Optimal Solution to Transportation Problem with Heptagonal Fuzzy Numbers

Madhav Fegade and Aniket Muley

***Abstract* — In this paper, we have proposed another calculation to track down optimalanswers for the fuzzy transportation problem. Here, positioning strategy is utilized to defuzzify the Heptagonal fuzzy numbers. This article gives procedure that cuts down the optimal arrangement. The mathematical model represents the legitimacy of our proposed technique.**

***Keywords* —Fuzzy, heptagonal fuzzy numbers, optimality, ranking, transportation.**

I. INTRODUCTION

Operations research is a condition of craftsmanship approach utilized for problem-addressing and navigation. It assists any association with accomplishing their best exhibition under the given imperatives or circumstances. The transportation problem is one of the exceptional regions observed overall which is useful to tackle genuine problems. All things considered, transportation problems assume a significant part underway; conveyances and so on purposes and are an exceptional instance of straight programming problems. It helps in limiting the expense work. There are various things that choose the expense of transport. It incorporates the distance between the two areas, the way followed, method of transport, the quantity of units that are shipped, the speed of transport, and so forth. In this way, the concentration here is to ship the items with least transportation cost with no split the difference in organic market. The transportation model can likewise be utilized in going with area choices. In this paper, it is seen that there are a few exploration studies to carry the best optimal answer for the transportation problems. The problem that should be settled is, to arrive at savvy creation in different creation organizations. This article gives technique that cuts down the optimal arrangement.

Reference [1] called attention to that much of the time it isn't to imaginable to limit the enrollment capacity to the typical structure and proposed the idea of summed up fuzzy numbers. There are a few papers in the writing wherein summed up fuzzy numbers are utilized for tackling genuine problems however as far as we could possibly know, till now nobody has involved summed up fuzzy numbers for taking care of the transportation problems. In this paper, another strategy is proposed for taking care of fuzzy transportation problems by expecting that a chief is dubious about the exact upsides of the transportation cost, accessibility and request of the item. In the proposed strategy transportation cost, accessibility and request of the item are addressed by summed up trapezoidal fuzzy numbers. To represent the proposed technique a mathematical model is tackled and the acquired outcomes are contrasted and the consequences of existing strategies. Since the proposed technique is an immediate expansion of old style strategy so the proposed strategy is exceptionally straightforward and to apply on genuine transportation problems for the chiefs.

Reference [2] proposes a technique for settling fuzzy multi-objective straight programming (FMOLP) problems where every one of the coefficients are three-sided fuzzy numbers and every one of the imperatives are fuzzy equity or disparity. Utilizing the deviation degree gauges and weighted max-min strategy, the FMOLP problem is changed into fresh straight programming (CLP) problem. In the event that leaders fix the upsides of deviation levels of two side fuzzy numbers in every requirement, then the d-pareto-optimal arrangement of the FMOLP problems can be gotten by taking care of the CLP problem. The greater the upsides of the deviation degrees are, the better the targets work values will be. So we likewise propose a calculation to track down an equilibrium pareto-optimal arrangement between two objectives in struggle: to further develop the targets work values and to diminish the upsides of the deviation degrees. At last, to outline our technique, we settle a mathematical model.Reference [3] talked about a fuzzy transportation problem(FTP) including trapezoidal fuzzy numbers. We arranged one more calculation to observe an underlying essential fuzzy achievable arrangement which will be very closer to the optimal arrangement. The optimal arrangement of the given fuzzy transportation problems is

