



# مجلة التربوي

## مجلة علمية محكمة تصدر عن كلية التربية جامعة المرقب

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## An optimal fuzzy zero point method for solving fuzzy transportation problem

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### Abstract

One of the first uses for Linear Programming (LP) issues was the transportation problem. In order to cut costs, transportation models are widely used in transportation and the supply chain. When the demand, cost and supply amounts, and other relevant information are precisely known, effective techniques have been created to solve the transportation problem. In the real world, unpredictability and imprecisions are unavoidable due to certain events. For the purpose of solving fuzzy transportation problems, an optimal fuzzy zero point technique is suggested in this study. The approach makes exact assumptions about the product's availability, demand, and transportation cost. The suggested method uses generalized trapezoidal fuzzy numbers to describe transportation costs, product availability, and demand. The suggested approach is relatively simple to comprehend and apply to actual transportation issues because it is a direct extension of the classical method. It will be an essential tool for decision-makers when they are dealing with a variety of logistical issues with fuzzy features.

**Keywords:** Transportation Problem; Fuzzy Transportation Problem (FTP); Fuzzy Optimal Solution; Fuzzy Zero Point Method (FZPM); Trapezoidal Fuzzy Numbers;

### Introduction

Among the most well-known issues in LP is the transportation problem. Given the state of world economics and the present marketplace, the transportation of products is becoming more and more crucial, and understanding the system of transportation is essential for a business's efficient and cost-efficient functioning as well as for cutting costs and enhancing service. They make sure that raw materials and finished commodities are moved effectively and are available when needed (Mathur, Srivastava, and Paul 2018). The problem of transportation involves moving goods from diverse sources to numerous locations. Finding the ideal quantity of a commodity to convey from multiple supplier sites to different consumption points while keeping the overall expense of transportation to a minimum is the objective of the transportation problem. The standard transportation problem belongs to a subclass of LP problems where every constraint is associated with the equivalence form. It is frequently applied in the management of inventories, communication networks, general planning, employee organizing, and people assignments, among other fields. Figure 1 depicts the basic structure of the transportation problem. The problem of transportation could be divided into linear and nonlinear types based on the characteristics of the cost factor (Kumar 2020).

The key elements of the transportation problem involve costs per unit, or the expense of moving a single unit from a certain supplying location to a specific demand site, as well as the quantities that are accessible at the supply points and the quantities that are needed at request regions. Whenever demand, supply, and cost factors are exactly recognized effective models have been created to solve transportation problems. As a specific instance of a LP challenge, the problem of transportation enables researchers to identify the ideal route for



shipping among sources and recipients. The response to the problem will enable to decide how many units should be carried from a certain source to a particular location in order to maximize profit while minimizing expenses, time, or both. A transportation problem is considered to have imprecise quantities when it comes to transportation costs, supplies, and consumption. The data that is accessible in real-world issues is either inadequate or perhaps just provided as hazy representations. This requires modeling the issue using the given data, which may be accomplished by employing the theory of fuzzy sets (Malini 2019).

