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Fuzzy Transportation Problem in Octadecagonal Fuzzy Number

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Abstract: *The transportation problem is one of the special type and the applications of linear programming problems. The usual transportation problem is unspecified that the decision maker is sure about the accurate values of transportation cost, supply and demand of the product. In some situations decision maker is not in the position to specify the objective precisely but rather than which can be specified in fuzzy concepts. We study fuzzy transportation problem (FTM) using Octadecagonal fuzzy number and its membership function. We have defined the ranking to the Octadecagonal fuzzy numbers to convert the fuzzy valued transportation to crisp valued transportation problem. To illustrate these approaches, a real life problem has been solved using the Least Cost Method.*

Keywords: Fuzzy transportation problem (FTM), Octadecagonal fuzzy number, membership function, least cost method

I. INTRODUCTION

The fuzzy set was offered to the world by Zadeh[1]. The fruits of fuzzy sets are extended to engineering and technology, management and economics by many researchers .The transportation problem originally developed by Hitchcock. The transportation problems are most useful to the industries and others to reduce the cost and maximize the profit. The transportation problem is a special case of linear programming problem. In a fuzzy transportation problem, costs, supply and demand values are fuzzy values. There are many approaches to solve the fuzzy transportation problem by different Authors. In many real life situations, it is not possible to determine both transportation unit cost and quantities, but the fuzzy numbers give best approximation of them. Raju and Jayagopal [2] introduced the Icosikaitetragonal fuzzy numbers and its membership function. Because there is always no possible to restrict the membership function in a particular form. Icosagonal fuzzy number is complex when it is compared to the triangular and trapezoidal fuzzy number both in form and computation. Using Octadecagonal fuzzy numbers to solve the fuzzy transportation problem gives best optimal value when we compared with triangular and trapezoidal fuzzy numbers. Michael has proposed algorithm for solving transportation problem with fuzzy constraints and has investigated the relationship between the fuzzy algebraic structure of the optimum solution of the deterministic problem and its fuzzy equivalent. In this paper, we have solved fuzzy transportation problem using Octadecagonal uzzy number. We have illustrated fuzzy transportation problem using ranking technique with Enneadecagonal fuzzy numbers.

II. PRELIMINARIES

In this section, we give the preliminaries that are required for this study.

Definition 2.1. *A fuzzy set A is defined by* $A = \{(x, \mu_A(x)): x \in A, \mu_A(x) \in [0,1]\}$. *Here* x *is crisp set A and* $\mu_A(x)$ *is membership function in the interval* $[0,1]$.

Definition 2.2. *The fuzzy number A is a fuzzy set whose membership function must satisfy the following conditions.*

(i) A fuzzy set A of the universe of discourse X is convex

(ii) A fuzzy set A of the universe of discourse X is a normal fuzzy set if $x_i \in X$ exists

(iii) $\mu_A(x)$ is piecewise continuous

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Definition 2.3 *An α-cut of fuzzy set A is classical set defined as* $^{\alpha}[A] = \{x \in X | \mu_A(x) \geq \alpha\}$

Definition 2.4 *A fuzzy set A is a convex fuzzy set iff each of its α-cut* $^{\alpha}A$ *is a convex set.*

Definition 2.5 Mathematical formulation of a fuzzy transportation problem

The general form of Transportation problem is

Minimize (total cost) $z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$

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

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

$x_{ij} \geq 0$ For all i and j

2.6 Ranking of Octadecagonal fuzzy number:

Let I be a normal Octadecagonal fuxxy number. The value $M(I)$, called as measure of I is calculated as

$$M(I) = \frac{e_1 + e_2 + e_3 + e_4 + e_5 + e_6 + e_7 + e_8 + e_9 + e_{10} + e_{11} + e_{12} + e_{13} + e_{14} + e_{15} + e_{16} + e_{17} + e_{18}}{18}$$

$$where\ \ 0 \leq k_1 \leq k_2 \leq k_3 \leq k_4 \leq 1$$

III. BALANCED TRANSPORTATION PROBLEM

The general form of Transportation problem is

Minimize (total cost) $z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$

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

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

$x_{ij} \geq 0$ For all i and j

If total supply from all the sources is equal to the total demand in all destinations, then it is called as balanced transportation problem