Published on July 21, 2022.
M. Fegade, Digambarrao Bindu Arts, Commerce and Science College, Bhokar-431801 (M. S.) India.
(corresponding e-mail: mrfegade@gmail.com)
A. Muley, Swami Ramanand Teerth Marathwada University, Nanded-431606 (M. S.) India.
(e-mail: aniket.muley@gmail.com)

confirmed by utilizing the fuzzy variant of Modified Distribution technique without changing into its journalist old style structure. A couple of mathematical problems are settled to show the proposed calculation and the arrangement is contrasted and the arrangements acquired by utilizing a current calculations.Reference [4] proposed a fuzzy transportation problem under a fuzzy climate is tackled utilizing octagonal fuzzy numbers. The transportation problem is huge and has been broadly concentrated in the field of applied science to tackle an arrangement of direct equation.Reference [5] to observe the least transportation cost of certain wares through a capacitated network, when the inventory and the interest of hubs and the limit and cost edges are addressing fuzzy numbers. Here, they proposed a positioning procedure for tackling fuzzy transportation problem, where fuzzy interest and supply are in type of Triangle Squared and Trapezoidal Squared fuzzy numbers. Here, straightforward calculation is proposed for processed fuzzy transportation problem lastly practicality of the proposed study is checked with a mathematical model. Reference [6] proposed a few strategies for taking care of transportation problems in fuzzy climate yet in every one of the proposed techniques the boundaries are addressed by typical fuzzy numbers. Reference [7] planned to concentrate on a capacitated transportation problem (CTP) with punishment cost, supplies, and requests addressed by hexagonal fuzzy numbers. In light of positioning capacity, the provisions and requests are changed over completely to the fresh structure. Then utilization of the α-level, the problem is changed over into span straight programming. To advance the span objective capacity, we characterize the request relations addressed by strategy creator's decision between stretches. The expansion (minimization) problem considering the span objective capacity is changed to multi-objective streamlining problem in view of request relations presented by the inclination of strategy producers between stretch benefits (costs). A mathematical model is given for representation and to actually take a look at the legitimacy of the recommended approach.Reference [8] proposed intuitionistic fuzzy (IF) numbers. Further, the impediments and the inadequacies of every one of these it were called attention to exist techniques. To beat these impediments and deficiencies another positioning methodology by altering a current positioning methodology is proposed for looking at IF numbers. Accordingly, with the assistance of proposed the positioning methodology, another technique is proposed to track down the optimal arrangement of such unequal least expense stream (MCF) problems in which every one of the boundaries are addressed by IF numbers.

Reference [9] proposed an inventive way to deal with advance transportation problems through summed up trapezoidal numbers in a fuzzy climate. The principal commitment here is to foster a creative technique to streamline the summed up fuzzy trapezoidal transportation problem and decrease the computational multifaceted design of the current strategies. On the other hand this technique gives many better outcomes against old style North-West Corner and Least-Cost plans in Fuzzy climate. An extra value of the proposed plot is that for a few fuzzy transportation problems it outfits the most ideal way out straightforwardly. It is easy to comprehend and apply. The arrangement interaction is exemplified through two mathematical models and correlation for certain standard existing techniques. Reference [10] managed the optimal estimated answer for a unique kind of streamlining problem called a fuzzy transportation problem utilizing pentagonal fuzzy numbers. The upsides of the expense, supply, and interest for fuzzy transportation problems are taken as pentagonal fuzzy numbers. The pentagonal fuzzy numbers are changed over into fresh qualities utilizing a clever proposed positioning capacity. By contrasting this and the regular positioning techniques, we can accomplish improved outcomes with the guide of the proposed new positioning strategy. Vogel's Approximation Method is then applied to get the arrangement. A few examinations have been led to research the recommended method.Reference [11] explores a proper charge strong transportation problem (FCSTP) under a fuzzy climate, wherein the both immediate and fixed costs should be fuzzy numbers. This is one of the essential and most significant problems in transportation and organizationresearch regions. To tackle such a difficult problem, three metaheuristics, in particular factor area search (VNS), reenacted strengthening (SA) and mixture VNS are utilized. Supposedly, neither SA nor VNS has been considered for any sort of transportation problems. Also, the curiosity of the proposed calculations is to utilize different new area structures connected with the idea of the problem, which are proposed and utilized interestingly. The effectiveness of utilized boundaries is estimated by the Taguchi trial plan strategy that is a helpful and new way to deal with tune the boundaries and diminish the conceivable number of investigations in this examination region. To assess the exhibition of the proposed calculations, a broad computational review has been directed and the related outcomes got by the calculations are contrasted and one another. At last, an end and further exploration regions are introduced. Reference [12] a fuzzy ranking of heptagonal fuzzy number was used to predict a fuzzy Min-Max transportation problem, and to discover the best solution. Further, they have performed comparative study of proposed model with different algorithms viz., Russell’s method, North West methods, Least cost method, Vogel’s approximation methods to find the best solution.

