

A PROPOSED STRATEGY FOR FINDING SOLUTIONS TO THE MATHEMATICAL TRANSPORTATION PROBLEM

RASHA JALAL MITLIF*, AREEJ M. ABDULDAIM, ANWAR KHALEEL FARAJ

Department of Mathematics and Computer Applications, College of Applied Sciences, University of Technology, Baghdad, Iraq

*Corresponding author: rasha.j.mitlif@uotechnology.edu.iq

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ABSTRACT. In operation research (OR), there are various and many applications in decision – making (DM) across all economic projects. Transportation is one of the most important (MI) topics that can be needed in all scientific projects to determine optimal decisions. We use a transportation model (TM) that can reduce the cost of transferring outputs from the manufacturing site to the point of consumption. This study proposes an optimal strategy to find the best solutions to the fuzzy transportation (FT) issue. Since all the parameters are decimal, we will convert all the parameters of the fuzzy decimal numbers into a single number based on two new two-order functions. The issue is solved using two proposed solutions: the North West corner (NWC) process and a least cost (LC) process. To demonstrate the effectiveness of the proposed strategy using the novel ordinal functions, a numerical example is presented. The solutions show that the least cost (LC) method yields better results than the North West corner (NWC) method. This strategy and technique can be applied to various real – world decision- making applications.

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1. INTRODUCTION

In mathematics and the field of economics transportation strategy refers to the investigation of ideal transportation (IT) and material allocation. French scientist Gaspard Monge established the problem in 1781. Unquestionably, comprehending the method and evaluating the findings are not simple projects. The procedure is extremely sophisticated. The transportation problem (TP) discusses the issue about how to organize manufacturing and distribution in such an industry with multiple strategies in different regions and an extensive variety of users for the products. The transportation issue (TI) is determined with the location of commodities from many places, including manufacturing facilities, additionally

referred to as sources, to a variety of places of demand, such as storage facilities, or locations. Every supplier has the capacity or availability to deliver a specific number of units of product, and each location has a predetermined request, often known as conditions. Transportation problems (TPs) may be the most beneficial application of interest study. The main goal of the transportation object is to transport various quantities held at various locations to different destinations while incurring the lowest possible transportation costs. A fuzzy transportation (FT) issue exists when some or all of its parameters are fuzzy numbers (FN). Pathade and Ghadle [1] presented Fuzzy Transportation (FT) issue with Octagonal Fuzzy (OF) digits are utilized and exhibited membership (EM) role with normal graphical representation. Sikander [2] used a novel ranking technique was used to turn fuzzy transportation (FT) issues into crisp valued (CV) transportation problems (TP), which were ultimately resolved with the Max-Min process. This ranking was applied to both odd and even numbers (ENs) of fuzzy numbers (FNs). Dhurai and Karpagam [3] proposed a novel model for solving OF numbers and FT issues. By assigning a rating to the OF numbers, the fuzzy valued (FV) transportation issue is transformed into a crisp valued (CVs) transportation issue, which may then become addressed via the DK technique to obtain an initial feasible solution. Gorhe and Ghadle [4] suggested a novel ranking approach and algorithm for solving pentagonal FT issue and compared the results to those of existing methods. Ramya and Presitha [5] studied an unbalanced fuzzy transportation (FT) issue in which estimate the cost, prerequisite, and quantity are heptagonal fuzzy (HF) digits and applied the provided strategy to resolve it. Using the Robust Ranking approach, researchers can convert a FT issue into a CV transportation issue. Bisht et al. [6] proposed a novel ranking (NR) algorithm to identify the most effective solution (MES) for a pentagonal fuzzy (PF) transportation issue. Initially, the created ranking approach depending on the barycenter idea is used. This changes the PF transportation issue into a crisp transportation (CT) issue, which is subsequently solved using the proposed approach.

