Solution of Fuzzy Transportation Problem using Ranking Methodology

[1]M. R. Fegade, [2]A. A. Muley
[1]Head, Dept. of Statistics, Digambarrao Bindu College, Bhokar, Dist. Nanded, M.S., India
[2]Dept. of Statistics, School of Mathematical Sciences, S. R. T. M. University, Nanded. M.S., India

Abstract: In this paper, we have proposed an algorithm to obtain optimal solution for fuzzy transportation problem (FTP). Here, a method is proposed to solve FTP with ranking technique method. Further, it is solved with the help of zero point method. It is observed that, the proposed methodology gives better solution to the decision maker. It is illustrated with a numerical example.

Keywords - **Fuzzy, Transportation problem, Trapezoidal membership function, ranking technique.**

I. INTRODUCTION

In real life problems, to deal with inexact coefficients in transportation problems, many researchers (Chinneck and Ramadan 2000; Das et al. 1999; Ishibuchi and Tanaka1990; Oliveira and Antunes 2007; Tong 1994) have proposed fuzzy programming techniques for solving them. Various efficient methods were developed for solving transportation problems with the assumption of precise source, destination parameter, and the penalty factors. Bai and Liu (2016) represented a new robust optimization method for supply chain network design problem by employing variable possibility distributions. The main motivation for building their optimization model was to make tools available for producers to develop robust supply chain network design. Their proposed optimization method incorporates the uncertainties encountered in the manufacturing industry. They worked on a food processing company with four suppliers, five plants, five distribution centres and five customer zones. Experimental results showed that their parametric optimization method can be providing an effective and flexible way for decision makers to design a supply chain network. Bharati et al. (2017) defined a new distance function between two trapezoidal fuzzy (TrF) numbers which satisfies all the properties of metric and a degree of deviation between two TrF numbers and used to solve a fully fuzzy multi-objective linear programming problem (FMOLPP). The proposed algorithm uses converting a FMOLPP into crisp linear programming problem and then to get Pareto-optimal solution to the problem with minimum deviation degree in decision variables. Das et al. (2017) introduced an efficient method to solve fully fuzzy linear programming problems. The proposed method is derived from the multi objective linear programming problem and lexicographic ordering method. Theoretical analysis for the proposed method has been provided. Ebrahimnejad (2016) introduced a formulation of TP involving interval-valued trapezoidal fuzzy numbers for the transportation costs and values of supplies and demands. A fuzzy linear programming approach for solving interval-valued trapezoidal fuzzy numbers transportation problem approach is proposed based on comparison of interval-valued fuzzy numbers with signed distance ranking. Their results illustrates that interval-valued trapezoidal fuzzy numbers transportation problem gives rise to the same expected results as those obtained for TP with trapezoidal fuzzy numbers. Ebrahimnejad and Verdegay (2018) formulated the intuitionistic fuzzy TP (IFTP) and proposed a solution approach for solving the problem. The main contributions of their paper were in five-fold as they converted the formulated IFTP into a deterministic classical LP problem based on ordering of TrIFNs using accuracy function; proposed a new approach that provides an intuitionistic fuzzy optimal solution; negative parts in the obtained intuitionistic fuzzy optimal solution and intuitionistic fuzzy optimal cost, they proposed a new method that provides non-negative intuitionistic fuzzy optimal solution and optimal cost; they discussed advantages of the proposed method over the existing methods; demonstrated the feasibility and richness of the obtained solutions.

Das et al. (1999) proposed a method, called fuzzy technique to solve interval transportation problem by considering the right bound and the midpoint of the interval. Since, the transportation problem is essentially a linear programming problem; one straight forward idea is to apply the existing fuzzy linear programming techniques (Buckley 1988; Julien 1994; Rommelfanger et al. 1989) to solve the fuzzy transportation problem. Unfortunately, most of the existing techniques (Wolf and Hanuscheck 1989; Tanaka, Ichihashi and Asai 1984) provide only crisp solutions for the fuzzy transportation problem. Chanas et al. (1984) developed a method for solving transportation problems with fuzzy supplies and demands via the parametric programming technique using the Bellman-Zadeh criterion (1970). In this paper, we have proposed a ranking method for finding an optimal solution to fuzzy transportation problem.

