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# Fuzzy Transportation Problems with New Kind of Ranking Function

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**ABSTRACT**
*The transportation problem is one of the earliest applications of linear programming problems. In the survey of literature, several methods are proposed for solving transportation problems in fuzzy environment but in all the proposed methods, the parameters are normal fuzzy numbers. In this paper, a general fuzzy transportation problem is discussed. In the proposed method, transportation cost, availability and demand of the product are represented by triangular fuzzy numbers. We develop fuzzy version of Vogel's algorithms for finding fuzzy optimal solution of fuzzy transportation problem. This is due to uncertainty and impreciseness when the sets are translated into numerical values so a device is necessary to solve these problems Crisp values are used in complicated formulations and equations to get optimal results. A numerical example is given to show the efficiency of the method.*

**Keywords**: *Fuzzy sets, Fuzzy numbers, Fuzzy transportation problem, Fuzzy ranking, Fuzzy arithmetic.*

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## I. INTRODUCTION

The Transportation problem is a special type of linear programming problem which deals with the distribution of single product (raw or finished) from various sources of supply to various destination of demand in such a way that the total transportation cost is minimized. There are many effective algorithms for solving the transportation problems when all the decision parameters, i.e. the supply available at each source, the demand required at each destination as well as the unit transportation costs are given in a précised way. But in real life, there are many diverse situations due to uncertainty in one or more decision parameters and hence they may be expressed in a precise way. Measurement inaccuracy, lack of evidence, computational errors, and high information cost, whether conditions etc. could be some of the reasons uncertainty. Hence we cannot apply the traditional classical methods to solve the transportation problems successfully. Therefore the use of Fuzzy transportation problems is more appropriate to model and solve the real world problems. A fuzzy transportation problem is a transportation problem in which the transportation costs, supply and demand are fuzzy quantities. Bellman and Zadeh [2] proposed the concept of decision making in Fuzzy environment. After this pioneering work, several authors such as Shiang-Tai Liu and Chiang Kao[12], Chanas et al[1],Pandian et.al [11], Liu and Kao [10] etc proposed different methods for the solution of Fuzzy transportation problems. Chanas and Kuchta [1] proposed the concept of the optimal solution for the Transportation with Fuzzy coefficient expressed as Fuzzy numbers. Chanas,Kuchta [4] developed a concept of optimal solution of the transportation with Fuzzy cost co-efficient, Fuzzy sets and systems. Liu and Kao [10] described a method to solve a Fuzzy Transportation problem based on extension principle. They introduced a genetic algorithm to solve Transportation with Fuzzy objective functions.Nagoor Gani and Abdul Razak [7] obtained a fuzzy solution for a two stage cost minimizing fuzzy transportation problem in which supplies and demands are trapezoidal fuzzy numbers.Shanmugasundari,Ganesan[6] solved Fuzzy optimal solution of fuzzy transportation problem. Pandian and Natarajan [11] proposed a Fuzzy zero point method for finding a Fuzzy optimal solution for Fuzzy transportation problem where all parameters are trapezoidal fuzzy numbers. In general, most of the existing techniques provide only crisp solutions for the fuzzy transportation problem. In this paper we propose a simple method, for the solution of fuzzy transportation problems without converting them in to classical transportation problems using Triangular Fuzzy number.

## II. PRELIMINARIES

The aim of this section is to present some notations, notations and results which are of useful inour further consideration.

**Fuzzy numbers.**

A fuzzy set $\tilde{A}$defined on the set of real numbers R is said to be a fuzzy number if its membership $\tilde{A}: R \rightarrow [0\ 1]$ has following characteristics

(i) $\tilde{A}$ is convex.

(ii) $\tilde{A}$is convex it means that for every $x_1$,$x_2$ЄR,$\tilde{A}(\lambda x_1, +(1-\lambda)x_2)$≥ min $\{\tilde{A}(x_1), \tilde{A}(x_2)\}$, λЄ[0 1].

(iii) $\tilde{A}$is normal i.e. there exists an x ЄR such that$\tilde{A}(x) = 1$.

(iv) $\tilde{A}$ispiecewise continuous.

**2.2.Triangular fuzzy numbers**

A fuzzy number $\tilde{A}$in R is said to be a triangular fuzzy number if its membership function$\tilde{A}: R \rightarrow [0\ 1]$.
$\tilde{A}: R \rightarrow [0\ 1]$.has the following characteristics

$$\tilde{A}(x) = \begin{cases} \dfrac{x-a_1}{a_2-a_1} & a_1 < x < a_2 \\ 1 & x = a_2 \\ \dfrac{a_3-x}{a_3-a_2} & a_2 < x < a_3 \\ 0 & otherwise \end{cases}$$

It is denoted by $A$ = $(a^{(1)}$,$a^{(2)}$, $a^{(3)})$ where$a^{(1)}$is Core (A), $a^{(2)}$is left width and $a^{(3)}$is right width. The geometric representation of Triangular Fuzzy number is shown in the following figure. Since, the shape of thetriangular fuzzy number $A$ is usually in triangle it is called triangular fuzzy set.