Reference [13] full fuzzy transportation problem (FFTP) is a transportation problem where transport costs, request, supply and choice factors are communicated in type of fuzzy numbers. To tackle fuzzy transportation problem, fuzzy number boundary should be switched over completely to a fresh number

called defuzzification technique. In this new all out essential positioning strategy with fuzzy numbers from change of trapezoidal fuzzy numbers to hexagonal fuzzy numbers got consequence of consistency defuzzification on even fuzzy hexagonal and non balanced type 2 numbers with fuzzy three-sided numbers. To work out of ideal arrangement FTP utilized fuzzy transportation calculation with most minimal expense technique. From this ideal arrangement, observed utilization of fuzzy number structure absolute indispensable positioning with list of confidence gives different ideal worth. Likewise, all out basic positioning worth utilizing hexagonal fuzzy numbers has an optimal worth better than the absolute indispensable positioning worth utilizing trapezoidal fuzzy numbers.

II. Preliminaries

A. Definitions

Fuzzy set:$\tilde{A}$ is fuzzy set on R is defined as a set ordered pairs$\tilde{A} = \{X_0, \mu_A(X_0) | \, X_0 \in \tilde{A}\,, \mu_A(X_0) \to [0,1]\}$, where $\mu_A(X_0)$is said to be the membership function.
Fuzzy number: $\tilde{A}$ is fuzzy set on R, likely bounded to the stated conditions given beneath

i. $\mu_A(X_0)$ is part by continuous
ii. There exist at one $X_0 \in R$ with $\mu_A(X_0) = 1$
iii. $\tilde{A}$ is a regular and convex

Heptagonal fuzzy number:A fuzzy number $\tilde{A}$ on R is said to be the heptagonal fuzzy number or linear number which is names as $(\tilde{a}_1\tilde{a}_2, \tilde{a}_3, \tilde{a}_4, \tilde{a}_5, \tilde{a}_6, \tilde{a}_7)$ if it membership function $\mu_A(X_0)$ has the following characteristic

$$\mu_A(X) = \begin{cases} 0, \;\; X < \tilde{a}_1 \\ \frac{1}{2}\left(\frac{X-\tilde{a}_1}{\tilde{a}_2-\tilde{a}_1}\right), \tilde{a}_1 \le X \le \tilde{a}_2 \\ \frac{1}{2}, \tilde{a}_2 \le X \le \tilde{a}_3 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{X-\tilde{a}_3}{\tilde{a}_4-\tilde{a}_3}\right), \tilde{a}_3 \le X \le \tilde{a}_4 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{\tilde{a}_5-X}{\tilde{a}_5-\tilde{a}_4}\right), \tilde{a}_4 \le X \le \tilde{a}_5 \\ \frac{1}{2}, \tilde{a}_5 \le X \le \tilde{a}_6 \\ \frac{1}{2}\left(\frac{\tilde{a}_7-X}{\tilde{a}_7-\tilde{a}_6}\right), \tilde{a}_6 \le X \le \tilde{a}_7 \\ 0, X >, \tilde{a}_7 \end{cases}$$

III. Methodology

A. Proposed Algorithm

Step1: Convert the given Heptagonal fuzzy numbers to crisp number using following range ranking Function: Range = Max-Min
Step 2: Check whether the given transportation problem is balanced or unbalanced.
2.1: If it is balanced, then go to step 3.
2.2: If it is unbalanced, then add a dummy row or dummy column to fulfil the requirement.
Step 3: First of all find minimum and maximum of each row and make the difference between them and the difference is divided by the number of rows in the given table in each iteration.
Step 4: First of all find minimum and maximum of each column and make the difference between them and the difference is divided by the number of column in the given table in each iteration.
Step 5: After simplifying step 3 and 4, select the largest difference and allocate as much as possible to the smallest element in the respective row (Column) to fulfil the demand or to exhaust the availability.
Step 6: If maximum difference ratio value may occur more than once in the rows or columns then arbitrarily select any one row or columnbut not both.
Step 7: Repeat the step 3 to 6, until all the availability and demand will get exhausted or fulfilled.
Step 8: To check if the number of allocations is m+n-1 or not. If it is less than m+n-1, then apply the MODI method to check the optimality of the given problem.