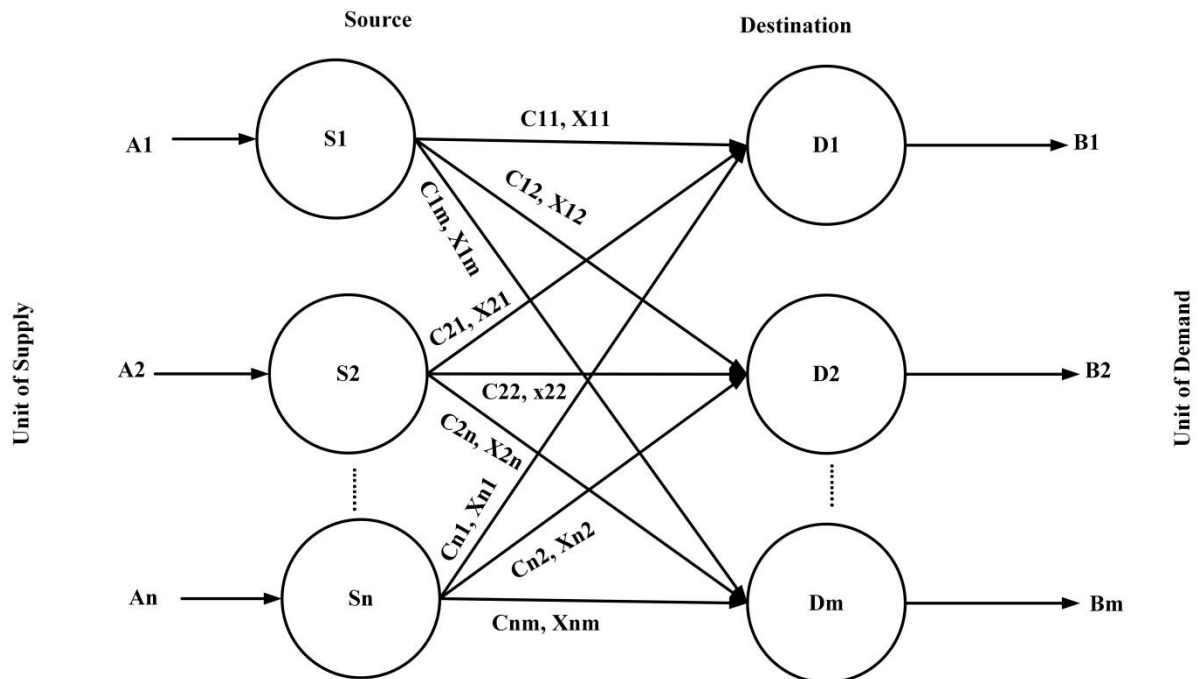


Figure 1: **Basic structure of transportation problem**

Problems specific to transportation arise in optimization. These are connected to actual, logistically organized actions. Transportation of a single manufactured item in several supplies to a number of distinct locations is an issue. The objective is to minimize the overall transportation costs for goods that will fulfill consumption at multiple locations (Mitlif, Rasheed, and Shihab 2020). The accessibility, requirements, and unit price of transportation might not be required to be known in real-time applications. Fuzzy numbers are the name given to these ambiguous facts. Each of the selected variables in the fuzzy transportation problem is an ambiguous integer. The aim of FTP is to identify the timetable for fuzzy transporting that minimizes overall fuzzy transportation expenses whilst fulfilling fuzzy accessibility and fuzzy need (Karthi and Ganesan 2019). Organizations are under pressure to discover new ways to produce as well as supply value-added services to clients for emerge greater in today's highly competitive marketplace. It became increasingly difficult to determining how and when to supply goods in large numbers to clients in a cost-effective way. Modeling of transport offers a strong foundation to handle the task. It guarantees the timely flow of both raw materials and completed commodities (Venkatachalapathy and Samuel 2016).

The problem of transportation is a subset of linear programs with equality or disparity as the constraints that Hitchcock initially defined in 1941. In its traditional form, the issue seeks to reduce the overall expense of conveying a good that is needed at different locations but is accessible at certain points (Ahmed et al. 2016). The STP/3D-transportation problem



was initially introduced by Haley in 1962. The STP is the procedure of moving specific goods from their production locations (sources) to the various request locations (destinations), employing a variety of conveyances and taking into account various transportation abilities and expenses, fixed charge expenses, etc. to ensure that the overall cost of transportation is as low as possible. A lack of knowledge regarding the transit system or unanticipated issues like strikes, natural catastrophes, celebrations, etc. causes ambiguity when addressing real-world issues. Therefore, it is crucial for practical reasons that the transportation problem takes into account the aforementioned unpredictable surroundings (Jana and others 2020).

Numerous problems, including planning, manufacturing, expenditures, plant setting, control of inventory, and personnel planning, might be affected by transportation difficulties. The premise that the transportation expenses and worth of supply and requests are described in an accurate way, or in a clear surrounding, is how transportation problems are often handled. Various programs help people solve challenges in daily life. The quantity of expenses, supply, and demand make up the dimensions of the transportation problem. Transportation-related concerns with an item's worth frequently arise amid ambiguity and have a tendency to vary over time. This occurs as a result of a lack of knowledge about the importance of these issues. The number of expenses, inventory, and demand for value are the factors contributing to the transportation challenge (Satheeshkumar et al. 2017). The FZPM and the approach with the zero suffixes are two techniques used to discover the best way to save transportation expenses.

The FTP is regarded as a specific class of fuzzy LP issues. It is crucial to compute FTP while working with fuzzy numbers. To describe a fresh, sophisticated approach for locating a fuzzy, ideal FTP response. An optimum solution is one that can be achieved that minimizes or increases an objective response. It indicates a superior choice among all possible outcomes (Pandian and Natarajan 2010). Vogel's approximate approach was employed to arrive at a basic, workable fuzzy response (Thamaraiselvi and Santhi 2015). The goal of this research is to propose an algorithmic solution to the transportation problem that is both practical and straightforward. Needs, supply, and expenses for transportation are a few examples of transportation factors that aren't always clear-cut and may be unpredictable for a variety of factors. Thus, it could be difficult to calculate the precise values in certain situations. This kind of ambiguity could be handled using fuzzy, and numerous scholars have discussed this transportation problem using type 1 fuzzy parameters. Type 2 fuzzy parameter provides the ability to cope with uncertain/inexact/fuzzy data of any actual-life scenario in a conceptually suitable way by extending a range of freedom to current ambiguities.

The following is the study's key contribution:

- It helps to transport goods from source to destination at low cost
- This work suggests an ideal FZPM to address the fuzzy transportation problems.
- The availability, demand, and cost of transportation for the commodity are all accurate assumptions made in this study.
- It employs generalized trapezoidal fuzzy numbers to describe the price of transportation, the availability of the commodity, and the level of demand.

The organization of this study is as follows. The many approaches currently being used to address the transportation problem are described in Section 2. The structure of the suggested strategy for resolving the transportation problem is described in Section 3. It summarizes the



results of the suggested system in Section 4. The findings and the plan for further research are presented in Section 5 at the end.

### **Related Works**

Among the key issues in linear programming challenges (LPP), transportation problems (TP) focus on the issues associated with moving and distributing commodities with the goal of maximizing revenue or minimizing expenses, based on the problem category. A novel approach to resolving transportation problems was put forth in this investigation, using an objective function of the kind of profit maximization employed. This method was developed by drawing inspiration from a previously published study that addresses an identical issue using an objective function of the miniaturization kind. The effectiveness of this novel approach was evaluated based on the kinds of outcomes it produced whenever applied to a variety of real-world transportation problems, a few of which were highlighted in this report. The findings of the approach were subsequently compared between the suggested methodology and the three widely used traditional techniques, NWCM, LCM, and VAM. However, the outcomes obtained with the novel approach were those that were necessary and near the ideal response (Kadhim, Shiker, and Al-Dallal 2021).