II. PRELIMINARIES

Let D denote the set of all closed bounded intervals on the real line R. That is, D= $\{ [a, b], a \leq b$ and a and b are in $R\}$.

The following definitions of the basic arithmetic operators and partial ordering on closed bounded intervals (Moore 1979; Klir and Yaun 2008):

201

Definition 1: A fuzzy number $\tilde{A}$ is a trapezoidal fuzzy number denoted by(a, b, c, d) where a, b, c and d are real number and its membership function $\mu_A(x)$ is given below:

$$\mu_{\tilde{A}}(x)=\begin{cases}0, & for\ x\le a\\ (x-a)/(b-a), & for\ a\le x\le b\\ 1, & for\ b\le x\le c\\ (c-x)/(d-c), & for\ b\le x\le c\\ 0, & for\ x\ge d\end{cases} \quad (1)$$

Definition 2: let $\tilde{A}=(a_1,b_1,c_1,d_1)$ *and* $\tilde{B}=(a_2,b_2,c_2,d_2)$ be two trapezoidal fuzzy numbers. Then

(1) $\tilde{A}\oplus\tilde{B}=(a_1,b_1,c_1,d_1)\oplus(a_2,b_2,c_2,d_2)=(a_1+a_2,b_1+b_2,c_1+c_2,d_1+d_2)$

(2) $\tilde{A}\square\ \tilde{B}=(a_1,b_1,c_1,d_1)\ \square\ (a_2,b_2,c_2,d_2)=(a_1-a_2,b_1-b_2,c_1-c_2,d_1-d_2)$

(3) $\tilde{A}\otimes\tilde{B}=(a_1,b_1,c_1,d_1)\otimes(a_2,b_2,c_2,d_2)=(t_1,t_2,t_3,t_4)$

Where,

$t_1=\text{minimum}\{a_1a_2,b_1b_2,c_1c_2,d_1d_2\}$ $t_2=\text{minimum}\{b_1b_2,b_1c_2,c_1b_2,c_1c_2\}$

$t_3=\text{maximum}\{b_1b_2,b_1c_2,c_1b_2,c_1c_2\}$ $t_4=\text{minimum}\{a_1a_2,b_1b_2,c_1c_2,d_1d_2\}$

III. FUZZY TRANSPORTATION PROBLEM

Consider, the following fuzzy transportation problem as follows:

Minimize $\tilde{z}=\sum_{i=1}^{m}\sum_{j=1}^{n}\tilde{c}_{i_j}\tilde{x}_{i_j}$

Subject to

$$\sum_{j=1}^{n}\tilde{x}_{i_j}=\tilde{a}_i,\ i=1,2,....m\ \sum_{i=1}^{m}\tilde{x}_{i_j}=\tilde{b}_j,\ j=1,2,....n$$

$\sum_{i=1}^{m}\tilde{f}_{ij}^{(k)}\tilde{x}_{i_j}\le\tilde{R}_j^{(k)}$ $,j=1,2,....n;k=1,2,..l$ $\tilde{x}_{i_j}\ge\tilde{0}$, for all *i* and *j*.

Where, all the unit shipping costs; $\tilde{c}_{i_j}$ supply quantities $\tilde{a}_{i_j}$; demand quantities $\tilde{b}_{ij}$.

The solution procedure of obtain in an optimal solution to problem

IV. PROPOSED METHODOLOGY

Step 1: Construct the fuzzy transportation problem.

Step 2: If $\tilde{A}=(a,b,c,d)$ be generalized fuzzy numbers then, R($\tilde{A}$) is calculated as follows:

$$R(\tilde{A})=\frac{d(b-a)+a(d-c)}{(b-a)+(d-c)} \quad (2)$$

Above relation shows, if the fuzzy number is symmetrical (a = d), the relations may be simplified more. For simplicity, based on the results obtained, hereafter the trapezoidal fuzzy number $\tilde{A}$ will be represented as $\tilde{A}=(a,b,c,d)$ respectively. Further, using this step of conversion of trapezoidal number into crisp is to solve the transportation problem.