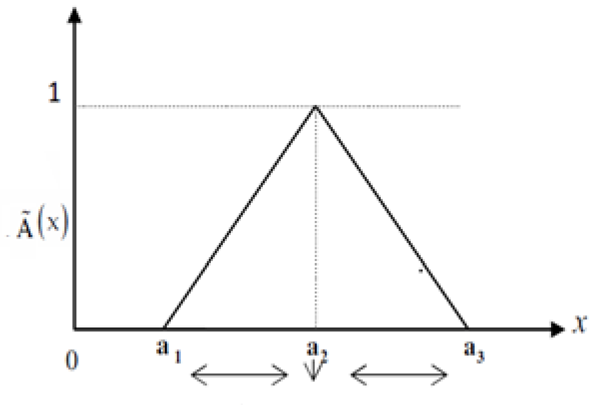


Fig 1. Triangular fuzzy number $\tilde{A} = (a_1, a_2, a_3)$

The Parametric form of a triangular fuzzy number is represented by
$A = [a^{(1)}+a^{(2)}(1-r), a^{(1)}+a^{(3)}(1-r)]$

**4. Arithmetic operations of triangular fuzzy number**

Ming Ma et al. [9] have proposed a new fuzzy arithmetic based upon both location index and fuzziness index functions. The location index number is taken in the ordinary arithmetic, whereas the fuzziness index functions are considered to follow the lattice rule which is least upper bound in the lattice L. That is for a, b∈L we define, a$\vee b$=max {a, b} and a$\wedge$b=min {a, b}.

For arbitrary triangular fuzzy numbers Operations are defined by $\tilde{A}$= $(a_1, a_2, a_3)$ and $\tilde{B}$= $(b_1, b_2, b_3)$

(i) Addition
$\tilde{A} + \tilde{B}$=$(a_1, a_2, a_3)$+ $(b_1, b_2, b_3)$

(ii) subtraction
$\tilde{A} - \tilde{B}$=$(a_1, a_2, a_3)$- $(b_1, b_2, b_3)$

(iii) multiplication

$\tilde{A}\tilde{B}$=$(a_1, a_2, a_3)$ $(b_1, b_2, b_3)$

(iv) Division

$\frac{\tilde{A}}{\tilde{B}}$=$\frac{(a_1,a_2,a_3)}{(b_1,b_2,b_3)}$=$(\frac{a_1}{b_1}$, max$(a_2, a_3)$ , max(b_2, b_3)

**3. Ranking of Triangular Fuzzy number**

Several approaches for the ranking of fuzzy numbers have been proposed in literature. An efficient approach for comparing the fuzzy numbers is solved by the use of a ranking function based on their graded means. That is, for every $A$ = ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) ∈F(R), the ranking functionR: F(R) →R by graded mean is defined as

$$R(A) = \frac{a_1+a_2+a_3}{3}$$

For any two fuzzy triangular Fuzzy numbers $A$ = ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) and $B$ = ($b^{(1)}$,$b^{(2)}$, $b^{(3)}$) in F(R), we have the following comparison.

(i) $A$ <$B$ If and only if R (A) < R (B)
(ii) $A$ >$B$ If and only if R (A) > R (B)
(iii) $A$ =$B$ If and only if R (A) = R (B)
(iv) $A$ – $B$ If and only if R (A)-R (B) = 0

A triangular fuzzy number $A$ = ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) in F(R) is said to be positive if R(A)> 0 and denoted by A>0, also if R(A)< 0 and denoted by A< 0, if the triangular numbers are said to be equivalent and is denoted by A=0 and, if R(A)=R(B) then the triangular number A and B are said to be equal and it is denoted by A≈B.

## III. FUZZY TRANSPORTATION PROBLEM

In the literature (Chanas and Kuchta 1996, Kaufmann and Gupta 1988) it is understood that to solve such type oftransportation problems the costs are represented as normal fuzzy numbers. Thefuzzy transportation problems, in which a decision maker is uncertain about the precise values of transportation cost from the $i^{th}$ source to the $j^{th}$destination, but sure about the supply and demand of the product, can be formulated as follows:

Minimize $\sum_{i=1}^{m}\sum_{j=1}^{n}\widetilde{c_{ij}}x_{ij}$

Subject to $\sum_{j=1}^{n}x_{ij} = a_i$; i=1, 2, 3,…..n

$\sum_{j=1}^{m}x_{ij} = b_j$; j=1, 2, 3,…..m

Where$a_i$: total availability at the $i^{th}$ source.

$b_j$ :Total demand at the $j^{th}$ destination.

$x_{ij}$ :Total amount of product to be supplied from the $i^{th}$ source to $j^{th}$destination.

$\widetilde{c_{ij}}$: Unit fuzzy cost of tranportaton of unit product from $i^{th}$ source to $j^{th}$destination.