3.1 Unbalanced Transportation Problem:

The general form of Transportation problem is

Minimize (total cost) $z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$

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

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

$x_{ij} \geq 0$ For all i *and* j

If in a transportation problem total supply from all the sources is not equal to the total demand in all destinations, then it is called as unbalanced transportation problem. But for a feasible solution to exist, total supply must be equal to the total demand thus it is necessary convert unbalanced problem into balanced problem.

3.2 Procedure for Solving Least Cost Method (LCM)

Step 1: Select the cell having minimum unit cost C_{ij} and allocate as much as possible,

i.e., $\min\left(s_i, d_j\right)$

Step 2: Subtract this minimum value from supply S_i and demand d_j

Step 3: If the supply is S_i is zero then strike out that row and if the demand d_j is zero then strike that column

Step 4: If minimum unit cost cell is not unique, then select the cell where maximum allocation can be possible

Step 5: Repeat this steps for all uncrossed rows and columns until all supply and demand values are zero

IV. NUMERICAL EXAMPLE

Consider the following fuzzy transportation problem

	Destination			Supply
Origin	(-4,-3,-2,-1, 0,1,2,3, 4,5,6,7, 8,9,10,11, 12,13,14)	(-3,-2,-1,0, 1,2,3,4, 5,6,7,8, 9,10,11,12, 13,14,15)	(1,2,3,4, 5,6,7,8, 9,10,11,12, 13,14,15,16, 17,18,19)	(-4,-3,-2,-1, 0,1,3,5, 6,7,8,10, 12,13,15,17, 19,20,21)
	(-3,-2,-1,0, 1,2,3,4, 5,6,7,8, 9,10,11,12, 13,14,15)	(-2,-1,0,1, 2,3,4,5, 6,7,8,9, 10,11,12,13, 14,15,16)	(0,1,2,4, 5,6,7,8, 9,10,11,12, 13,14,16,18, 20,22,24)	(-10,-9,-8,-7, -6,-4,-2,-1, 0,1,2,3, 4,5,6,7, 9,10,11)
	(0,1,2,3, 4,5,6,7, 9,10,11,13, 14,15,17,19, 21,22,25)	(1,2,3,6, 8,9,10,12, 13,15,16,17, 19,20,22,23, 25,28,30)	(-3,-2,-1,0, 1,2,3,4, 5,6,7,8, 9,10,11,12, 13,14,15)	(2,4,5,6, 8,10,12,13, 15,17,18,19, 20,22,23,24, 25,26,28)
Demand	(2,3,4,6, 7,8,9,10, 11,12,13,14, 15,16,17,18, 19,20,21)	(-1,0,1,2, 3,5,6,7, 8,9,10,11, 12,13,14,15, 16,17,18)	(-7,-6,-5,-4, -3,-2,-1,0, 1,2,3,4, 5,6,7,8, 9,10,11)	

This problem is solved by taking the values *for* $k_1 = \frac{1}{5}, k_2 = \frac{2}{5}, k_3 = \frac{3}{5}, k_4 = \frac{4}{5}$. We obtain the values of Measure of matrix A and is denoted by $\mu_{EDC}(a_{ij})$

a_{11}	-4,-3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14	$\mu_{EDC}(a_{11}) = 5$
a_{12}	-3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	$\mu_{EDC}(a_{12}) = 6$

