AN APPROACH FOR DETERMINING THE BEST SOLUTION FOR INTUTIONISTIC FUZZY TRANSPORTATION PROBLEM

[1]ReemaAgarwa, [2]AnkurAgrawal

[1]JIMS Engineering Management Technical Campus, Greater Noida, Uttar Pradesh, India
[2]*Sharda School of Business Studies, Sharda University, Greater Noida, India*

Corresponding Author Email: [1] mrsreemaagarwal@gmail.com

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Abstract: The research study determines the best optimal solution to a usual kind of optimization issue which is known as problem of intuitionistic fuzzy transportation using triangular fuzzy values. The triangular values in terms of fuzzy shows the utility of the worth or the prices, supply, requirement, request, order and demand for solving the problems of transportation in terms of fuzzy values.The major motive of this study is to obtain the lowest entire transportation worth of commodities which fulfils the requirements of the consumers from different origins to the different landing places. For this, an approach named Vogel's Approximation Method is implementing for getting desired answer.

Keywords: *Transportation Problem, Tri-angular fuzzy values, Vogel's-Approximation-Method (VAM).*

Introduction

The compliance of transportation has been considered as a type of linear-programming. In this problem, commodities areshifted from m origins to n landing places having dimensions $u_1, u_2, u_3, \dots u_m$ and $v_1, v_2, v_3, \dots v_n$. Moreover, c_{ij}shows a cost associated with penalties of goods which are to be shifted from different origins i.e. i to different landing places i.e. j. These penalties are considered as cost, price, flexibility in delivery, time of delivery, security of delivery of goods, etc. The unspecified commodity which is to be shifted from m origins to n landing places is denoted byx_{ij}.A compliance concerning fuzzy-transportation is that where transportation amounts concerning prices, requirement, request, order as well as command are considered in terms of fuzzy values.

The major motive of this paper is the computation of the shipped scheme for fuzzy-transportation compliance for obtaining the lowest entire worth of fuzzy-transportation by considering that the limited part of order and requirement through tri-angular intutionistic-fuzzy values is applying to compute the best optimize answers for the fuzzy-transportation compliance. The major interest of intuitionistic-fuzzy theory marks the gradation of the membership & non-membership function of every member for fuzzy sets and also easily deals with the concept of uncertainty when compared with fuzzy sets. Thus, this study is an effort to answer the problem of the intutionistic fuzzy transportation by transporting goods or commodities from different origins to different landing placesby considering lowest costs and highest gains by tri-angular intutionistic-fuzzy numerals through VAM approach.

Literature Review

Firstly, the fundamental framework of developing the difficulty related to transportation had been introduced by is by Hitchcock [1] integrated with the problems of LPP. The major motive of the transportation compliance is to shipped goods or commodities from different origins to different landing places by considering lowest costs and highest gains. The three approaches termed as north-west-corner rule, least-cost entry rule and VAM are commonly implemented to calculate the answer initially for transportation compliance. Among all these approaches, VAM approach isprecise and accurate to determine the best and appropriate optimal solution o a transportation problem and also shows better results when compared to the entire method o the transportation problem [2,19].

A fuzzy concept was discovered by Zadeh [3]. Chanas and Kuchta[4] introduced the conceptualization of the best optimize answer of the fuzzy transportation compliance through the application of the fuzzy values as well as presented a procedure for attaining the required optimal answer.Atanassov in [5] suggested the concept of sets having properties' of Intuitionistic Fuzzy and named as IFSs which are applicable to overcome the problem of uncertainty.Many researchers have answeredthe problem related to intuitionistic fuzzy transportation in which they transform the supplies and demand accessibilities from fuzzy to crisp numerals (Hussain& Kumar [6]; Nagoorgani&Abbas [7]).