Step 3: Solve the crisp transportation problem using zero point method (Fegade et al. 2011).

Step 4: Moving towards our original fuzzy transportation problem and rewrite the fuzzy transportation problem.

Step 5: Compute the total minimize cost of fuzzy transportation problem.

V. NUMERICAL EXAMPLE:

ABC Company makes 3 different grades of plastic wrapping films.

1) PP film
2) PE film
3) PPCP film

Each type film needs to be manufactured in 3 different types of combinations. Each type has specific property and end use. The following table displays the cost of transportation, availabilities, requirements and the maximum catalyst contents are in the form of fuzzy numbers.

	Combinations			Available
	1	2	3	
PP film	(1,2,4,7)	(0,1,3,6)	(0,1,2,3)	(1,2,4,5)
PE film	(1,2,4,7)	(2,3,6,7)	(3,5,7,10)	(2,3,5,6)
PPCP film	(3,5,7,10)	(1,2,4,7)	(2,3,6,7)	(3,4,6,7)
Required	(2,3,5,6)	(2,3,5,6)	(2,3,5,6)	

Solution:
First of all, using step 2 conversion of trapezoidal number into crisp is done as follows:

$$\tilde{A}_{11}=(1,2,4,7)=2.5\ \tilde{A}_{12}=(0,1,3,6)=1.5\ \tilde{A}_{13}=(0,1,2,3)=1.5\ \tilde{A}_{21}=(1,2,4,7)=2.5\ \tilde{A}_{22}=(2,3,6,7)=4.5$$

$$\tilde{A}_{23}=(3,5,7,10)=5.8\ \tilde{A}_{31}=(3,5,7,10)=5.8\ \tilde{A}_{32}=(1,2,4,7)=2.5\ \tilde{A}_{33}=(2,3,6,7)=4.5$$

Available:

$$\tilde{A}_1=(1,2,4,5)=3\ \tilde{A}_2=(2,3,5,6)=4\ \tilde{A}_3=(3,4,6,7)=5$$

Required:

$$\tilde{B}_1=(2,3,5,6)=4\ \tilde{B}_2=(2,3,5,6)=4\ \tilde{B}_3=(2,3,5,6)=4$$

	1	2	3	Supply
1	2.5	1.5	3 1.5	3
2	4 2.5	0 4.5	5.8	4
3	5.8	4 2.5	1 4.5	5
Demand	4	4	4	12

After solving the problem, we obtained the solution as follows:
$x^{o}_{13}=3$, $x^{o}_{21}=4$, $x^{o}_{22}=0$, $x^{o}_{32}=4$, $x^{o}_{33}=1$. And the total value of the problem is $z=29$.
According to Fegade et al. (2012) the problem has the same allocation solution as follows:
$x^{o}_{13}=3$, $x^{o}_{21}=4$, $x^{o}_{22}=0$, $x^{o}_{32}=4$, $x^{o}_{33}=1$ but the optimal solution of the problem is $z=37$.
Now, we again move towards original fuzzy return to initial problem and obtain the solution of the fuzzy transportation problem

	Combinations			Available
	1	2	3	
1			(1,2,4,5)	(1,2,4,5)
2	(2,3,5,6)	(0,0,0,0)		(2,3,5,6)
3		(2,3,5,6)	(1,1,1,1)	(3,4,6,7)
Required	(2,3,5,6)	(2,3,5,6)	(2,3,5,6)	

Thus, optimal solution for the given fuzzy transportation problem is same as Fegade et al. (2012).

$$\tilde{x}_{13}=(1,2,4,5),\ \tilde{x}_{21}=(3,3,5,6),\ \tilde{x}_{22}=(0,0,0,0),\ \tilde{x}_{32}=(2,3,5,6)\ \tilde{x}_{33}=(1,1,1,1)\ \tilde{z}=(6,17,54,106)$$

V. CONCLUSION

In this paper, ranking technique is proposed for trapezoidal membership data values and further it is compared with our FTP. It is found that; modified algorithm gives us better results i.e. minimum the transportation cost. It simply states the efficiency of the proposed methodology. This technique can be use various problems occur in transportation. It has wide scope in logistics and supply chain.