The present work is separated into 9 parts. Part 2 covers the fundamental notions of fuzzy set (FS) theory. Part 3 introduces decagonal fuzzy (DF) digits, and Part 4 develops innovative two ranking methods for decagonal fuzzy (DF) digits. Part 5 describes the fuzzy numerical (FN) processes for decagonal fuzzy (DF) digits. Part 6 shows the numerical model (NM) for a fuzzy transportation (FT) issue. Part 7 introduces the proposed algorithm for addressing the fuzzy transportation (FT) issue, while Part 8 provides a numerical example (NE). Finally, Part 9 gives the conclusions.

2. BASIC PRINCIPLES

This portion covers partially fundamental principles.

Fuzzy set [7]: Let X be a non-empty collection. A fuzzy set (FS) \tilde{A} is defined by its membership function (MF): $M_{\tilde{A}}(x) : X \rightarrow [0, 1]$, where $\tilde{A}(x) = \{(x, M_{\tilde{A}}(x)) \mid X \rightarrow [0, 1]\}$.

Fuzzy number [8]: A fuzzy number (FN) is a convex standardized FS on the real line \mathbb{R} that achieves the following states:

- (1) It appears at least one x_0 in \mathbb{R} with $M_{\tilde{A}}(x) = 1$.
- (2) $M(x)$ is divided into continuous parts.
- (3) \tilde{A} is a regular fuzzy set (FS).

3. DECAGONAL FUZZY NUMBERS [9]

In this study, suggest a membership function (MF) $M_{\tilde{A}_{dec}}(x)$ of a DFN $\tilde{A}_{dec} = (\kappa_1, \kappa_2, \kappa_3, \kappa_4, \kappa_5, \kappa_6, \kappa_7, \kappa_8, \kappa_9, \kappa_{10})$, where $\kappa_1 \leq \kappa_2 \leq \kappa_3 \leq \kappa_4 \leq \kappa_5 \leq \kappa_6 \leq \kappa_7 \leq \kappa_8 \leq \kappa_9 \leq \kappa_{10} \in \mathbb{R}$.

$$M_{\tilde{A}_{dec}}(x) = \begin{cases} 0 & \text{if } x < \kappa_1 \\ \frac{x-\kappa_1}{3(\kappa_2-\kappa_1)} & \text{if } \kappa_1 \leq x < \kappa_2 \\ \frac{1}{3} \left(1 + \frac{x-\kappa_2}{\kappa_3-\kappa_2} \right) & \text{if } \kappa_2 \leq x < \kappa_3 \\ \frac{2}{3} & \text{if } \kappa_3 \leq x < \kappa_4 \\ \frac{1}{3} \left(2 + \frac{x-\kappa_4}{\kappa_5-\kappa_4} \right) & \text{if } \kappa_4 \leq x < \kappa_5 \\ 1 & \text{if } \kappa_5 \leq x < \kappa_6 \\ \frac{1}{3} \left(2 - \frac{x-\kappa_6}{\kappa_7-\kappa_6} \right) & \text{if } \kappa_6 \leq x < \kappa_7 \\ \frac{2}{3} & \text{if } \kappa_7 \leq x < \kappa_8 \\ \frac{1}{3} \left(1 - \frac{x-\kappa_8}{\kappa_9-\kappa_8} \right) & \text{if } \kappa_8 \leq x < \kappa_9 \\ \frac{x-\kappa_{10}}{\kappa_9-\kappa_{10}} & \text{if } \kappa_9 \leq x < \kappa_{10} \\ 0 & \text{if } x \geq \kappa_{10} \end{cases}$$