Antony et al. [8] answered the problem of transportation by using intuitionistic fuzzy values through VAM approach and find the best optimize final answer. But the drawback is that they did not show the details of optimality factor for finding the best optimal answer.Singh &Yadav [9] applied an excellent algorithm to answer the type-one problem of the intuitionistic fuzzy transportation.Ebrahimnejad and Verdegay[10] introduced an excellent mathematical techniqueto solve the problems of type-II intuitionistic fuzzy transportation through the application of fuzzy numerals. Singh &Yadav [11] developed an approach to answer the problems of intuitionistic fuzzy-transportation through the application of fuzzy values. Annie Christi [12] answered the problems of intuitionistic fuzzy transportation through the application of pentagonal fuzzy numerals by using the ranking method and Russell's technique.

Bharati & Malhotra [13] introduced an approach to solve the problem of transportation in two-stage through the application of the intuitionistic fuzzy values. Gupta &Anpum[14] implemented a new technique to solve the problem of transportation of type-II by using intuitionistic fuzzy values. Roy et al.[15] appliedan efficient methodto answer the multiple-objective problems of intuitionistic-fuzzy-transportation through the application of fuzzy values. Mahmoodirad et al. [16] applied an approachto answer the difficulties of completely intuitionistic fuzzy transportation through the application of fuzzy terms. Kumar [17] implemented a new extended technique based onintuitionistic fuzzy zero pointto solve the problems of type-II intuitionistic-fuzzy-transportation through the application of fuzzy numerals. Karagul & Sahin [20] presented a noval approximation method to obtain initial basic feasible solution of transportation problem. Chhibber et al. [21] analysed a problem from fuzzy transportation problem to non-linear intuitionistic fuzzy multi-objective transportation problem. Ahmed et al. [22] applied a fuzzy multi-objective defuzzification method to solve a transportation problem. Zhu et al. [23] applied a fixed charge transportation problem with damageable items under uncertain environment.

The structure of this paper is: Preliminaries are shown in part three where as in partfourth, procedures of the VAM approach are discussed. In part fifth, numerical part of 4×4 Intuitionistic-Fuzzy-Transportation-Problem is estimated. The outcomes as well as future upcoming was shown in part 6.

Preliminaries -Definition 3.1 Fuzzy Set –Suppose U is a non-blank group. A fuzzy set F of U is stated as: $\boldsymbol{F} = \{< x, \mu_{\boldsymbol{F}}(\boldsymbol{x}) > where\ x \in \boldsymbol{U}.$ Here, $\mu_{\boldsymbol{F}}(\boldsymbol{x})$is termed as membership function lies between zero and one.

Definition 3.2 Fuzzy Number –It does not consider only one value but considers a group of attainable values which lies betweenzero and one.

Definition 3.3 Tri-angular Fuzzy Numeral -A Tri-angular fuzzy numeral F is designated as 3 sub-strings (m_1, m_2, m_3) which show that$m_1 \leq\ m_2 \leq m_3$ with membership function is as under:

$$\mu_F(x) = \frac{x - m_1}{m_2 - m_1}\ ;\ \ for\ m_1 \leq x \leq m_2$$

$$\frac{m_3 - x}{m_3 - m_2}\ ;\ for\ \ m_2 \leq x \leq m_3$$

$$zero\quad ;\quad otherwise$$

Definition 3.4 Intuitionistic Tri-angular Fuzzy Numeral-A Intuitionistic Tri-angular fuzzy numeralF^I is denoted by $F^I = (m_1, m_2, m_3)(m_1', m_2, m_3')\ where\ m_1' \leq m_1 \leq m_2 \leq m_3 \leq m_3'$ with membership $\mu_{F^I}(x)$ and non-membership function $v_{F^I}(x)$.