REFERENCES

[1] Bai, X., & Liu, Y. 2016. Robust optimization of supply chain network design in fuzzy decision system. Journal of Intelligent Manufacturing, 27(6):1131-1149.

[2] Bellman R.E. and Zadeh L.A.1970. Decision making in a fuzzy environment. Management sci., 17(B): 141-164.

[3] Bharati, S. K., & Singh, S. R. 2017. A computational algorithm for the solution of fully fuzzy multi-objective linear programming problem. International Journal of Dynamics and Control: 1-8.

[4] Buckley J. J.1988. Possibilistic linear programming with triangular fuzzy numbers. Fuzzy Sets and Systems, 26: 135-138.

[5] Chinneck J. W. and Ramadan K. 2000. Linear programming with interval coefficients. Journal of the Operational Research Society, 51: 209– 220.

[6] Das, S. K., Mandal, T., & Edalatpanah, S. A. (2017). A mathematical model for solving fully fuzzy linear programming problem with trapezoidal fuzzy numbers. Applied intelligence, 46(3), 509-519.

[7] DasS.K., GoswamiA. And AlamS.S. 1999. Multiobjective transportation problem with interval cost, source and destination parameters. European Journal of Operational Research, 117: 100– 112.

[8] Ebrahimnejad, A. 2016. Fuzzy linear programming approach for solving transportation problems with interval-valued trapezoidal fuzzy numbers. Sādhanā, 41(3):299-316.

9] Ebrahimnejad, A., & Verdegay, J. L. 2018. A new approach for solving fully intuitionistic fuzzy transportation problems. Fuzzy Optimization and Decision Making, 17(4): 447-474.

10] Fegade M.R., Jadhav V. A., Muley A. A. 2012. A Fuzzy approach to solve impurity constraints in transportation problem using Ranking Methodology, SRTMU's Research Journal of Science, 1 (2): 47-55.

11] Fegade M.R., JadhavV. A., Muley A. A. 2012. Solving Fuzzy Transportation Problem using Zero Suffix and Robust Ranking Methodology. International Organization of Scientific Research of Engineering, 2(7): 36-39.

12] Fegade M.R., Jadhav V. A., Muley A. A. 2011. Finding an optimal solution of transportation problem using interval and triangular membership functions. European Journal of Scientific Research, 60 (3): 415-421.

13] Fegade M.R., Jadhav V. A., Muley A. A. 2011. Solution of multi-objective transportation problem using zero suffix and separation method. International eJournal of Mathematics and Engineering, 118: 1091-1098.

4] IshibuchiH. and Tanaka H. 1990. Multi-objective programming in optimization of the interval objective function. European Journal of Operational Research, 48: 219–225.

5] Julien B.(1994). An extension to possibilistic linear programming, Fuzzy Sets and Systems, 64: 195-205.

6] Klir George and Yaun Bo. 1995. Fuzzy sets and fuzzy logic: Theory and applications. PHI New Delhi.

7] MooreR.E.1979.Method and applications of interval analysis. SLAM, Philadelphia, PA.

8] Oliveira C and Antunes C. H. 2007. Multiple objective linear programming models with interval coefficients–an illustrated overview. European Journal of Operational Research,181: 1434-1463.

9] Rommelfanger H., wolf J., Hanuscheck R.1989. Linear programming with fuzzy objectives. Fuzzy Sets and Systems, 29: 195.

] Tanaka H., Ichihashi H., Asai K.1984. A formulation of fuzzy linear programming based on comparison of fuzzy numbers. Control and Cybernetics, 13: 185-194.

] Tong S.,1994, Interval number and fuzzy number linear programming, Fuzzy Sets and Systems, 66: 301-306.

] Zadeh L.A.1978. Fuzzy sets as a basis for a theory of possibility. Fuzzy Sets and Systems,1: 3-28.

] Zimmermann H.J. 1996. Fuzzy sets theory and its applications. Kluwer Nijhoff, Boston.

[illegible]