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SOCRATIC TECHNIQUE TO SOLVE THE BULK HEXADECAGONAL FUZZY TRANSPORTATION PROBLEM USING RANKING METHOD

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ABSTRACT. A Bulk Hexadecagonal Fuzzy Transportation Problem (BHDFTP) plays with the problem of minimizing the total cost or time for the transportation problem. It changes from the Classical transportation problem in a way that the total demand of each destination is to be satisfied from only one source; however subject to the availability of the product at the source, a source can deliver to any number of destinations. In this paper, the minimum cost of BHDFTP has obtained by a Socratic technique hence providing simple and alternative procedures to obtain the minimum cost of the BHDFTP.

1. INTRODUCTION

The Classical transportation problem [4] is a special case of linear programming problem, which has been studied extensively in literature. A various number of algorithms have been created for solving the Classical transportation problem. The Classical transportation problem was introduced by Hitchcock Dantzig further developed the theory of Classical transportation problem. So many authors studied different single objective transportation problems. The BTP is another case of transportation problems introduced in literature by Maio and Roveda with the objective of minimizing the total bulk transportation cost. The authors computed the problem by an iterative technique. The authors also

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delivered an industrial application of the BTP wherein different warehouses of a firm are supplying to different destinations; each destination was supplied from only one warehouse to maintain organizational efficiency. Later on, the technique based on the branch and bound method was presented by Srinivasan and Thompson. A method based on lexicographic minimum to solve the BTP was formulated by Murthy. Bhatia, Foulds and Gibbons summarized the cost minimizing BTP. Verma and Puri developed a branch and bound method for cost minimizing BTP. D. Santhosh Kumar and G. Charles Rabinson have developed a new proposed method to solve fully fuzzy transportation problem using least allocation method. G. Charles Rabinson and R. Chandrasekaran have presented a method for solving a pentagonal transportation problem via ranking technique and ATM. This paper presents a much simpler and alternative solution techniques for the BTP, the application of which is very simple as compared to the existing methods. In Section 1, introduction based on all the new terminologies. In Section 2, the formulation of the BHDFTP is presented. In Section 3, discusses the procedures of the proposed algorithm. In Section 4, a numerical example is presented, lastly in Section 5, some concluding remarks are exhibited.

Definition 1.1. *The classical transportation problem concerns minimizing the cost of transporting a single product from sources to destinations, see [3]. It is a network-flow problem that arises in industrial logistics and is considered as a special case of linear programming. The total number of units produced at each source, the total number of units required at each destination and the cost to transport one unit from each source to each destination are the basic inputs. The objective is to minimize the total cost of transporting the units produced at sources to meet the demands at destinations.*

Definition 1.2. *A fuzzy number is a quantity whose value is imprecise, rather than exact as is the case with "ordinary" (single-valued) numbers. Any fuzzy number can be thought of as a function whose domain is a specified set. Each numerical value in the domain is assigned a specific "grade of membership" where* 0 *represents the smallest possible grade, and* 1 *is the largest possible grade.*

Definition 1.3 ([1,7,8]). *Let* X *be a nonempty set. A fuzzy set* $\hat{A}$ *in* X *is characterized by its membership function* $\mu_{\hat{A}}(x) : X \to [0,1]$ *and* $\mu_{\hat{A}}(x)$ *is interpreted as the degree of membership of element x in fuzzy set* $\hat{A}$ *for each* $x \in X$*. It is clear that* $\hat{A}$ *is completely determined by the set of tuples* $\hat{A} = \{(x, \mu_{\hat{A}}(x)) | x \in X\}$*. Frequently* *we will write* $\hat{A}(x)$ *instead of* $\mu_{\hat{A}}(x)$. *The family of all fuzzy sets in X is denoted by* $F(X)$.

Definition 1.4. *Bulk Transportation problem (BTP) is a special type of transportation problem having wide industrial applications. In a BTP the requirement of each destination has to be met from only one source; however, subject to the availability of a commodity, a source can supply to any number of destinations. The paper presents an outline survey of the methods used in solving a BTP. The paper is motivated by the importance of BTP and the need for researchers to be acquainted with all existing methods in order to solve such problems or develop new improved simple methods.*

Definition 1.5. *[6] A new form of fuzzy number called Hexadecagonal fuzzy number is introduced which can be much useful in solving many decision making problems. A fuzzy number* $\mu_{\hat{A}}(x) = \{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15}, a_{16}\}$ *is said to be Hexadecagonal fuzzy number.*

2. FORMULATION OF BULK TRANSPORTATION PROBLEM

Let there be m sources (s_i) producing a particular product and n destinations (d_j) having some requirement [2, 4]. Let c denote the total cost of bulk transportation. The mathematical formulation of the problem is as follows:

$$\text{Minimize}(C) = \sum_{i}^{m} \sum_{j}^{n} c_{ij} x_{ij}$$

Subject to Constraints

$$\sum_{j}^{n} b_{ij} x_{ij} \leq a_i, i = 1 \text{ to } m$$

$$\sum_{i}^{m} x_{ij} \leq 1, j = 1 \text{ to } n$$

$$x_{ij} = 0 \text{ or } 1, i = 1 \text{ to } m \text{ and } j = 1 \text{ to } n$$

where a_i, b_j and c_{ij} are non negative real numbers defined below:

- a_i represents the number of unit of the product available at the i^{th}source
- b_j represents the number of unit of the product required at the j^{th}destination

- c_{ij} represents the cost of bulk transportation product from i^{th}source to j^{th} destination
- x_{ij} represents the decision variable assuming the values 1 or 0 depending upon whether the demand at the destination j is met or not met from source i.