$$\mu_F(x) = \frac{x - m_1}{m_2 - m_1}\ ;\ \ for\ m_1 \leq x \leq m_2$$

$$\frac{m_3 - x}{m_3 - m_2}\ ;\ for\ \ m_2 \leq x \leq m_3$$

$$zero\quad ;\quad otherwise$$

$$v_F^I(x) = \frac{m_2 - x}{m_2 - m_1'} \; ; \; for \; m_1' \le x \le m_2$$

$$\frac{x - m_2}{m_3' - m_2} \; ; \; for \; m_2 \le x \le m_3'$$

$$1 \quad ; \quad otherwise$$

Definition 3.5 Arithmetic processes of tri-angular fuzzy numerals- Let I and Jbe two positive triangular fuzzy numbers. Hence, the main algebraic operations are:$I = (l, m, n) \; and \; J = (u, v, w)$(Wu et al. 2009 [18]) is:

(i) Addition $(+)$: $\mathrm{I} + \mathrm{J} = (\mathrm{l}, \mathrm{m}, \mathrm{n}) + (\mathrm{u}, \mathrm{v}, \mathrm{w}) = (\mathrm{l} + \mathrm{u}, \mathrm{m} + \mathrm{v}, n + w)$

(ii) Subtraction $(-)$: $\mathrm{I} - \mathrm{J} = (\mathrm{l}, \mathrm{m}, \mathrm{n}) - (\mathrm{u}, \mathrm{v}, \mathrm{w}) = (\mathrm{l} - \mathrm{u}, \mathrm{m} - \mathrm{v}, n - w)$

(iii) Multiplication$(\times)$: $\mathrm{I} \times \mathrm{J} = (\mathrm{l}, \mathrm{m}, \mathrm{n}) \times (\mathrm{u}, \mathrm{v}, \mathrm{w}) = (\mathrm{l} \times \mathrm{u}, \mathrm{m} \times \mathrm{v}, n \times w)$

(iv) Division $(\div)$: $\mathrm{I} \div \mathrm{J} = (\mathrm{l}, \mathrm{m}, \mathrm{n}) \div (\mathrm{u}, \mathrm{v}, \mathrm{w}) = \left(\frac{\mathrm{l}}{\mathrm{u}}, \frac{\mathrm{m}}{\mathrm{v}}, \frac{n}{w}\right)$

Methodology

Step 1- Examine that the whole order is same as whole requirement. Step 2- Computing the best and optimize answer through VAM approach. For finding penalties of all rows/columns by taking the differences of the two cells which has the minimum cost in that row/column. Step 3- Select greatest cost of penalty. Step 4- Allocate that cell having least cost of transportation and greatest cost of penalty in rows / columns. Step 5-Estimate an optimize answer of the intuitionistic-fuzzy-transportation compliance. Step 6- Compute the entire min. cost of the goods.

Numerical Analysis

Table1 4×4 Intuitionistic-Fuzzy-Transportation-Problem (IFTP)

Order/Demand	D_1	D_2	D_3	D_4	Goods
O_1	16	1	8	13	<(2,4,5)(1,4,6)>
O_2	11	4	7	10	<(4,6,8)(3,6,9)>
O_3	8	15	9	2	<(3,7,12)(2,7,13)>
O_4	6	12	5	14	<(8,10,13)(5,10,16)>
Demand	<(3,4,6)(1,4,8)>	<(2,5,7)(1,5,8)>	<(10,15,20)(8,15,22)>	<(2,3,5)(1,3,6)>	

Solution- In this problem, supply is same as demand by using step 1. Through step 2, computing the penalties of all the rows/columns which depicts Table 2. Through step 3, selecting the highest penalty at col. 4 i.e. 8. Allocate the max. attainable components to min. cost location at (3,4) i.e. <(2,3,5)(1,3,6)>. Showing the rest in row 3 by eliminating the 4th col. by dotted line) that depicts Table 2. Repeat steps 2, 3 & 4.

