$$

$$\sum_{i=1}^{m} x_{ij} = \tilde{b}_j, \qquad j = 1, 2, ..., m,$$

$$x_{ij} \geq 0, \qquad i = 1, 2, ..., m, \qquad j = 1, 2, ..., n,$$

where m : *total number of sources,*

n : *total number of destinations.*

$\tilde{a}_i$: *fuzzy public transport supply.*

b_j : *fuzzy demand for public transport at j-destination.*

c_{ij} : *fuzzy transportation costs per unit of transportation from the i-th source to the j-th destination.*

x_{ij} : *fuzzy quantity transported from the i-th source to the j-th destination (or fuzzy decision variables) to minimize the overall fuzzy transportation [13-14].*

Algorithm for solving and computational experiment:

1. Build a table in which the cells of the intersection of the departure point A_i and point of consumption B_j write down the costs in conventional units for the carriage of goods from the corresponding point of departure to the corresponding point of consumption. It turned out the following table:

Table 1

Condition of the transport problem

Point of departure	Destination				Offer
	*B*1	*B*2	*B*3	*B*4	
*A*1	(1,2,3)	(4,5,6)	(5,6,7)	(3,4,5)	(30,40,50)
*A*2	(1,2,3)	(3,4,5)	(4,5,6)	(1,2,3)	(50,60,70)
*A*3	(1,2,3)	(2,3,4)	(3,4,5)	(0,1,2)	(90,100,110)
Demand	(25,35,45)	(25,35,45)	(70,80,90)	(40,50,60)	

2. We construct an initial transportation plan, applying the rule of the minimum element.

2.1. From all the cells in the table, select the cell with the minimum transportation cost. This is a cage A_3B_4. It corresponds to the cost c_{34} = R(0,1,2). This is the cell corresponding to the departure point A_3 and the point of consumption B_4. Stock of cargo at the point A_3 is equal to R (90,100,110) units, and the demand for cargo at the point B_4 – R(40,50,60) units.

2.2. We will satisfy the need of the item B_4 at the expense of a point A_3: write in the lower right corner of the cell A_3B_4 number R(40,50,60), and the cost equal to R (0,1,2), we take in a circle.

2.3. Now, according to the rule of the minimum element, the next cell with the minimum element should be searched for either in the column or in the row in which the passed cell is located A_3B_4. In our case, at the point of departure A_3 R (40,50,60) cargo units remained unspent. Therefore, we look for the next cell with the minimum cost in the line corresponding to the point of departure A_3. This cell A_3B_1 with minimal cost c_{31} = R(1,2,3). Point of consumption B_1 R (25,35,45) cargo units are required. Let us satisfy the need of a point B_1 at the expense of a point A_3: we will enter the number R (25,35,45) in the lower right corner of the cell A_3B_1, and we will take the cost R (1,2,3) in a circle.

2.4. Next, you should move either along the column or along the line in which the A_3B_1 cell is located. R (5,15,25) cargo units remained unspent at the point of departure A_3. Therefore, we move along the line again and find the cell A_3B_2 with the minimum cost c_{32} = R (2,3,4). We send the remaining units at the point A_3 R (5,15,25) to the point of consumption B_2, write the number R (5,15,25) in the lower right corner of the cell A_3B_2, and take the cost R (2,3,4) in a circle.

2.5. Again, we have to move either along the column or along the line in which the passed cell is located. In the passed cell, the cargo stocks A_3B_2 at the departure point A_3 were used up, so we move on along the column. We arrive at the line corresponding to the point of departure A_2, to the cell A_2B_2, with the minimum cost of transportation in this column c_{32} = R (3,4,5). The consumption point has unmet needs in R (10,20,30) units. We will satisfy these needs at the expense of the departure point: in the lower right corner of the cell A_2B_2 we enter the number R (10,20,30), and we take the cost R (3,4,5) in a circle

2.6. At the point of departure A_2 left unspent R(30,40,50) units. We fall into the cage A_2B_3. Requirements of points of consumption B_1, B_2 and B_4 already satisfied, therefore R (30,40,50) units required by the point of consumption B_3, direct to this point, to the lower right corner of the cell A_2B_3 write the number R (30,40,50), and take the cost R (4,5,6) in a circle.

2.7. All stocks at the point of departure A_2, used up, so we move further along the column and get into the cell A_1B_3, corresponding to the point of departure A_1. Cargo stocks at this point are R (30,40,50) units, and unmet cargo needs at the point of consumption B_3 - also R (30,40,50) units. We will satisfy the needs of the item B_3 at the expense of a point A_1, write in the lower right corner of the cell A_1B_3 number R(30,40,50), and take the cost of transportation R (5,6,7) in a circle.

On this, the needs at all points of consumption are satisfied, and the stocks at all points of departure are used up.

3. Let's find the value of the linear form corresponding to the original transportation plan:

$z(x)$ = R(5,6,7)·R(30,40,50) +R(3,4,5)·R(10,20,30) + R(4,5,6)·R(30,40,50) + R(1,2,3)·R(25,35,45) + R(2,3,4)·R(5,15,25) + R(0,1,2)·R(40,50,60) = R(640,685,710).

Cells of the table containing circles will be called "occupied places", and cells without circles - "free places". Original transportation plan has been drawn up.

Transport models are widely used in logistics and supply and demand chains to reduce costs. In this article, we have obtained an optimal solution to a fuzzy transport problem using a triangular fuzzy number. To obtain an optimal solution, arithmetic operations on triangular fuzzy numbers are used.

References:

1. Bellman R, Zadeh L.A. (1970), 'Decision making in a fuzzy environment', Management science, vol. 17, pp. 141 - 164
2. Roseline, S. S., &Amirtharaj, E. H. (2013). A new ranking of intuitionistic fuzzy numbers with distance method based on the circumcenter of centroids. International Journal of Applied Mathematics&Statistical Sciences (IJAMSS), 2(4), 37-44.
3. Mukhamedieva D T 2020 Journal of Physics: Conference Series1546(1) 012091
4. Muxamediyeva D K 2019 IOP Conf.Journal of Physics: Conf. Series 1210
5. Juraev Z Sh, Muhamediyeva D T and Sotvoldiev D M 2020 IOP Conf. Journal of Physics: Conf. Series 1546(1)012083
6. Muhamediyeva D., Sotvoldiyev D., Mirzaraxmedova S., Fozilova M. Approaches to handwriting recognition // International Conference on Information Science and Communications Technologies, ICISCT 2020, 2020, 9351505. 4-6 november. DOI: 10.1109/ICISCT50599.2020.9351505
7. Farmonov SH.R, Bekmuratov T.F, Muhamedieva D.T. About the dodges plans of the continuous selective control // International Conference on Information Science and Communications Technologies, ICISCT 2020, 2020, 9351415. 4-6 november. DOI: 10.1109/ICISCT50599.2020.9351415
8. Mirzayan K., Dilnoz M., Barno S. (2021) The Problem of Classifying and Managing Risk Situations in Poorly Formed Processes. // In: Aliev R.A., Yusupbekov N.R., Kacprzyk J., Pedrycz W., Sadikoglu F.M. (eds) 11th World Conference "Intelligent System for Industrial Automation" (WCIS-2020). WCIS 2020. Advances in Intelligent Systems and Computing, vol 1323. Springer, Cham. Pp 280-286. https://doi.org/10.1007/978-3-030-68004-6_36