The numerous objectives fractionated fixed-charge transporting problem (MFFTP) are addressed in this work along with a broad structure to guide decisions. To translate a multifaceted nonlinear transportation problem into its linear structure, a transformation approach is changed. The planned strategy variables are thought to be unclear. To cope with these fuzzy settings, the study uses several forms of fuzzy scales, such as potential, trustworthiness, and necessary measurements. The study uses recommended MFFTP and, utilizing the fuzzy chance-constrained rough approximate (FCRA) method, retrieves the most desirable optimum result. The original outcome is contrasted with the robustness rankings (RR) method's output. By taking into account two estimates, the study additionally employs the notion of approximate sets to enlarge and divide the MFFTP's feasible area in order to handle more data. Using those estimations, the study provides two variations of the proposed MFFTP: the lesser approximate (LA) and the upper approximate (UA). Lastly, the study presents the ideal responses to the suggested problems utilizing these frameworks. It additionally offers an actual scenario to illustrate the relevance and efficiency of the MFFTP. The work's fundamental idea is that it approaches an MFFTP utilizing two distinct types of ambiguity and broadens its practical field in search of the best solution. The developed strategy optimal solutions, derived via the FCRA approach, may be divided into two categories: "surely area" and probable area." Given that these are minimum values, the best option in the "undoubtedly area" is superior to those in the "probably area" and other situations. Finally, a description of the methodology is given, together with suggestions for the planned direction of a subsequent investigation. Another of the FCRA technique's drawbacks is how time-consuming it's to convert from a model that is fuzzy to a comparable crisp form (Midya, Roy, and Weber 2021).

Particle Swarm Optimization (PSO) has imitated the foraging behaviors of various social creatures, including a flock of birds and a group of fish. Whenever described as a computer process, this communicating socialization has provided solutions to a variety of challenging issues. PSO has changed throughout time and there are now many different variations. In order to minimize the expenses related to transportation (a parameter and stable) of transporting products while fulfilling supply/demand restrictions, PSO has been hybridized with two novel techniques in this work. It was additionally looked into to solve the issue independently using variable costs at first, and then adding fixed costs. This was



shown that the suggested PSO performs better when the objective function is left unaffected. The findings from the simulation show that the suggested strategy has significantly improved in terms of effectiveness as well as efficacy when applied to various testing issues. The suggested PSO was additionally evaluated against the answers obtained by other current approaches (whether it's precise or heuristic) in order to verify the assertions. As a result of its inadequate answers, this approach is ineffective (Singh and Singh 2021).

The fractionated transportation problem, which has several objectives, is addressed in this study using a soft computation optimizing operational strategy. According to the suggested method, a mathematical representation is developed to represent the multi-objective aspiring levels fractionated transportation problem (MOFTP) dependent on the greatest worth of each and every modeling goal. To find the most ideal approach dependent on symmetric information, it additionally employed the symmetry principle in the framework. Investigation created membership ratings for the collection of symmetrical variables that were requested. To find the best option for fuzzy multi-objective fractionated transportation, this investigation also applied the notion of ranking functions in the mathematical framework. The ambition values are linked to the MOFTP goal functions in this suggested method. The work also suggests a novel method to perform concurrent optimization of the targets of the numerator functional and denominator function in fractionated situations. Additionally, a technique is devised to determine the typical expenditure for every fractional modeling target. The defuzzification approach will then be used to discover the ranked functions for every value. The study should be capable to transform the MOFTP into a bi-objective transportation problem using this way. Mathematical computations are used to clarify the offered approach in order to demonstrate its exquisite simplicity and potency (Sharma et al. 2021).

### **Proposed solution for Fuzzy Transportation Problem**

It is demanded in traditional transportation issues that the decision-maker is certain of the precise figures relating to transportation costs, product availability, and demand. Due to unpredictable circumstances, it's possible that each of these transportation problem characteristics will not be accurately understood in real-world applications (Maity et al. 2019). When a product needs to be carried for the first time to a location and no expert is familiar with the cost of transportation, there might be the following difficulties that occur in real-world issues. When a new product is introduced to the market, there is always some degree of uncertainty regarding the demand for that specific item.

The FTP might be expressed as follows when a decision-maker is unable to determine the exact amount of transportation costs from the  $i$ th source to the  $j$ th destination but is confident about the supply and demand of the product (Gupta, Ali, and Ahmed 2018). The formulation is given in Eq.1 and Eq. 2:

$$\sum_{y=1}^n i_{xy} = p_x, \quad x = 1, 2, \dots, m \quad (1)$$

$$\sum_{x=1}^m i_{xy} = q_y, \quad y = 1, 2, \dots, n \quad (2)$$

where  $i_{xy}$  is the amount of components of the good, which must be transported through the  $x$ th origin to the  $y$ th destination or decision factors;  $p_x$  will be the total rate of the goods that are accessible at the  $x$ th source;  $q_y$  will be the total rate of the goods that are necessary at the  $y$ th destination;  $r$  is the approximation of the cost for transporting one unit the amount of the goods from the  $x$ th origin to the  $y$ th destination; The overall cost of fuzzy transportation is  $\sum_{x=1}^m \sum_{y=1}^n r_{xy} i_{xy}$