IV. Result and Discussion

A resolution that affirms the fuzzy transportation problem which involves transportation cost, customer needs and demands and existence of products using pentagonal fuzzy numbers. Observe the following transportation problem as stated in Table I [12]:

TABLE I:Given Dataset

	D_1	D_2	D_3	Availability
O_1	(3,6,2,1,5,0,4)	(2,3,1,4,3,6,5)	(2,4,3,1,6,5,2)	(2,2,1,2,1,1,0)
O_2	(2,7,7,6,3,2,1)	(1,3,5,7,9,11,13)	(0,1,2,4,6,0,5)	(3,2,1,4,5,0,1)
O_3	(3,6,3,2,1,8,7)	(3,4,3,2,1,1,0)	(2,4,6,8,10,12,14)	(2,4,3,1,6,5,2)
Demand	(0,1,2,4,6,0,5)	(0,4,6,4,6,2,0)	(2,7,7,6,3,2,1)	

By using ranking technique (Step 2) we have defuzzified the given transportation problem and represented Table II.

TABLE II: Defuzzified Transportation Problem

	D_1	D_2	D_3	Availability
O_1	6	5	5	2
O_2	6	12	6	5
O_3	7	4	12	5
Demand	6	6	6	

The given problem is an unbalanced one. So, it is to be transformed into balanced one. Using Step 3 to 7, we obtained the following Tables III to VI:

TABLE III: First Iteration

	D_1	D_2	D_3	Availability	$\frac{Max - Min}{4}$
O_1	6	5	5	2	0.3333
O_2	6	12	6	5	2
O_3	7	4	12	5	2.6666
O_4	0	0	6 0	6	0
Demand	6	6	6		
$\frac{Max - Min}{3}$	1.75	3	3 ↑	18	

TABLE IV:Second Iteration

	D_1	D_2	D_3	Availability	$\frac{Max - Min}{3}$
O_1	6	5	5	2	0.3333
O_2	6	12	6	5	2
O_3	7	5 4	12	5	2.6666
Demand	6	6	0	12	
$\frac{Max - Min}{3}$	0.3333	2.66666 ↑	2.3333		

TABLE V:Third Iteration

	D_1	D_2	D_3	Availability	$\frac{Max - Min}{2}$
O_1	6	1 5	5	2	0.5 ←
O_2	6	6	6	5	0
Demand	6	1	0	7	
$\frac{Max - Min}{3}$	0	0.3333	0.3333		

TABLE VI: Final Iteration

	D_1	D_3	Availability	$\frac{Max - Min}{2}$
O_1	1 6	5	1	0.5 ←
O_2	5 6	6	5	0
Demand	6	0	6	
$\frac{Max - Min}{2}$	0	0.5		

Total Minimum cost=$6 \times 0 + 5 \times 4 + 1 \times 5 + 1 \times 6 + 5 \times 6 = 61$

The comparison of the proposed method with NCWM, LCM, Russell's Approximation method, Row minima method, column minima method and VAM is tabulated below (Table VII):

TABLE VI: COMPARATIVE RESULTS

Methods	Optimal Solutions
NCWM	224.125
LCM	219.750
Russell's Approximation Method	280.375
VAM Method	184.125
Min-Max Method [12]	159.375
Proposed method	61

V. CONCLUSION

In this review, the proposed calculation gives the most ideal suitability of the fuzzy transportation problem for pentagonal fuzzy numbers. As a rule, this calculation can be valuable for a wide range of fuzzy transportation problems. This approach could be summed up to determine comparable sorts of transportation problems. The proposed technique helps in finding another office, an assembling plant or an office when at least two areas are getting looked at. The all out transportation cost, dissemination cost or delivery cost and creation costs are to be limited by applying the model.