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a_{13}	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19	$\mu_{EDC}(a_{13}) = 10$
a_{21}	- 3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	$\mu_{EDC}(a_{21}) = 6$
a_{22}	- 2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	$\mu_{EDC}(a_{22}) = 7$
a_{23}	0,1,2,4,5,6,7,8,9,10,11,12,13,14,16,18,20,22,24	$\mu_{EDC}(a_{23}) = 10.63$
a_{31}	0,1,2,3,4,5,6,7,9,10,11,13,14,15,17,19,21,22,25	$\mu_{EDC}(a_{31}) = 10.68$
a_{32}	1,2,3,6,8,9,10,12,13,15,16,17,19,20,22,23,25,28,30	$\mu_{EDC}(a_{32}) = 14.16$
a_{33}	- 3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15	$\mu_{EDC}(a_{33}) = 6$

Fuzzy supplies are noted as follows

S_1	-4,-3,-2,-1,0,1,3,5,6,7,8,10,12,13,15,17,19,20,21	7.74
S_2	-10,-9,-8,-7,-6,-4,-2,-1,0,1,2,3,4,5,6,7,9,10,11	0.58
S_3	2,4,5,6,8,10,12,13,15,17,18,19,20,22,23,24,25,26,28	21.54

And Fuzzy demands are depicted as follows

D_1	2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	11.84
D_2	-1,0,1,2,3,5,6,7,8,9,10,11,12,13,14,15,16,17,18	8.74
D_3	-7,-6,-5,-4,-3,-2,-1,0,1,2,3,4,5,6,7,8,9,10,11	2

And Total fuzzy supply and the total fuzzy demands are shown as follows

S	-12,-8,-5,-2,2,7,13,17,21,25,28,32,36,40,44,48,53,56,60	23.95
D	-6,-3,0,4,7,11,14,17,20,23,26,29,32,35,38,41,44,47,50	22.58

The crisp valued transportation is as follows

	Destination			Supply
Source	5	6	10	7.74
	6	7	10.63	0.58
	10.68	14.16	6	15.63
Demand	11.84	8.74	2	

Then the solution is explained in the following tables

	Destination				Supply
Source	5	6	10	0	7.74
	6	7	10.63	0	0.58
	10.68	14.16	6	0	15.63
Demand	11.84	8.74	2	1.37	23.95

The initial basic feasible solution is obtained by least cost method. We get the solution containing 8 non negative independent allocations equal to m+n-1

	Destination				Supply
Source	5 7.74	6	10	0	~~7.74~~
	6	7	10.63	0	0.58
	10.68	14.16	6	0	15.63
Demand	~~11.84~~ 4.1	8.74	2	1.37	

Step 2

	Destination				Supply
	6 0.58	7	10.63	0	~~0.58~~
	10.68	14.16	6	0	15.63
Demand	~~4.1~~ 3.52	8.74	2	1.37	
	Destination				Supply
origin	10.68	14.16	6	0	~~15.63~~ 12.11
Demand	~~3.52~~	8.74	2	1.37	

	Destination			Supply
Origin	14.16	6	0	~~12.11~~
Demand	~~8.74~~	2	1.37	3.37

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	Destination		Supply
Origin	6 2	0	~~3.37~~ 1.37
Demand	~~2~~	1.37	

	Destination	Supply
Origin	0 1.37	~~1.37~~
Demand	~~1.37~~	

The transportation cost is $(5\times 7.74)+(6\times 0.58)+(3.52\times 10.68)+(8.74\times 14.16)+(2\times 6)+(0\times 1.37)$
= 38.7 + 3.48 +37.5936 + 123.7584 + 12 + 0
Total cost = 215.532

V. CONCLUSION

In this paper, unbalanced transportation problem has been solved with Enneadecagonal fuzzy number. The use of Enneadecagonal fuzzy number in fuzzy transportation problem is given. Fuzzy transportation problem converted to crisp valued problem and is illustrated by an example Optimal value obtained using Enneadecagonal fuzzy numbers are more optimal than the solution obtained by using hexadecagonal and Icosagonal fuzzy numbers.

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