The function is defined as:

$$\tilde{A}_{dec}\rho = \begin{cases} \kappa_1 + 3\rho(\kappa_2 - \kappa_1) & \text{if } \rho \in [0, \frac{1}{3}] \\ \kappa_2 + (3\rho - 1)(\kappa_3 - \kappa_2) & \text{if } \rho \in [\frac{1}{3}, \frac{2}{3}] \\ \kappa_4 + (3\rho - 2)(\kappa_5 - \kappa_4) & \text{if } \rho \in [\frac{2}{3}, 1] \\ \kappa_6 + 3(1 - \rho)(\kappa_7 - \kappa_6) & \text{if } \rho \in [\frac{2}{3}, 1] \\ \kappa_8 + (2 - 3\rho)(\kappa_9 - \kappa_8) & \text{if } \rho \in [\frac{1}{3}, \frac{2}{3}] \\ \kappa_9 + (1 - 3\rho)(\kappa_{10} - \kappa_9) & \text{if } \rho \in [0, \frac{1}{3}] \end{cases}$$

Where

$$\left(\inf_1 \tilde{A}_{dec}(\rho) + \sup_3 \tilde{A}_{dec}(\rho) \right) = [\kappa_1 + 3\rho(\kappa_2 - \kappa_1) + \kappa_9 + (1 - 3\rho)(\kappa_{10} - \kappa_9)], \quad \rho \in [0, \frac{1}{3}]$$

$$\left(\inf_2 \tilde{A}_{\text{dec}}(\rho) + \sup_2 \tilde{A}_{\text{dec}}(\rho) \right) = [\kappa_2 + (3\rho - 1)(\kappa_3 - \kappa_2) + \kappa_8 + (2 - 3\rho)(\kappa_9 - \kappa_8)], \quad \rho \in \left[\frac{1}{3}, \frac{2}{3} \right]$$

$$\left(\inf_1 \tilde{A}_{\text{dec}}(\rho) + \sup_1 \tilde{A}_{\text{dec}}(\rho) \right) = [\kappa_4 + (3\rho - 2)(\kappa_5 - \kappa_4) + \kappa_6 + 3(1 - \rho)(\kappa_7 - \kappa_6)], \quad \rho \in \left[\frac{2}{3}, 1 \right]$$

4. NEW TWO RANKING FUNCTIONS FOR DECAGONAL FUZZY NUMBERS

The ranking function (RF) is an effective method to order fuzzy numbers (FNs). Several types of ranking functions (RFs) have been presented for solving transportation issues (TIs) with fuzzy elements. The (RF) is shown by $\mathcal{F}(\mathcal{R})$, where $\mathcal{F}(\mathcal{R}) : \mathcal{R} \rightarrow \mathcal{R}$, and $\mathcal{F}(\mathcal{R})$ is a collection of fuzzy numbers (FNs) explained on an actual path with natural ordering.

When utilizing the ranking function (RF) to compare fuzzy transportation problems (FTPs). Typically, a crisp model is defined that is identical to the fuzzy programming problem (FPPs), and the minimum total cost (TC) of this model is used to calculate the minimum total cost (MTC) for the transportation problem (TP).

4.1. New First Ranking Function.

$$\mathcal{R}(\tilde{A}) = \left(\frac{1}{2} \right) \int_0^1 \left(\frac{1}{7} \right) \left[\left(\inf_{\delta} \tilde{A}_{\text{dec}} \rho + \sup_{\delta} \tilde{A}_{\text{dec}} \rho \right) \right] d\rho$$

$$\iota = 1, 2, 3 \quad \delta = \begin{cases} \iota + 2 & \text{if } \iota = 1 \\ \iota & \text{if } \iota = 2 \\ \iota - 2 & \text{if } \iota = 3 \end{cases}$$

$$\mathcal{R}(\tilde{A}) = \left(\frac{1}{2} \right) \int_0^{\frac{1}{3}} \left(\frac{1}{7} \right) \left[\kappa_1 + 3\rho(\kappa_2 - \kappa_1) d\rho + (\kappa_9 + (1 - 3\rho)(\kappa_{10} - \kappa_9)) d\rho \right.$$

$$+ \int_{\frac{1}{3}}^{\frac{2}{3}} \left(\frac{1}{7} \right) (\kappa_2 + (3\rho - 1)(\kappa_3 - \kappa_2)) d\rho + (\kappa_8 + (2 - 3\rho)(\kappa_9 - \kappa_8)) d\rho$$