Tabular form of fuzzy cost transportation problem

| | **Destination** | | | | |
|---|---|---|---|---|---|
| | | 1 | ……………….. | n | **Supply** |
| | 1 | $\tilde{C}_{11}$ | | $\tilde{C}_{1n}$ | $\tilde{a}_1$ |
| **Sources** | .<br>.<br>.<br>. | ..<br>.<br>.<br>. | | .<br>.<br>.<br>. | .<br>.<br>.<br>. |
| | m | $\tilde{C}_{m1}$ | ………………… | $\tilde{C}_{mn}$ | $\tilde{a}_m$ |
| | **Demand** | $b_1$ | ………………… | $\tilde{b}_n$ | |

The fuzzy number is fully and uniquely represented by its r-cut, since the r-cut ofeach fuzzy number is closed interval of real numbers for all r(0, 1).This enables us to definearithmetic operations on fuzzy number in terms of arithmetic operations on their r-cut.

**Numerical Example**

Let us consider a balanced fuzzy transportation problem having two sources and two destinations in which only unit cost of product taken as a fuzzy numbers then the problem is designed as given in table 1.

**Solution:** Transportation table of the given fuzzy transportation problem is

**Table 1:** FuzzyTransportation Problem 

| | *Destination* | | Supply |
|---|---|---|---|
| ***Source*** | (18 ,20 ,22) | (28, 30, 32) | (150, 200 ,250) |
| | (6 ,10 ,14 ) | (35 ,40, 45) | (80 ,100, 120) |
| **Demand** | (100, 150, 200) | (100, 150 ,200) | (200 ,300 ,400) |

To apply the proposed algorithms and the fuzzy arithmetic, let us express all the triangular fuzzy numbers based upon both location index and fuzziness index functions. That is in the form of ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) given table 2

**Table 2:** Balanced fuzzy transportation problem in which all the triangular numbers are of the form ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$).

| | *Destination* | | Supply |
|---|---|---|---|
| ***Source*** | (20 ,2-2r, 2-2r) | (30, 2-2r ,2-2r) | (200 ,50-50r, 50-50r) |
| | (10 ,4-4r ,4-4r) | (40 ,5-5r ,5-5r) | (100, 20-20r, 20-20r) |
| **Demand** | (150 ,50-50r ,50-50r) | (150 ,50-50r ,50-50r) | (300 ,100-100r ,100-100r) |

By applying fuzzy version of Vogel's Approximation method (FVAM)), the initial fuzzy basic feasible solution is given in table 3.

**Table 3** Initial fuzzy basic feasible solution

| | *Destination* | | Supply |
|---|---|---|---|
| ***Source*** | (20, 2-2r, 2-2r)<br>(50, 50-50r ,50-50r) | (30 ,2-2r ,2-2r)<br>(50 ,50-50r ,50-50r) | (200 ,50-50r, 50-50r) |
| | (10, 4-4r ,4-4r)<br>(100 ,20-20r ,20-20r) | (40, 5-5r ,5-5r) | (100, 20-20r , 20-20r) |
| **Demand** | (150 ,50-50r ,50-50r) | (150 ,50-50r ,50-50r) | (300 ,100-100r ,100-100r) |

The corresponding initial fuzzy transportation cost is given by

IFTC≈ (20 ,2-2r ,2-2r) x (50 ,50-50r, 50-50r) + (30 ,2-2r ,2-2r) x (50 ,50-50r, 50-50r) + (10 ,4-4r ,4-r) x (100 ,20-20r,20-20r)

≈(6500 ,50-50r ,50-50r)

By applying fuzzy version of MODI method (FMODI), it can be seen that the current initial fuzzy basic feasible solution is optimal. Hence the fuzzy optimal solution in terms of location index and fuzziness index is given in the following cases as,

**Case (i).** When *r=0*, the fuzzy optimal transportation cost in terms of the form ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) is (6500, 50, 50) the corresponding fuzzy optimal transportation of the form is (6450, 6500, 6550) and its defuzzyfied transportation cost is 6500.

**Case (ii).** When *r = 0.5*, the fuzzy optimal transportation cost in terms of the form ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$)is (6500, 25, 25). The corresponding fuzzy optimal transportation cost of the form is (6475, 6500, and 6525) and its defuzzyfied transportation cost is 6500

**Case (iii).** When *r=1*, the fuzzy optimal transportation cost in terms of the form ($a^{(1)}$,$a^{(2)}$, $a^{(3)}$) is(6500, 0, 0).The corresponding fuzzy optimal transportation cost of the form is (6500,6500,6500) and its defuzzyfied transportation cost is 6500.

Optimum fuzzy transportation cost is (6500,6500.6500). Defuzzified fuzzy transportation cost is 6500.

## IV. CONCLUSION

In this paper, the transportation costs are considered as imprecise numbers. They are described by triangular fuzzy numbers which are more realistic and general in nature. Though the numbers taken are imprecise yet the results that we get are more precise than the traditional method. We proposed a fuzzy version of VAM algorithms to solve fuzzy transportation problem without converting them to classical transportation problems. One numerical exampleis solved using the proposed algorithms to prove that the results obtained are more precise than the existing results.

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