Let  $u'_x$  and  $v'_y$  represent the fuzzy dual factors linked to the xth row and yth column constraints, accordingly. In such case, the fuzzy dual of the FTP shown in Eq. (1) will be as follows Eq.3:

$$\max \sum_{x=1}^m p_x u'_x \oplus \sum_{y=1}^n q_y v'_y \quad (3)$$

### Trapezoidal Fuzzy Numbers

A set made up of a single trapezoidal fuzzy number or numerous trapezoidal fuzzy numbers is referred to as a trapezoidal fuzzy set. An individually linear and trapezoidal function of membership of a trapezoidal fuzzy number may represent the fuzzy characteristics of those linguistic evaluations (Fahmi, Abdullah, and Fazli 2018). The trapezoidal numbers are widely used in real-world applications and are relatively simple to use. The fundamental design of a trapezoidal fuzzy number is depicted in Figure 2.

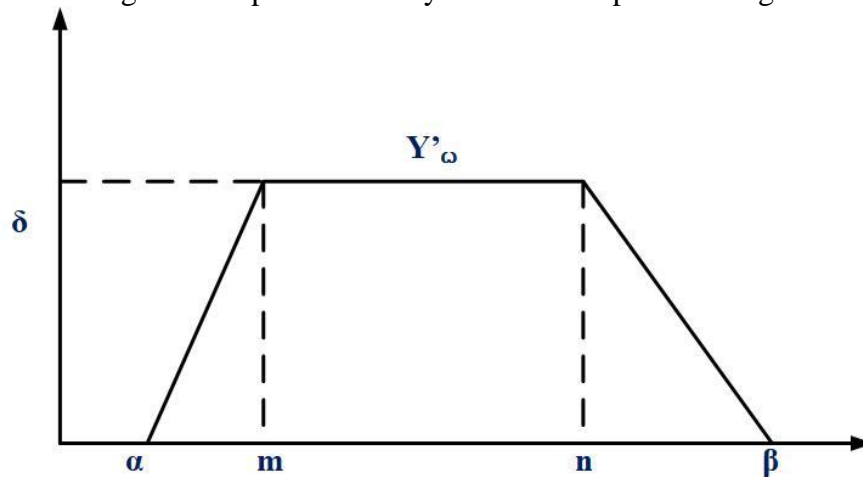


Figure 2: Fuzzy Trapezoidal Number

An indeterminate number  $L'$  is a trapezoidal fuzzy number, as well as its association function, is given below as  $(\alpha, \beta, m, \text{ and } n)$ , where, these are real numbers.

$$\begin{cases} 0 & \text{for } i \leq \alpha \\ (i - \alpha)/(m - \alpha) & \text{for } \alpha \leq i \leq m \\ 1 & \text{for } m \leq i \leq n \\ (n - i)/(\beta - n) & \text{for } n \leq i \leq \beta \end{cases} \quad (3)$$

The variable  $M(Y')$ , which is allocated to  $Y'$  is determined as follows: Let  $Y' = (Y(c), Y'(c))$ ,  $(0 \leq c \leq 1)$  be a fuzzy number in accordance with the definition of a trapezoidal fuzzy number provided in Eq.3.

$$M_0^{tp}(Y') = \frac{1}{2} \int_0^1 \{Y(c) + Y'(c)\} d = \frac{1}{4} [m + n + \alpha + \beta] \quad (4)$$

It makes calculations extremely simple as given in Eq.4.

The variable  $M_\delta^{tp}(Y')$ , provided to  $Y'_\delta$  might be determined as follows if  $Y'_\delta = (Y(c), Y'(c)) = \alpha + \frac{m-\alpha}{\delta}c, \beta + \frac{n-\beta}{\delta}c$  is an arbitrary trapezoidal fuzzy number with decision level greater than  $\delta \in [0, 1]$ .

If  $\delta > \gamma$ , then

$$M_\delta^{tp}(Y') = \frac{1}{2} \int_\gamma^\delta \{Y(c) + Y'(c)\} d = \frac{1}{4} [m + n + \frac{\gamma}{\delta} (m + n - \alpha - \beta) + \alpha + \beta] (\delta - \gamma) \quad (5)$$





It goes without saying that the previously stated amount will be zero if. It may also be demonstrated that the aforementioned quantities decrease to: if  $L'$  is a trapezoidal fuzzy number ( $\delta = 1$ ).

$$M_0^{tp}(Y') = \frac{1}{2} \int_0^1 \{Y(c) + Y'(c)\} d = \frac{1}{4} [m + n + \frac{\gamma}{1} (m + n - \alpha - \beta) + \alpha + \beta] (1 - \gamma) \quad (6)$$

The relationships may be further simplified as the two additional relations of Eq. 6 are cancelled out, if the fuzzy number is symmetrical ( $\alpha = \beta$ ). The trapezoidal fuzzy number  $Y'$  might be demonstrated as ( $\alpha, \beta, m$ , and  $n$ ) depending on the results.

### **Fuzzy Zero Point Method (FZPM)**

The study developed an entirely novel algorithm, the FZPM, for solving fuzzy transportation problems in a single step.