$$\left. + \int_{\frac{2}{3}}^1 \left(\frac{1}{7} \right) (\kappa_4 + (3\rho - 2)(\kappa_5 - \kappa_4)) d\rho + (\kappa_6 + 3(1 - \rho)(\kappa_7 - \kappa_6)) d\rho \right]$$

$$\mathcal{R}(\tilde{A}) = \frac{1}{84} (\kappa_1 + 2\kappa_2 + \kappa_3 + \kappa_4 + \kappa_5 + \kappa_6 + \kappa_7 + \kappa_8 + 2\kappa_9 + \kappa_{10})$$

4.2. New Second Ranking Function.

$$\mathcal{R}(\tilde{A}) = \left(\frac{1}{2} \right) \int_0^1 \left(\frac{1}{9} \right) \left[\left(\inf_{\delta} \tilde{A}_{\text{dec}} \rho + \sup_{\delta} \tilde{A}_{\text{dec}} \rho \right) \right] d\rho$$

$$\iota = 1, 2, 3 \quad \delta = \begin{cases} \iota + 2 & \text{if } \iota = 1 \\ \iota & \text{if } \iota = 2 \\ \iota - 2 & \text{if } \iota = 3 \end{cases}$$

$$\mathcal{R}(\tilde{A}) = \left(\frac{1}{2} \right) \int_0^{\frac{1}{3}} \left(\frac{1}{9} \right) \left[\kappa_1 + 3\rho(\kappa_2 - \kappa_1) d\rho + (\kappa_9 + (1 - 3\rho)(\kappa_{10} - \kappa_9)) d\rho \right.$$

$$\begin{aligned}
 & + \int_{\frac{1}{3}}^{\frac{2}{3}} \left(\frac{1}{9}\right) (\kappa_2 + (3\rho - 1)(\kappa_3 - \kappa_2)) d\rho + (\kappa_8 + (2 - 3\rho)(\kappa_9 - \kappa_8)) d\rho \\
 & + \int_{\frac{2}{3}}^1 \left(\frac{1}{9}\right) (\kappa_4 + (3\rho - 2)(\kappa_5 - \kappa_4)) d\rho + (\kappa_6 + 3(1 - \rho)(\kappa_7 - \kappa_6)) d\rho \Big] \\
 \mathcal{R}(\tilde{A}) & = \frac{1}{108} (\kappa_1 + 2\kappa_2 + \kappa_3 + \kappa_4 + \kappa_5 + \kappa_6 + \kappa_7 + \kappa_8 + 2\kappa_9 + \kappa_{10})
 \end{aligned}$$

5. FUZZY MATHEMATICAL OPERATIONS (FMOs) OF DFNs [10]

Assume $\tilde{A}dec$ and $\tilde{B}dec$ are two random DFNs, such that

$$\tilde{A}dec = \begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \end{bmatrix} \quad \tilde{B}dec = \begin{bmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix}$$

Define the three basic operations

$$\begin{aligned}
 1 - \tilde{A}dec \oplus \tilde{B}dec & = \begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \end{bmatrix} \oplus \begin{bmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix} \\
 & = \begin{bmatrix} \kappa_1 + \eta_1 & \kappa_2 + \eta_2 & \kappa_3 + \eta_3 & \kappa_4 + \eta_4 & \kappa_5 + \eta_5 \\ \kappa_6 + \eta_6 & \kappa_7 + \eta_7 & \kappa_8 + \eta_8 & \kappa_9 + \eta_9 & \kappa_{10} + \eta_{10} \end{bmatrix}
 \end{aligned}$$