2.1. **Ranking of Hexadecagonal Fuzzy Numbers.** Let $\hat{A}$ be a normal Hexadecagonal Fuzzy Number. The value

$$M^{HD}O(\hat{A}) = \frac{1}{2}\int_0^{k_1} \{l_1(u) + l_2(u)\}\, du + \frac{1}{2}\int_{k_1}^{k_2} \{g_1(v) + g_2(v)\}\, dv + \frac{1}{2}\int_{k_2}^{k_3} \{h_1(p) + h_2(p)\}\, dp + \frac{1}{2}\int_{s_1}^{1} \{j_1(q) + j_2(q)\}\, dq$$

$$M^{HD}O(\hat{A}) = \frac{1}{4}\{[a_1 + a_2 + a_{15} + a_{16}]k_1 + [a_3 + a_4 + a_{13} + a_{14}](k_2 - k_1) + [a_5 + a_6 + a_{11} + a_{12}](k_3 - k_2) + [a_3 + a_4 + a_{13} + a_{14}](1 - k_3)\}$$

Here $0 \leq k_1 \leq k_2 \leq k_3 \leq 1$. Let $k_1 = 0.25$, $k_2 = 0.5$, $k_3 = 0.75$.

3. Proposed technique

Step 1: [5] Convert the given bulk hexadecagonal fuzzy transportation problem into Crisp fuzzy transportation problem using ranking method.

Step 2: Check Crisp Fuzzy Transportation Problem is balanced or not. If it is balanced go to step 4 otherwise go to step 3.

Step 3:

Case(i) If demand side the shortage occurs add one column with zero entries and allocate the shortage value in the corresponding column.

Case(ii) If supply side the shortage occurs add one row with zero entries and allocate the shortage value in the corresponding row.

Step 4: Calculate Penalty from both sides. (i.e.) From each column or each row select the least value and the next least value.

Step 5: Check each requirement and availability from the given BHDFTP, if any one of the jth requirement is greater than the corresponding ith availability. Delete the ith availability cells.(requirement is greater than availability cells only). Otherwise go ahead.

Step 6: Find the penalty from these columns and rows respectively then select the highest penalty from the all penalties.

Step 7: If the highest penalty lies in jth column or ith row select the corresponding column or row.

Step 8: Select the least cell (i, j) which occur the highest penalty. If availability is greater than requirement allocate 1 the particular cell. If the difference of requirement and availability will remain availability is greater than requirement, subtract and plot the rest of the value which is in the place of previous availability.Otherwise delete the rest of from both sides.

Step 9: Select the allotted cells bulk transportation cost and add all the cost will get the minimum cost.

4. Illustration

Consider the following bulk transportation problem with hexadecagonal fuzzy numbers:

$(S_1, D_1) = (-3, 2, 1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12);$
$(S_1, D_2) = (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17);$
$(S_1, D_3) = (-8, -6, -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22);$
$(S_2, D_1) = (-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10);$
$(S_2, D_2) = (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15);$
$(S_2, D_3) = (-3, -1, 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27);$
$(S_3, D_1) = (5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20);$
$(S_3, D_2) = (2, 3, 5, 6, 8, 9, 11, 12, 14, 15, 17, 18, 20, 23, 24);$
$(S_3, D_3) = (0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30);$
$a_1 = (5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20);$
$a_2 = (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17);$
$a_3 = (-8, -6, -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22);$
$b_1 = (2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17);$
$b_2 = (1, 2, 3, 5, 6, 8, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20);$
$b_3 = (0, 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16).$

Now it is a balanced transportation problem.
After applying the algorithm, we are getting this table

TABLE 1. Conclusion

	D_1	D_2	D_3	D_3	a_i
S_1	4.5	9.5	12	0	12.5
S_2	2.5	-	7	0	9.5
S_3	12.5	13	15	0	12
b_i	9.5	10.8	8.0	5.6	

Both sides we have same value 9.5. (i.e) $a_1 = 9.5 = b_1$. Last cell (S_2, D_3) will be vanished by the rule of bulk transportation problem.

Therefore the Bulk Transportation Problem cost = $(1\times 0)+(1\times 9.5)+(1\times 2.5) = 12$.

5. CONCLUSION

Observation of this journal, it has produced minimum value for the problem compare with the existing methods. We have proposed a Socratic method to find the minimum cost of bulk transportation problem involving hexadecagonal fuzzy numbers. The proposed method is simple to apply and also reduces the computational work.

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