Table 2 Showing penalties and allocation in cell (3,4)

Order/Demand	D_1	D_2	D_3	D_4	Goods	Penalties
O_1	16	1	8	13	<(2,4,5)(1,4,6)>	7
O_2	11	4	7	10	<(4,6,8)(3,6,9)>	3
O_3	8	15	9	2[<(2,3,5)(1,3,6)>]	<(3,7,12)(2,7,13)>/<(-2,4,10)(-4,4,12)>	1
O_4	6	12	5	14	<(8,10,13)(5,10,16)>	1
Demand	<(3,4,6)(1,4,8)>	<(2,5,7)(1,5,8)>	<(10,15,20)(8,15,22)>	<(2,3,5)(1,3,6)>		
Penalties	2	3	2	8		

Repeating step 3, selecting the highest penalty in row 1 i.e. 7. Allocating the max. attainable components to the min. cost location at (1,2) i.e. <(2,4,5)(1,4,6)>. Showing the rest in row 2, by eliminating the Ist row by dotted line that depicts Table 3.

Table 3 Showing penalties and allocation in cell (1,2)

Order/Demand	D_1	D_2	D_3	D_4	Goods	Penalty
O_1	16	1[<(2,4,5)(1,4,6)>]	8		<(2,4,5)(1,4,6)>	7
O_2	11	4	7		<(4,6,8)(3,6,9)>	3
O_3	8	15	9	2[<(2,3,5)(1,3,6)>]	<(-2,4,10)(-4,4,12)>	1
O_4	6	12	5		<(8,10,13)(5,10,16)>	1
Demand	<(3,4,6)(1,4,8)>	<(2,5,7)(1,5,8)>/<(-3,1,5)(-5,1,7)>	<(10,15,20)(8,15,22)>			
Penalty	2	3	2			

Repeating step 3, selecting the highest penalty at col. 2 i.e. 8. Allocating the max. attainable components to the min. cost location at (2,2) i.e. <(-3,1,5)(-5,1,7)>. Showing the rest in row 2, after eliminating the 2nd col. by dotted line that depicts Table 4.

Table 4Showing penalties and allocation in cell (2,2)

Order/Demand	D_1	D_2	D_3	D_4	Goods	Penalty
O_1	16	1[<(2,4,5)(1,4,6)>]	8		<(2,4,5)(1,4,6)>	7
O_2	11	4[<(-3,1,5)(-5,1,7)>]	7		<(4,6,8)(3,6,9)>	3
O_3	8	15	9	2[<(2,3,5)(1,3,6)>]	<(-2,4,10)(-4,4,12)>	1
O_4	6	12	5		<(8,10,13)(5,10,16)>	1
Demand	<(3,4,6)(1,4,8)>	<(-3,1,5)(-5,1,7)>/0	<(10,15,20)(8,15,22)>			
Penalty	2	8	2			

Repeating step 3, selecting the highest penalty at row 2 i.e. 4. Now allocate the max. attainable components to the min. cost location at (2,3) i.e. <(-1,5,11)(-4,15,14)>. Showing the rest in row 2, by eliminating the 2nd row by dotted line that depicts Table 5.

Table 5 Showing penalties and allocation in cell (2,3)

Repeating step 3, selecting the highest penalty at row 3 i.e. 8. Allocating the max. attainable components to the min. cost location at

Order/Demand	D_1	D_2	D_3	D_4	Goods	Penalty
O_1		1[<(2,4,5)(1,4,6)>]				
O_2		4[<(-3,1,5)(-5,1,7)>]	7[<(-1,5,11)(-4,5,14)>			4
O_3	8		9	2[<(2,3,5)(1,3,6)>]	<(-2,4,10)(-4,4,12)>	1
O_4	6		5		<(8,10,13)(5,10,16)>	1
Demand	<(3,4,6)(1,4,8)>		<(10,15,20)(8,15,22)>/<(-1,10,21)(-6,10,26)>			
Penalty	2		4			

(3,1) i.e.<(-2,4,10)(-4,4,12)>. Showing the rest in row 3, after eliminating the 3rd row by dotted line that depicts Table 6.