$$\begin{aligned}
 2 - \tilde{A}dec \ominus \tilde{B}dec & = \begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \end{bmatrix} \ominus \begin{bmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix} \\
 & = \begin{bmatrix} \kappa_1 - \eta_{10} & \kappa_2 - \eta_9 & \kappa_3 - \eta_8 & \kappa_4 - \eta_7 & \kappa_5 - \eta_6 \\ \kappa_6 - \eta_5 & \kappa_7 - \eta_4 & \kappa_8 - \eta_3 & \kappa_9 - \eta_2 & \kappa_{10} - \eta_1 \end{bmatrix}
 \end{aligned}$$

$$\begin{aligned}
 3 - \tilde{A}dec \otimes \tilde{B}dec & = \begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \end{bmatrix} \otimes \begin{bmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix} \\
 & = \begin{bmatrix} \kappa_1 * \eta_1 & \kappa_2 * \eta_2 & \kappa_3 * \eta_3 & \kappa_4 * \eta_4 & \kappa_5 * \eta_5 \\ \kappa_6 * \eta_6 & \kappa_7 * \eta_7 & \kappa_8 * \eta_8 & \kappa_9 * \eta_9 & \kappa_{10} * \eta_{10} \end{bmatrix}
 \end{aligned}$$

$$\begin{aligned}
 4 - \nu \otimes \tilde{A}dec & = \begin{bmatrix} \lambda\kappa_1 & \lambda\kappa_2 & \lambda\kappa_3 & \lambda\kappa_4 & \lambda\kappa_5 \\ \lambda\kappa_6 & \lambda\kappa_7 & \lambda\kappa_8 & \lambda\kappa_9 & \lambda\kappa_{10} \end{bmatrix} \text{ if } \nu > 0 \\
 & = \begin{bmatrix} \lambda\kappa_{10} & \lambda\kappa_9 & \lambda\kappa_8 & \lambda\kappa_7 & \lambda\kappa_6 \\ \lambda\kappa_5 & \lambda\kappa_4 & \lambda\kappa_3 & \lambda\kappa_2 & \lambda\kappa_1 \end{bmatrix} \text{ if } \nu < 0
 \end{aligned}$$

$$5 - \text{If } 0 \notin \begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \end{bmatrix} \text{ then } \frac{\begin{bmatrix} \kappa_1 & \kappa_2 & \kappa_3 & \kappa_4 & \kappa_5 \\ \kappa_6 & \kappa_7 & \kappa_8 & \kappa_9 & \kappa_{10} \\ \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix}}{\begin{bmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 \\ \eta_6 & \eta_7 & \eta_8 & \eta_9 & \eta_{10} \end{bmatrix}} = \left(\frac{\kappa_1}{\eta_{10}}, \frac{\kappa_2}{\eta_9}, \frac{\kappa_3}{\eta_8}, \dots, \frac{\kappa_{10}}{\eta_1} \right)$$

6. MATHEMATICAL MODEL OF A FUZZY TRANSPORTATION PROBLEM [11]

Mathematical Model for Fuzzy transportation (FT) issues is represented below:

$$\text{Minimize } \xi \approx \sum_{\iota=1}^v \sum_{\delta=1}^{\gamma} \tilde{\zeta}_{\iota\delta} \tilde{\omega}_{\iota\delta}$$

$$\sum_{\delta=1}^{\gamma} \tilde{\phi}_{\iota\delta} \approx \tilde{\sigma}_{\iota}, \quad \iota = 1, 2, 3, \dots, v$$

Subject to

$$\sum_{\delta=1}^{\gamma} \tilde{\phi}_{\iota\delta} \approx \tilde{\varphi}_{\iota}, \quad \iota = 1, 2, 3, \dots, \gamma$$

$$\sum_{\iota=1}^v \tilde{\sigma}_{\iota} \approx \sum_{\delta=1}^{\gamma} \tilde{\varphi}_{\delta}, \quad \iota = 1, 2, 3, \dots, v, \delta = 1, 2, 3, \dots, \gamma \quad \text{and} \quad \tilde{\phi}_{\iota\delta} \geq 0$$

$$\sum_{\delta=1}^{\gamma} \tilde{\sigma}_{\iota} = \text{The total amount fuzzy availability of the item}$$