The Fuzzy Zero Point Method (FZPM) proceeds as follows.

Step 1: For the provided fuzzy transportation problem, generate the fuzzy transportation table, and if it is not balanced, convert it into a balance.

Step 2: From the row minimum, take every row values from the fuzzy transportation table.

Step 3: After utilizing Step 2, subtract every column values from the column minimum in the generated fuzzy transportation table.

Step 4: Verify that every fuzzy demand in a column is smaller than the total of the fuzzy supplies where lowered costs are fuzzy zero in that column. Additionally, make sure every row's fuzzy supply is lower than the sum of every column's fuzzy demands, where decreased costs are fuzzy zero in that row. Go to Step 7 if so. The allotment table is a similar smaller table. Go to Step 5 if not.

Step 5: Demonstrate the fewest amount of vertical and horizontal lines necessary to completely hide each of the fuzzy zeros in the lowered fuzzy transportation table, assuming certainly that none of the variables in the columns, and rows will not fulfil Step 4's requirement.

Step 6: Following are the steps to create the new revised lowered fuzzy transportation table: (i) locate the reduced fuzzy cost matrix's smallest entry that is not hidden by any lines. (ii) Subtract this entry from every one of the hidden entries and add it to each of the entries that are found at any two-line junction then proceed to Step 4.

Step 7: In the lowered fuzzy transportation table, choose a cell where reduced cost is the highest cost as  $\alpha, \beta$  Choose any cell if there is more than one

Step 8: Choose the only cell in the column or row of the lowered fuzzy transportation table where low cost is fuzzy zero, also assign that cell as much space as you can. Determine the next maximum so that the cell does appear if the maximum value does not have such a cell. Choose any cell in the lowered fuzzy transportation table, where lowest cost is fuzzy zero if such a cell is absent for any amount.

Step 9: After removing the fully utilized fuzzy supply points along with all established fuzzy demand points, reform the modified fuzzy transportation table. Additionally, modify it to add the partially utilized fuzzy supply points and partially established fuzzy demand points.

Step 10: Steps 7 through 9 should be repeated until all fuzzy demand points and supply points have been completely supplied.

Step 11: The supplied fuzzy transportation problem has a fuzzy solution as a result of this allocation.

### **Example of Fuzzy Zero Point Method**

The following example provides to show the FZPM, which is the suggested approach.



Consider the following FTP.

	(1,2,3,4)	(0,1,2,4)	(3,5,6,8)	Demand (5,7,8,10)
	(1,3,4,6)	(-1,0,1,2)	(5,8,9,12)	(1,5,6,10)
	(9,11,12,14)	(5,6,7,8)	(12,15,16,19)	(1,3,4,6)
	(5,7,8,11)	(0,1,2,3)	(7,9,10,12)	(1,2,3,4)
Supply	(2,6,7,12)	(0,1,2,3)	(6,10,12,17)	

Now, the overall fuzzy supply,  $S' = (8, 17, 21, 32)$  as well as the total fuzzy demand,  $D' = (8, 17, 21, 32)$ . As  $\text{Mag}(S') = \text{Mag}(D')$ , the problem is balanced.

Obtain the following simplified fuzzy transportation table after using Steps 2 through 3 of the FZPM.

	0	(-2,0,2,5)	0	Demand (5,7,8,10)
	(-3,0,2,5)	0	(-3,2,4,9)	(1,5,6,10)
	(-4,1,5,10)	0	(-5,2,6,13)	(1,3,4,6)
	(-3,2,6,12)	0	(-5,1,5,11)	(1,2,3,4)
Supply	(2,6,7,12)	(0,1,2,3)	(6,10,12,17)	

The following allocation table results from using Steps 4 through 6 of the FZPM.

	-22,-5,7,25	(-37,-6,16,48)	0	Demand (5,7,8,10)
	0	(-9,-1,4,13)	(-33,-7,9,34)	(1,5,6,10)
	0	0	0	(1,3,4,6)
	(-44,-10,13,49)	(-23,-5,7,24)	0	(1,2,3,4)
Supply	(2,6,7,12)	(0,1,2,3)	(6,10,12,17)	

The allocation is obtained, using the FZPM's allotment rules,

			(5,7,8,10)	Demand (5,7,8,10)
	(1,5,6,10)			(1,5,6,10)
	(-9,0,2,11)	(0,1,2,3)	(-9,-1,3,11)	(1,3,4,6)
			(1,2,3,4)	(1,2,3,4)
Supply	(2,6,7,12)	(0,1,2,3)	(6,10,12,17)	

Thus, the optimal fuzzy solution for the FTP is  $i_{13} = (5,7,8,10)$ ,  $i_{21} = (1,5,6,10)$ ,  $i_{31} = (-9,0,2,11)$ ,  $i_{32} = (0,1,2,3)$ ,  $i_{33} = (-9,-1,3,11)$ ,  $i_{43} = (1,2,3,4)$  with the fuzzy objective value  $k = (-275, 58, 188, 575)$  as well as the variable of the optimum FTP,  $k$  is 131.17

## Conclusion

The transportation issue was among the first LP application problems. Transportation models are frequently employed in transportation including the supply chain to save costs. There are efficient methods for resolving the transportation issue when the demand, supply and cost volumes, and other pertinent variables are exactly understood. In the real world,



unpredictability and inaccuracy are unavoidable due to a few unforeseen circumstances. The paper suggested an optimal FZPM for solving FTP. The strategy bases its decisions on precise presumptions on the product's supply, demand, and transportation expenses. The proposed approach describes transportation costs, product availability, and demand using generalized trapezoidal fuzzy numbers. As the suggested method is a straightforward extension of the conventional method, it is easier to learn and implement to real transportation problems. When decision-makers are faced with a variety of logistical problems with fuzzy features, it may prove to be an important tool.