Table 6 Showing penalties and allocation in cell (3,1)

Order/Demand	D_1	D_2	D_3	D_4	Goods	Penalty
O_1		1[<(2,4,5)(1,4,6)>]				
O_2		4[<(-3,1,5)(-5,1,7)>]	7[<(-1,5,11)(-4,5,14)>			
O_3	8[<(-2,4,10)(-4,4,12)>]			2[<(2,3,5)(1,3,6)>]	<(-2,4,10)(-4,4,12)>/0	8 ↔
O_4	6		5[<(-1,10,21)(-6,10,26)>]		<(-13,0,14)(-21,0,22)>	6
Demand	<(3,4,6)(1,4,8)>/<(-7,0,8)(-11,0,12)>					
Penalty	2					

Repeating step 3, selecting the highest penalty at row 4 i.e. 6. Now allocate the max. attainable components to the min. cost location at (4,1) i.e.<(-7,0,8)(-11,0,12)>. Showing the rest in row 4, after eliminating the 1st columnby dotted line that depicts Table 7.

Table 7 Showing penalties and allocation in cell (4,1)

Order/Demand	D_1	D_2	D_3	D_4	IF Goods	Penalty
O_1		1[<(2,4,5)(1,4,6)>]				
O_2		4[<(-3,1,5)(-5,1,7)>]	7[<(-1,5,11)(-4,5,14)>			
O_3	8[<(-2,4,10)(-4,4,12)>]			2[<(2,3,5)(1,3,6)>]		
O_4	6[<(-7,0,8)(-11,0,12)>]		5[<(-1,10,21)(-6,10,26)>]		<(-13,0,14)(-21,0,22)>	6 ↔
Demand	<(-7,0,8)(-					

	11,0,12)>/0					
Penalty	6					

The intutionistic fuzzy optimal answer through is as under:

X_{12} = (2,4,5)(1,4,6), X_{22} = (-3,1,5)(-5,1,7), X_{23} = (-1,5,11)(-4,5,14), X_{31} = (-2,4,10)(-4,4,12),X_{34} = (2,3,5)(1,3,6), X_{41} = (-7,0,8)(-11,0,12), X_{43} = (-1,10,21)(-6,10,26).Thus, the min. cost is:Min. z = 1×(2,4,5)(1,4,6)+4×(-3,1,5)(-5,1,7)+7×(-1,5,11)(-4,5,14)+8×(-2,4,10)(-4,4,12)+2×(2,3,5)(1,3,6)+6×(-7,0,8)(-11,0,12)+5×(-1,10,21)(-6,10,26)=(2,4,5)(1,4,6)+(-12,4,20)(-20,4,28)+(-7,35,77)(-28,35,98)+(-16,32,80)(-32,32,96)+(4,6,10)(2,6,12)+(-42,0,48)(-66,0,72)+(-5,50,105)(-30,50,130)=(-76,131,345)(-173,131,442).

Discussion

By using fuzzy transportation, we optimize the solution of the demand and supply. During the solving of the instuitiontic fuzzy numbers, we face the problem to minimize the cost of the transportation to reduce the transportation cost by taking the penalty method. We reduce the transportation cost and obtain the optimization the minimum transportation cost in a more effective way. By this research, we got the advantage to reduce the logistic cost by optimal solution. But the limitation of using this method is that it is little bit more computational process as in every table we have to find the penalty level. As future considerations, this method is more effective for all types of industries to optimize the transportation cost.

Conclusion

In this study, we compute the best optimize answer by answering the compliance of fuzzy-transportation by VAM method through tri-angular fuzzy numerals. The algorithmic steps observed in the study are relevant when the supplies, costs, penalties, requirements, orders and demands exist in real numerals and IFNs. In future study, we are going to upgrade the algorithmic steps for answering the difficulty issue of transportation with supplies, costs, penalties, requirements, orders, etc. It also modified to answer the issue in transportation when the supplies, costs, penalties, requirements, orders, etc. are of various kinds.

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