$$\sum_{\delta=1}^{\gamma} \tilde{\varphi}_{\delta} = \text{Total fuzzy demand (TFD) for the item}$$

$$\sum_{\iota=1}^v \sum_{\delta=1}^{\gamma} \tilde{\zeta}_{\iota\delta} \tilde{\omega}_{\iota\delta} = \text{Total fuzzy transportation (TFT) cost.}$$

$$\text{If } \sum_{\iota=1}^v \tilde{\sigma}_{\iota} \approx \sum_{\delta=1}^{\gamma} \tilde{\beta}_{\delta}$$

If the FT issue is balanced, it is referred to as such; otherwise, it is referred to as imbalanced.

7. PROPOSED STRATEGY FOR SOLVING FT PROBLEM

Despite the fact that there are numerous techniques for determining the minimal total cost solution to a transportation issue, we examined the fuzzy NWC method and the LC method for addressing transportation problems (TP).

1. Create a FT table for the specified FT problem and, if necessary, convert it to a balanced one.
2. By applying the two rankings as per equation, the FT problem is solved using the NWC approach and the LC Method.
3. NWC method:

- Assign the greatest number of units allowed via the supply- & demand- limits to the quantity x_{11} (i.e., the field in the upper left area (LA) of the transportation showcase). Cross off any columns (or rows) that are complete.
- Cross out only one of the residual choice elements in the column (or row) that are satisfied concurrently, regardless of which.
- Adapt supply and demand in uncrossed columns and rows of information.
- Use the maximum practicable solution quantity to the initial non-intersecting variables and elements in the subsequent column (NC) or row.
- When only any row or column (ORC) is left, all residual items are essential & are appointed the single available allotted.

4. LC method:

- Provide as much as feasible to the cell with the lowest unit cost in the entire tableau. If there is a tie, choose arbitrarily.
- Cross out the rows or columns that have met supply or demand. If both rows and columns are accomplished, only one should be crossed out.
- Determine supply & demand (SD) for crossed-out rows & columns.
- When only a single row or column remains, all residual variables (RV) are essential & are appointed the single possible allotted.

8. NUMERICAL EXAMPLE

The following numerical example in the Table-1 shows a full fuzzy formula data of transportation problem with parameters designed as decagonal form.

TABLE 1. Data transportation problem represents decagonal fuzzy

	FD ₁	FD ₂	FD ₃	Supply
FC ₁	[11,14,17,20,23,26,29,32,35,38]	[53,56,59,62,65,68,71,74,77,80]	[41,44,47,50,53,56,59,62,65,68]	[63,66,69,72,75,78,81,84,87,90]
FC ₂	[79,82,85,88,91,94,97,100,103,106]	[27,30,33,36,39,42,45,48,51,54]	[11,14,17,20,23,26,29,32,35,38]	[35,38,41,44,47,50,53,56,59,62]
FC ₃	[83,86,89,92,95,98,101,104,107,110]	[23,26,29,32,35,38,41,44,47,50]	[65,68,71,74,77,80,83,86,89,92]	[83,86,89,92,95,98,101,104,107,110]
Demand	[35,38,41,44,47,50,53,65,59,62]	[63,66,69,72,75,78,81,84,87,90]	[83,86,89,92,95,98,101,04,107,110]	

The following mathematical programming (FMP) form can be used to simulate the DFT issue by converting fuzzy variables to crisp values(CV) using the first ranking function.

TABLE 2. Application of first ranking formula to convert crisp form

	D ₁	D ₂	D ₃	Supply
C ₁	3.5000	9.5000	7.7857	10.9286
C ₂	13.2143	5.7857	3.5000	6.9286
C ₃	13.7857	5.2143	11.2143	13.7857
Demand	6.9286	10.9286	13.7857	

The present transportation problem (TP) is balanced.

Total supply $\sum \alpha_i =$ Total demand $\sum \beta_\delta = 31.6429$.