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## الفهرس

الصفحة	اسم الباحث	عنوان البحث	رت
1-10	Manal Mohammed bilkour	An optimal fuzzy zero point method for solving fuzzy transportation problem	1
11-24	Mohamed Bashir M. Ismail	Assessing the Adaptability of Students and Teachers in the Faculty of Arts at Alasmarya Islamic University to the Sudden Transition to Online Teaching and Learning Processes during the COVID- 19 Pandemic	2
25-34	Dawi Muftah Ageel	Environmental study for Cyanobacteria Blooms using Envisat data at the western coastal of Libya	3
35-53	Nuria Mohamed Hider	Possible solutions to ensure data protection in cloud computing to avoid security problems	4
54-60	Gharsa Ali Elmarash Najla Mokhtar	A printed book or an e-book? Student Preferences & Reasons	5
61-75	هدية سليمان هويدي نادية عطية القدار دعاء عبد الباسط باكير	التشهير الإلكتروني عبر مواقع التواصل الاجتماعي من وجهة نظر طلبة كلية طب الأسنان بمدينة زليتن	6
76-89	Hamza A. Juma Saif Allah M. Abgenah Mustafa Almahdi Algaet Munayr Mohammed Amir	Designing an Autonomous Embedded System for Temperature Monitoring and Warning in Medical Warehouses	7
90-101	Salem Msaoud Adrugi Tareg Abdusalam Elawaj Milad Mohamed Alhwat	The effect of using electronic mind maps in learning visual programming through e-learning platforms An experimental study of computer departments students at Elmergib University	8
102-110	Suad Mohamed Ramadan Zainab Ahmed Dali Ahlam Mohammad Aljarray Zenoba Saleh Shubar	Performance analysis of different anode materials of double chamber Microbial Fuel Cell technology using different types of wastewater	9
111-116	Faiza Farag Aljaray Saad Belaid Ghidhan	Evaluation of Hardness for Electroless Ni-P Coatings	10
117-128	Saleh Meftah Albouri Hadya S Hawedi Mansur Ali Jaba	Using Smartphone in Education: How Smartphone has impacted in Education, A Review Paper	11
129-139	Ibrahim O, Sabri	The Concept of Illegal Immigration and Its Causes in North Africa Region	12
140-151	A.S. Deeb I.A.S. Gjam	Solution of a problem of linear plane elasticity in region between a circular boundary with slot by boundary integrals	13



152-173	Musbah Ramadan Elkut	Transforming TESOL Pedagogy: Navigation Emerging Technology and Innovative Process	14
174-192	سالم علي سالم شخطور	آراء أبي محمد القيسي في خزانة الأدب "دراسة وتحليل"	15
193-217	نورية صالح إفريج	اعتراضات النحاة على حجية الشواهد في مسألة إعادة حرف الجر مع حتى العاطفة	16
218-238	نجاه صالح اليسير	الازدواجية اللغوية وأثرها في تعليم اللغة العربية الصفوف الأولى من المرحلة الابتدائية (أنموذجاً)	17
239-256	محمود محمد رحومة الهوش	الرضا الوظيفي وأثره على الاداء المهني لدى معلمي ومعلمات التربية البدنية ببلدية العجيلات	18
257-272	إبراهيم رمضان هدية	السرد الروائي عند إبراهيم الكوني في رواية الدنيا أيام ثلاثة	19
273-279	ابراهيم علي احمدودة ابراهيم علي ارحومة	التحليل الاستراتيجي لشركة الخطوط الجوية الليبية دراسة تطبيقية على الشركة باستخدام النماذج	20
280-294	Ismail F. Shushan Emad Eldin A. Dagdag Salah Eldin M. Elgarmadi	Petrography of Abushyba Formation columnar-jointed sandstones (Triassic-Jurassic) from Jabal Nafusa- Gharian, NW-Libya	21
295-307	Samera Albghil	Multimodal discourse analysis of variations in Islamic dress code in Bo-Kaap, Cape Town	22
308-317	عبداللطيف بشير المكي الديب رجب فرج سالم اقنيير	( استخدام نظم المعلومات الجغرافية والاستشعار عن بعد في تقدير النمو العمراني وأثره على البيئة المحلية بمنطقة سوق الخميس - الخمس / ليبيا)	23
318-331	حنان عبد السلام سليم عائشة حسن حويل	تطوير الخدمات العقارية باستخدام تقنية المعلومات ( تطبيق أندرويد للخدمات العقارية أنموذجاً)	24
332-338	Mahmoud Mohamed Howas	Hepatoprotective Potential of Propolis on Carbontetrachloride-Induced Hepatic Damages in Rats	25
339-352	نورية محمد النائب الشريف	البناء العشوائي في مدينة الخمس (مفهومه - أسبابه - تأثيره على المخطط)	26
353-371	إسماعيل حامد الشعاب معمر فرج الطاهر سالم العامري	اختلاف القراء السبعة في البناء للفاعل وغير الفاعل وأثره في توجيه المعنى "نماذج مختارة"	27
372-376	عبد السلام صالح أبوسديل عطية رمضان الكيلاني	دراسة على مدى انتشار Gnathia sp. في بعض الأسماك البحرية المصطادة من شواطئ الخمس- ليبيا	28
377-392	الصغير محمد المجري	(بيان فعل الخير إذا دخل مكة من حج عن الغير) للملا علي القاري المتوفي سنة 1014هـ دراسة وتحقيق	29
393-421	نجيب منصور ساسي	فضل المواهب في شرح عيون المذاهب لعبد الرؤوف الأنطاكي (1009هـ) (الاستنجا ونواقض الوضوء من كتاب الطهارة) دراسة وتحقيقا	30
422-439	حنان ميلاد عطية	برنامج ارشادي معرفي سلوكي في خفض مستوى الوحدة النفسية لأبناء النازحين الليبيين	31
440-457	Hanan A. Algrbaa,	Speaker recognition from speech using Gaussian mixture model (GMM) and (MFCC)	32
458-467	هشام علي مرعي	علاقة المنطق بالعلوم الشرعية عند الغزالي	33



