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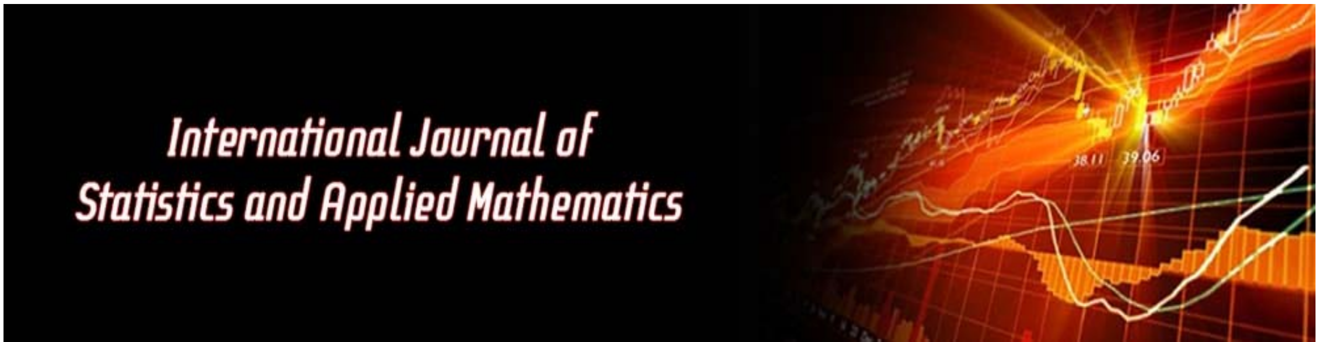

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Fuzzy transportation problem solving approach using ranking function

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Abstract
A variety of methods are proposed for solving fuzzy transportation problems but all the methods in literature, demonstrate the parameters by normal fuzzy numbers. In most of the work it is quite impossible to limit the membership function to the normal form. So in this paper a generalized approach for fuzzy numbers for transportation problem is proposed. In proposed work, a new approach is presented for solving real life fuzzy transportation problems by assuming that a decision maker is uncertain about the accurate values of the demand, availability as well as the transportation cost of the given product. In this paper Vogel's Approximation Method (VAM) is introduced which provide optimum initial solution rather than northwest corner method and intuitive low cost method. In the proposed method demand, availability as well as the transportation cost of the product are represented by generalized trapezoidal fuzzy numbers. The proposed VAM method is very easy to understand and easy to apply on real life fuzzy transportation problems for the decision makers.

Keywords: Ranking function, fuzzy numbers, Vogel's Approximation Method (VAM)

Introduction
In modern competitive market, the demand from organizations to find effective ways to produce and deliver value to consumers become robust. How to send the products to the consumers within the tight deadline in effective and optimized manner, become more challenging task in present scenario. Transportation models is a platform to provide a powerful framework to meet this deadlines. The fundamental transportation problem was first developed by Hitchcock [1]. The transportation problems can be cast as a typical linear programming model, which can be easily solved by the simplex method. It is very simple mathematical approach to evaluate the necessary information. The stepping stone method which yields an alternative approach of determining the simplex method information in 1954 by Charnes and Cooper [2].
An initial basic feasible solution (IBFS) for the transportation problem can be procured by using the north-west corner method (NWCM) and intuitive low cost method. The Vogel's approximation method is useful for finding the optimal solution for the fuzzy transportation problem. A fuzzy transportation problem is a problem in which the transportation expenditures, demand and supply quantities are belongs to fuzzy set. Ranking normal fuzzy number is a crucial step in different mathematical models and initially popularized by Jain for decision making in fuzzy situations [4]. In many situations it is quite impossible to limit the membership function to the general form [5] and proposed the concept of generalized trapezoidal fuzzy numbers for transportation cost, availability and demand in the present work. This paper is organized as follows: In Section 2, basic terminology to solve generalized trapezoidal fuzzy numbers is presented. In Section 3, Vogel's approximation method with fuzzy transportation problems is presented. The conclusions are discussed in Section 4.