All data in table 2 is converted by using the first ranking formula to crisp value and by applying the NWC method to obtain the minimum total cost as shown in the following Table-3.

TABLE 3. The solution by the NWC Method.

	D_1	D_2	D_3	Supply
C_1	3.5000 6.9286	9.5000 4.0000	7.7857	10.9286
C_2	13.2143	5.7857 6.9286	3.5000 0	6.9286
C_3	13.7857	5.2143	11.2143 13.785	13.7857
Demand	6.9286	10.9286	13.7857	

Next, we calculate the total value cost and the associated allotted value of supply demand, as given in Table 3.

The total cost = 256.9339

All data in table 2 is converted by using the first ranking formula to crisp value and by applying the Least Cost (LC) method to obtain the minimum total cost as given in the following Table-4.

TABLE 4. The solution by the Least Cost Method.

	D_1	D_2	D_3	Supply
C_1	3.5000 6.9286	9.5000	7.7857 4.0000	10.9286
C_2	13.2143	5.7857	3.5000 6.9286	6.9286
C_3	13.7857	5.2143 10.9286	11.2143 2.8571	13.7857
Demand	6.9286	10.9286	13.7857	

Next, we determine the total cost and the associated allotted value of supply demand, as given in Table 4. The total the cost= 168.6684.

The following mathematical programming (FMP) form can be used to simulate the DFT issue by converting fuzzy variables to crisp values using the second ranking function.

TABLE 5. Application of second ranking formula to convert crisp form

	D_1	D_2	D_3	Supply
C_1	2.7222	7.3889	6.0556	8.5000
C_2	10.2778	4.5000	2.7222	5.3889
C_3	10.7222	4.0556	8.7222	10.7222
Demand	5.3889	8.5000	10.7222	

The present transportation problem (TP) is balanced.

Total supply $\sum \alpha_i =$ Total demand $\sum \beta_\delta = 24.6111$.

All data in table 5 is converted by using the second ranking formula to crisp value and by applying the NWC method to obtain the minimum total cost (TC) as shown in the following Table-6.

TABLE 6. The solution by the North West Corner Method.

	D_1	D_2	D_3	Supply
C_1	2.7222 5.3889	7.3889 3.1111	6.0556	8.5000
C_2	10.2778	4.5000 5.3889	2.7222 0	5.3889
C_3	10.7222	4.0556	8.7222 10.7222	10.7222
Demand	5.3889	8.5000	10.7222	

Next, we determine the total cost and the associated allotted value of supply demand, as given in Table 6. The total cost = 155.4285.

All data in table 5 is converted by using the second ranking formula to crisp value and by applying the Least Cost (LC) method to obtain the minimum total cost (TC) as given in the following Table-7.

TABLE 7. The solution by the Least Cost Method.

	D_1	D_2	D_3	Supply
C_1	2.7222 5.3889	7.3889	6.0556 3.1111	8.5000
C_2	10.2778	4.5000	2.7222 5.3889	5.3889
C_3	10.7222	4.0556 8.5000	8.7222 2.2222	10.7222
Demand	5.3889	8.5000	10.7222	

Next, we determine the total cost and the associated allotted value of supply demand, as given in Table 7. The total cost = 102.0340.

Figure (1) shows the Comparison results of NWC with LC and SA for transportation problem for different n .

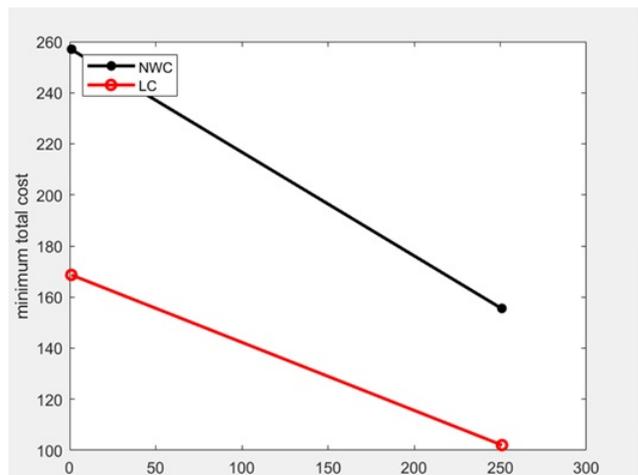


FIGURE 1. Comparison results of NWC with LC and SA for transportation problem for different n .