468-476	خالد الهادي الفيتوري زينب أحمد زوليه	الحلول العددية للمعادلات التفاضلية الملزمة باستخدام ب-سبلين التكعيبية	34
478-500	خميس ميلاد الدزيري	تأثير نظم معلومات التسويقية على توزيع السلعة " دراسة تطبيقية على إدارة مصنع إسمنت المرقب "	35
501-517	منصور عمر سالم فرعون	إدارة الوقت في الإدارة المدرسية في ضوء مهامهم الإدارية	36
518-533	فائزة محمد الكوت	أراء العلامة الدماميني النحوية في باب الظروف في كتاب خزانة الأدب ولب لباب لسان العرب	37
534-547	محمد محمد مولود الأنصاري حمزة مسعود محمد مكاري	"فوائد الفرائد في الاستعارة " عبد الجواد بن إبراهيم بن شعيب الأنصاري (1073هـ)	38
548-559	عبدالرحمن بشير الصابري إبراهيم عبد الرحمن الصغير أبوبكر أحمد الصغير	حروف الجر بين التناوب والتضمين دراسة تطبيقية على آيات من القرآن الكريم "دراسة وصفية تحليلية"	39
560-565	Ayda Saad Elagili Abdualah Ibrahim Sultan	An Application of "Kushare Transform" to Partial Differential Equations	40
566-598	أمل إجمد إقميع فاطمة محمد ابوراس	الأداء الوظيفي للمعلم وأثره على العملية التربوية دراسة سوسولوجية على عينة من معلمين ومعلمات مرحلة التعليم الأساسي	41
599-623	خيري عبدالسلام كليب عبدالسلام بشير اشتوي طارق أبوفارس العجيلي محمد عبدالسلام الأسطي فتحية خليل طحيشات	مدى التزام المصارف التجارية بتطبيق مبادئ إدارة الجودة الشاملة (دراسة ميدانية على مصرف الجمهورية فرع المرقب)	42
624-633	Abdulrhman Iqneebir Khaled Muftah Elsherif	Determination of Some Physical and Chemical Parameters of Groundwater in Ashafyeen-Masallata Area	43
634-650	أحمد على معتوق الزائدي	أحكام الأهلية وعوارضها عند الإنسان	44
651-671	عمر مصطفى النعاس السيد مصطفى السنباطي	الثقة بالنفس وعلاقته بالتوجه نحو الحياة لدى طالبات كلية الآداب	45
672-700	فاطمة جمعة الناكوع	معايير جودة آليات التدريب الميداني	46
701-718	إيمان عمر بن سعد بثينة علي أبو حليقة عمر محمد بشينه وليد حسين الفقيه	أثر المخاطر المالية في الأداء المالي للمصارف التجارية الليبية للفترة من (2011-2017)	47
719-730	هدي الهادي عويطي	دور مداخل ادارة المعرفة في تحسين ادارة الموارد البشرية في المؤسسات الحديثة	48
731-739	Khaled Abdusalam B. A Eman Mohammed Alshadhli Tasnim Adel Betro Amera Lutfi Kara Mawada Almashloukh	Antimicrobial Activities of Methanol Extract of Peganum harmala Leaves and Seeds against Urinary Tract Infection Bacteria	49
740-750	فتحية زايد شنييه نجاة بشير الصابري	الصور البيانية في سورة الواقعة	50