Basic terminology
In this section a basic terminology is defined to solve fuzzy transportation problem using ranking of trapezoidal fuzzy numbers.

Definitions

Type 1: If y is a set of objects represented ordinary by Y, then a fuzzy set X in Y is defined as a set of ordered pairs X= {(y, μX(y)/ y Є Y} where μX(y) is called the membership function for the fuzzy set X the membership function maps each element of y to a membership interval [0, 1].

Type 2: A fuzzy set X is defined on universal set of real numbers is said to be a generalized fuzzy number if its membership function has the following characteristics

- $\mu_X(y)$ =R → [0, 1] is continuous
- $\mu_X(y)$ = 0 for all y Є X (-∞, p] U [s,∞)
- $\mu_X(y)$ is strictly increasing on [p, q] and strictly decreasing on [r, s]
- $\mu_X(y)$ = ω for all y Є [q, r], where 0 < ω ≤ 1

Type 3: A generalized fuzzy number X= (p, q, r, s, ω) is said to be a generalized trapezoidal fuzzy number if its membership function is given by

$$\mu_x(y) = \begin{cases} \dfrac{\omega(y-p)}{q-p} \text{.........}, p \le y \le q \\ \omega \text{.........}, q \le y \le r \\ \dfrac{\omega(y-p)}{r-s} \text{.........}, r \le y \le s \\ 0 \text{........................}, Otherwise \end{cases} \quad (1)$$

If ω =1, then X = (p, q, r, s; 1) is a normalized trapezoidal fuzzy number and X is a generalized or non-normaltrapezoidal fuzzy number if 0 < ω< 1, as a particular case if q=r, the trapezoidal fuzzy number reduces to a triangular fuzzy number given by X= (p, q, s; 1).

Type 4: Let X_1= (p1, q1, r1, s1, ω1) and X_2= (p2, q2, r2, s2, ω2) be generalized trapezoidal fuzzy number defined on real numbers R then following conditions occurs:

- $X_1 + X_2$ = (p1+p2, q1+q2, r1+r2, s1+s2 ; min(ω1, ω2))
- $X_1 - X_2$ = (p1-s2, q1-r2, r1-q2, s1-p2 ; min(ω1, ω2))

Ranking calculation of Trapezoidal Fuzzy numbers:

A new concept for ranking of generalized trapezoidal fuzzy number is presented using trapezoid as reference point. This Ranking methods map fuzzy number directly in to the real line.

U: F→ R which associate every fuzzy number with a real number and then use the ordering ≥ on the real line.

Let X_1= (p1, q1, r1, s1; ω1)be generalized trapezoidal fuzzy numbers then R(X) is calculated as following steps:

Step 1: Find ω = minimum (ω1, ω2)

Step2: Find R(X) = [k(p1+s1)+2(1- k)(q1+r1)], wherek Є (0,1)

Vogel's approximation method

Vogel's approximation method (VAM) is used to find out an optimum initial solution by takinginto account the costs associated with each route rather than north-west corner rule and intuitive low cost method.

Problem: In this paper a solution to fuzzy transportation problem involving shipping cost, customer demand and availability of products using trapezoidal fuzzy numbers. Consider the following fuzzy transportation problem.

	Destination				Stocks
Source	(10,1,1,2)	(0,8,3,2)	(10,5,5,10)	(1,1,2,1)	(18,11,8,8)
	(14,9,4,16)	(2,3,8,0)	(3,6,3,4)	(12,9,2,14)	(0,19,21,0)
	(4,3,6,3)	(1,2,1,1)	(16,4,9,14)	(2,1,1,10)	(22,39,21,18)
Requirement	(14,2,9,12)	(8,8,11,18)	(0,20,16,0)	(22,26,14,18)	

The above problem is simplified using ranking calculation of trapezoidal fuzzy numbers. The given fuzzy problem is converted into a crisp value problem shown in table below. The problem is simplified by taking k as 0.5 and ω=1.