9. CONCLUSION

Transportation models (TMs) are widely used in logistics and the supply and demand chain to save costs. In this research, we got the minimal overall cost for a fuzzy transportation (FT) problem utilizing a decagonal fuzzy number (DFN). After studying the results and comparing them, the following are obtained: The minimum total cost (lowest value) has been achieved when applying the second ranking function and least cost method see fig.1.

Authors' contributed. All authors have read and approved the final version of the manuscript. The authors contributed equally to this work.

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REFERENCES

- [1] P.A. Pathade, K.P. Ghadle, Optimal Solution of Balanced and Unbalanced Fuzzy Transportation Problem by Using Octagonal Fuzzy Numbers, *Int. J. Pure Appl. Math.* 119 (2018), 617–625.
- [2] Sikander, Optimal Solution for Fuzzy Transportation Problem Using Median Ranking, *Int. J. Stat. Appl. Math.* 7 (2022), 01–06. <https://doi.org/10.22271/math.2022.v7.i3b.838>.
- [3] K. Dhurai, A. Karpagam, New Ranking Function on Octagonal Fuzzy Number for Solving Fuzzy Transportation Problem, *Int. J. Pure Appl. Math.* 119 (2018), 125–131.
- [4] S. Gorhe, K. Ghadle, A New Algorithm to Solve Pentagonal Fuzzy Transportation Problem, *J. Algebr. Stat.* 13 (2022), 4847–4855.

- [5] S. Ramya, B.J. Presitha, Solving an Unbalanced Fuzzy Transportation Problem Using a Heptagonal Fuzzy Numbers by Robust Ranking Method, *Int. Rev. Pure Appl. Math.* 15 (2019), 94–105.
- [6] M. Bisht, I. Beg, R. Dangwal, Optimal Solution of Pentagonal Fuzzy Transportation Problem Using a New Ranking Technique, *Yugosl. J. Oper. Res.* 33 (2023), 509–529. <https://doi.org/10.2298/YJOR221120002B>.
- [7] R.J. Mitlif, An Efficient Algorithm for Fuzzy Linear Fractional Programming Problems via Ranking Function, *Baghdad Sci. J.* 19 (2022), 0071. <https://doi.org/10.21123/bsj.2022.19.1.0071>.
- [8] R.J. Mitlif, I.H. Hussein, Ranking Function to Solve a Fuzzy Multiple Objective Function, *Baghdad Sci. J.* 18 (2021), 0144. <https://doi.org/10.21123/bsj.2021.18.1.0144>.
- [9] I.H. Hasan, I.H. Al Kanani, Employing Novel Ranking Function for Solving Fully Fuzzy Fractional Linear Programming Problems, *Baghdad Sci. J.* 21 (2024), 2395–2402. <https://doi.org/10.21123/bsj.2023.8243>.
- [10] I.H. Hasan, I.H.A. Kanani, Optimal Fuzzy Solution for Fully Fuzzy Quadratic Fractional Programming Problems with Decagonal Membership Function and Ranking Function Technique, *AIP Conf. Proc.* 3061 (2024), 040010. <https://doi.org/10.1063/5.0196008>.
- [11] R.J. Mitlif, I.H. Hussein, Proposal Yager Ranking Function to Solve the Fuzzy Transportation Model via Trapezoidal Fuzzy Number, *J. Phys.: Conf. Ser.* 2322 (2022), 012019. <https://doi.org/10.1088/1742-6596/2322/1/012019>.