CONFLICT OF INTEREST

Authors do not have any conflict of interest.

REFERENCES

[1] Chen SH. Operations on fuzzy numbers with function principal. *Tamkang Journal of Management Sciences*.1985;6: 13–25.
[2] Cheng H, Huang W, Zhou Q, Cai J. Solving fuzzy multi-objective linear programming problems using deviation degree measures and weighted max–min method. *Applied Mathematical Modelling*. 2013;37(10-11): 6855-6869.
[3] GeorgeG, Maheswari PU, GanesanK. A modified method to solve fuzzy transportation problem involving trapezoidal fuzzy numbers. *In AIP Conference Proceedings*. *AIP Publishing LLC*. 2020; 2277(1): 090005.
[4] GurukumaresanD, DuraisamyC, Srinivasan R. Optimal Solution of Fuzzy Transportation Problem Using Octagonal Fuzzy Numbers. *Computer Systems Science And Engineering*.2021; 37(3): 415-421.
[5] JayaramanP, JahirhussianR. Fuzzy optimal transportation problems by improved zero suffix method via robust rank techniques. *International Journal of Fuzzy mathematics and systems*.2013, 3(4): 303-311.
[6] KaurA, KumarA. A new approach for solving fuzzy transportation problems using generalized trapezoidal fuzzy numbers. *Applied Soft Computing*.2012; 12(3): 1201-1213.
[7] KhalifaAEW, KumarP, AlharbiMG. Enhancement of Capacitated Transportation Problem in Fuzzy Environment. *Advances in Fuzzy Systems*. 2020: 1-9.
[8] KumarA, KaurM. A ranking approach for intuitionistic fuzzy numbers and its application. *Journal of Applied Research and Technology*. 2013; 11(3): 381-396.
[9] MathurN, SrivastavaPK. An Inventive Approach to Optimize Fuzzy Transportation Problem. *Int. J. Math. Eng. Manage. Sci*.2020;5: 1-10.
[10] MitlifRJ, Rasheed M, Shihab S. An Optimal Algorithm for a Fuzzy Transportation Problem. *Journal of Southwest Jiaotong University*. 2020; 55(3): 1-11.
[11] Molla-Alizadeh-ZavardehiS, NezhadSS, Tavakkoli-Moghaddam R, YazdaniM. Solving a fuzzy fixed charge solid transportation problem by metaheuristics. *Mathematical and Computer Modelling*.2013;57(5-6): 1543-1558.
[12] Rubeelamary S, Sivaranjani S. Ranking of the Heptagonal Fuzzy Number to Solve Fuzzy Min –Max Transportation Problem. *The International Journal of Analytical and Experimental Modal Analysis*. 2020;12(1): 39-44.
[13] Sam'anM, Hariyanto S, Surarso B. Optimal solution of full fuzzy transportation problems using total integral ranking. *In Journal of Physics: Conference Series. IOP Publishing*. 2018; 983(1): 012075.

M. Fegade was born in 1988 in India. Author have completed M.Sc. (2010) and received Ph.D. (2014) degrees in Statistics from Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (India). He is currently working as an Assistant Professor in the Department of Statistics, Digambarrao Bindu College, Bhokar Dist. Nanded (India).

Author published 0 1books and 09 National / International reseaech articles in journals and book chapters form. Authors research current interests areas are Operations Research, Applied Statistics.

A. Muley was born in 1983 in India. Author have completed M.Sc. (2006) and received Ph.D. (2009) degrees in Statistics from Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (India). He is currently working as an Assistant Professor in the Department of Statistics, School of Mathematical Sciences, Swami Ramanand Teerth Marathwada University, Nanded (India).

Author published 02 books and 88 National/International reseaech articles in journals and book chapters form. Authors research current interests areas are Operations Research, Applied Statistics, Data Mining, Machine Learning and Deep Learning. He has got Best Paper Award IEEE International Conference on Granular Computing, held at Kaohsiung, Taiwan duringNov 8-10, 2011.