	Destination				Stocks	Penalties
Source	2	3	5	1	8	1
	7	3	4	6	10	1
	4	1	7	2	20	1
Requirement	6	8	9	15	38	
Penalties	2	2	1	1		

VAM Step 1: Write the difference of minimum cost and next to minimum cost against each row in the penalty column. This difference is known as penalty.

Step 2: Write the difference of minimum cost and next to minimum against each column in the penalty row.

Step 3: Identify the maximum penalty. In this case it is at column one and at column 2.

	Destination				Stocks	Penalties
Source	2(6)	3	5	1	8-6=2	1
	7	3	4	6	10	1
	4	1	7	2	20	1
Requirement	6-6=0	8	9	15	32	
Penalties	2	2	1	1		

Step 4: Consider any of the two columns and allocate the maximum units to the place where the cost is minimum.

Step 5: Consider column one, the position (1, 1) has minimum cost so assign the maximum possible units (six units to this position).

Step 6: Now write the remaining stock in row one.

Step 7: After removing first column and then by repeating the steps.

	Destination				Stocks	Penalties
Source	2(6)	3	5	1	8-6=2	2←
		3	4	6	10	1
		1	7	2	20	1
Requirement		8	9	15	32	
Penalties		2	1	1		

Here we can choose row as well as column with highest penalty. So we choose row with penalty 2.

	Destination				Stocks	Penalties
Source	2(6)	3	5	1(2)	2-2=0	2←
		3	4	6	10	1
		1	7	2	20	1
Requirement		8	9	15-2=13	32-2=30	
Penalties		2	1	1		

Source	Destination				Stocks	Penalties
	2(6)			1(2)		
		3	4	6	10	1
		1	7	2	20	1
Requirement		8	9	13	32-2=30	
Penalties		2	3	4		

Source	Destination				Stocks	Penalties
	2(6)			1(2)		
		3	4	6	10	1
		1	7	2(13)	20-13=7	1
Requirement		8	9	13-13=0	32-2=30	
Penalties		2	3	4←		

Source	Destination				Stocks	Penalties
	2(6)			1(2)		
		3	4		10	1
		1	7	2(13)	7	6←
Requirement		8	9		17	
Penalties		2	3			

Source	Destination				Stocks	Penalties
	2(6)			1(2)		
		3	4		10	1
		1(7)	7	2(13)	7-7=0	6←
Requirement		8-7=1	9		10	
Penalties		2	3			

After following the above mentioned steps the final conclusive table shown below which is required to calculate total transportation cost.

Source	Destination				Stocks	Penalties
	2(6)			1(2)		
		3(1)	4(9)			
		1(7)		2(13)		
Requirement						
Penalties						

Total Cost= (2*6)+(1*2)+(3*1)+(4*9)+(1*7)+(2*13)=86.
The crisp valueof the optimum fuzzy transportation for the given problem is 86RS. Also note that there are other possible solutions that depend on how the ties are broken. It means when there is a tie between two highest penalty we use one, so it is possible to get optimal solution by choosing another path.

Conclusion
In the Vogel's approximation method demand availability and transportation cost of the product are represented by generalized trapezoidal fuzzy numbers. To illustrate the VAM method a numerical example is solved and transportation cost is calculated. Ranking fuzzy numbers is a prominent task in a fuzzy decision making process. Each ranking method results a different point of view on fuzzy numbers. This proposed work shows anew ranking method which is simple and efficient than the north-west corner &intuitive low cost method. It is little bit difficult to conclude a final answer to the question on which fuzzy ranking method is the best. Most of the time choosing a method rather than another is a matter of preference. However, believing that the results obtained in this paper gives us the optimum cost for the fuzzy transportation problems.

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