751-757	Afifa Milad Omeman	Phytochemical, Heavy Metals and Antimicrobial Study of the Leaves of Amaranthus viridis	51
758-765	أسماء جمعة القلعي	قواعد المنهج عند ديكرت	52
766-777	فرج مجد صالح الدريع	النفط والاقتصاد الليبي 1963م – 1969م	53
778-789	عمر عبدالسلام الصغير رضا القدافي الأسمر	تقويم دية القتل الخطأ بغير الأصل	54
790-804	أبو عجيبة رمضان عويلي أحمد عبد الجليل إبراهيم	مناقشة المسألة الأربعين من كتاب المسائل المشكلة للفارسي	55
805-823	فتحية أبو عجيبة جبران صالحة عمر الخرارزة	في منطقة سوق الخميس التلوث البيئي الناتج عن محطات الوقود (بحث مقدم للحصول على ترقية عضو هيئة تدريس)	56
824-856	هنية عبدالسلام البالوص	بعض المشكلات الضغط النفسي وعلاقتها بالصحة النفسية	57
857-871	احمد علي عزيز علي مفتاح بن عروس	تطبيقات البرمجة الخطية ونماذج صفوف الانتظار في مراقبة وتحسين الأداء دراسة إحصائية تطبيقية على القطاع الصحي بمدينة الخمس	58
872-879	Mona A. Sauf Fathi Shakurfow Sana Ali Soof Abdel-kareem El-Basheer	Isolation of Staphylococcus Aureus From Different Clinical Samples And Detects on Its Antibiotic Resistance	59
880-885	Wafa Mohamed Alabeid Omar Alamari Alshbaili	Combined Method of Wavelet Regression with Local Linear Quantile Regression in enhancing the performance of stock ending-prices in Financial Time Series	60
886-901	خالد مجد بالنور خالد أحمد قناو	حجم الدولة الليبية وأثره عليها طبيعياً وبشرياً	61
902-918	Amna Ali Almashrgy Hawa Faraj Al-Burrki Khadija Ali AlHebshi	EFL Instructors' and Students' Attitudes towards Using PowerPoint Presentation in EFL Classrooms	62
919-934	سالمة عبد العالی السيليني	اضطرابات الشخصية الحدية وعلاقتها بالجمود المعرفي	63
935-952	Samah Taleb	Common English Pronunciation Difficulties Encountered by Third Year Students at the Faculty of Education- English Department- Elmergib University	64
953-958	Hassan M. Krifa	A Study on Bacterial Contamination of Libyan Currency in Al-Khoms, Libya	65
959-964	Jamal Hassn Frjani	A New Application of Kushare Transform for Solving Systems of Volterra Integral Equations and Systems of Volterra Integro-differential Equations	66
965-978	Ismail Elforjani Shushan Saddik Bashir Kamyra Hitham A. Minas	Study of chemical and biological weathering effects on building stones of the Ancient City of Sabratha, NW-Libya	67
979-991	مجد عبد السلام دخيل	الآثار الاجتماعية والثقافية المصاحبة للتغير الاجتماعي في المجتمعات النامية	68





992-998	Ismael Abd-Elaziz Fatma Kahel	Molecularly imprinted polymer ( poly-pyrrole ) modified glassy carbon electrode on based electrochemical sensor for the Sensitive Detection of Pharmaceutical Drug Naproxen	69
999-1008	خالد رمضان الجربوع علي إبراهيم بن محسن صلاح الدين أبوغالية	علي الجمل وقصيدته (اليوم الأربعاء في رثاء النورس الكبير)	70
1009-1014	نادية مجد الدالي ايمان احمد اخميرة	Comparing Review between Wireless Communication Technologies	71
1015-1024	Khairi Alarbi Zaglom Foad Ashur Elbakay	The importance of Using Classroom Language in Teaching English language as a Foreign Language	72
1025-1042	حمزة بن ربيع لقرون	الأدلة المختلف فيها التي نُسب الاختصاص بها إلى مذهب مُعَيَّن (دراسة تحليلية مقارنة)	73
1043-1052	أسماء السنوسي لحيو	معدل انتشار بعض الأوليات المعوية الطفيلية في مدينة الخمس، ليبيا	74
1053-1067	برنية صالح إجمد صالح	استعمالات (ما) النافية في سورة البقرة	75
1068-1085	اسماعيل عبدالكريم اعطية	عوامل نجاح وفشل نظام المعلومات دراسة تطبيقية على شركة الأشغال العامة بني وليد	76
1086-1098	نجوى الغويلي	"الرعاية الاجتماعية والدعم الاجتماعي والتربية الإيجابية للطفل"	77
1099-1105	Seham Ibrahim abosoria Fatheia Masood Alsharif Abdussalam Ali Mousa Hamzah Ali Zagloun	The Error Correction in second language writing	78
1106-1128	ميسون خيري عقيلة	أساليب المعاملة الوالدية وعلاقتها بالتحصيل الدراسي لدى عينة من طلبة كليات جامعة المرقب بمدينة (الخمس)	79
1129-1135	Majdi Ibrahim Alashhb Mohammed Alsunousi Salem Mustafa Aldeep	Quality of E-Learning Learning Based on Student Perception Al Asmarya University	80
1136-1150	Ekram Gebрил Khalil	The Importance of Corrective Feedback in leaning a Foreign Language	81
1151-1164	سكينة الهادي الحوات فوزي مجد الحوات سلمية رمضان الكوت	شكل العلاقات الاجتماعية في ظل انتشار الأوبئة والأمراض السارية (جائحة كوفيد 19 نموذجاً)	82
1165-1175	Salma Mohammad Abad	A comparative study of the effects of Rhazya stricta plant residue on Raphanus sativus plant at the age of 15 and 30 days	83
1176-1191	مجد عمر مجد الفقيه الشريف	توظيف الاعتزال عند الزمخشري وانتصاره له من خلال تفسيره	84
1192	الفهرس		