International Journal of Multidisciplinary Research and Growth Evaluation.

Application of operations research to the fuzzy transport problem

Arif Rashid [1*], **Anisa Rashid** [2], **Bhawna Agrawal** [3]
[1-3] Department of Mathematics, Rabindranath Tagore University, Raisen, Madhya Pradesh, India

* Corresponding Author: **Arif Rashid**

Article Info

ISSN (online): 2582-7138
Volume: 04
Issue: 04
July-August 2023
Received: 25-06-2023
Accepted: 15-07-2023
Page No: 973-980

Abstract
One of the most essential elements needed by humans to carry out their tasks is transportation. It also sees as one of the most crucial elements for economic growth. Since operations research applications play a major role in the decision-making process on a scientific basis for planning productive and economical projects, they are interested in determining the best plan for transportation at the lowest costs from their production sources to their requesting bodies to arrive at the optimal decision. The problem of oil product transportation inside the Midland Oil Company has been the focus of this research in order to achieve this goal. As a result, in this work, fuzzy theory and a contemporary algorithm (ATM) were used to investigate whether adopting transport models could effectively lower the transportation costs of oil products in production institutions. When compared to utilizing a ready application (Win QSB), the approach used by the Midland Oil Company to distribute its oil products from its four main warehouses to the provinces that have contracts with the company is more effective at handling fuzzy data. The approaches employed to address the issue are the best ones for moving the product at the lowest possible cost, as shown by the findings Additionally, a number of recommendations and ideas have been made in light of the study' findings in order to assist in utilizing the solution techniques' contribution to decision-makers' ability to make decisions.

Keywords: Optimized fuzzy solution, Adjacent zero method, Robust fuzzy, Fuzzy zero method (FPZM). Fuzzy Transfer Problem

1. Introduction

Operations research is a quantitative approach to problem solving that employs a variety of mathematical tools. When you're trying to make a decision but the circumstances are ambiguous, and when competing goals are at odds, operations research can help. A fuzzy transportation problem is one in which the transportation expenses, supply, and demand quantities are all ambiguous. Ranking fuzzy numbers is a necessary step in many mathematical models. Zadeh [14] pioneered the concept of fuzzy sets.

It is believed that making decisions for the formation of scientific resource planning for industrial and productive institutions is a crucial issue. Analysis and scientific research are its pillars. Therefore, operations research is one of the most crucial instruments for finding the best solution, and its use is required in developing nations that must optimize investment for their limited resources and available capabilities. The transportation model is one of the applications of operations research that looks for the best way to transmit resources at the lowest possible cost between a collection of production sources and a group of demand and need centers. Additionally, it notices that there are several projects in various industries, It enables the use of transport models to create economic strategies to a variety of resources from industrial facilities are available to supply their demands and materials to project, which calls for both produced and raw materials. Fuzzy programming has emerged as the most efficient method for addressing scientific reality in light of technology advancement, therefore the fuzzy notion (Zadeh and Bellman) was applied in the decision-making process, where the fuzzy a programming issue has been identified Fuzzy linear programming involves fuzzy coefficients, thus make sure that Using the hippocampal way of layout, search provides a clear image of fuzzy logic. (Robust) for applying the AlRank in fuzzy data processing.

One of the most significant factors in picking this topic is an effort to investigate the issue of carrying oil products, which is one of the issues that directly affects the lives of citizens. A deeper look at how contemporary transportation techniques can help to lower the cost of shipping the product. Aside from the nation's current state, which sees the producing institutions of the nation living in a similar manner, studies are lacking. In addition to the dearth of field and applied studies that address the transportation issue, the research is also hampered by the need to connect the theoretical study to the reality of the situation. Additionally to attempting to give the company a competitive edge by lowering expenses and so improving the competitiveness of the product and thereby acquiring the best plan to transfer the symmetric product from many sources visiting numerous locations in order to emphasize the role that transport models play in cost-saving measures (Recommendations are used to create the Algerian message).

The format for the research is as follows

First: The fuzzy group's theoretical notion is part of the theoretical aspect.

Second: The practical component, which covers the company's fuzzy transportation issue by employing techniques to handle data with fuzzy coefficients, solve them, and then extract and analyze the results in order for them to come up with the best answer.

Third: It contained the most significant conclusions and suggestions in light of the research's findings to aid future specialists in this field of study. By making the appropriate choice to address the issue of health transportation, research is demonstrated to be important. Choosing the best quantity while evaluating the materials' lowest transit costs the tools offered by operations research and how they are used. No perfect answer can be found. when a budget has been established by the company and approved in its plans.

2. Research problem

One of the crucial industries in the nation is the oil industry. Since it directly affects citizen lives and plays a significant part in obtaining the vital financial resource for Iraq, interest in it has a significant impact. Therefore, the state is working hard to develop this industry. For this, it was important to determine the best way to move the required oil products from its primary warehouses to the parties making the request. Because the company had such a problem, we also had to deal with the hazy problem of data caused by not knowing the total cost of transportation, with determining the quantities that will be transferred in accordance with the request for the company's approval to transfer its products in a basin vehicle by contracting with a private company (Uruk) that was dealing with a high cost of transport as well as traffic accidents, fires, and emergency situations. As a result, fuzzy logic has been used to solve the model in order to meet the study's goal.

3. Research Importance

Decision-making is crucial in the many industrial and production sectors, which explains the significance of research. Particularly the large productive enterprises that base their decisions on the use of operations research systems to solve the problem of transporting oil products in oil installations and the lowest costs for transport by determining the optimal quantity and concentrating its attention on the most crucial tasks established to transfer goods or products at the lowest costs. The ideal option is not to discover that a budget that has been established by the organization and accepted in its plans exists using the techniques offered by operations research and application.

4. Research objective

The research looks forward to solving a foggy transfer problem to reach an optimal solution by achieving the following goals:

- The research aims to reduce the cost of transportation of a fuzzy nature to the Ministry of Oil / Midland Oil Company for the transportation of the product
- Determining the optimal transferred quantities from their primary locations to the organizations that needed to be supplied.

5. Research limits

The following were the search parameters:

A. Geographical restrictions: These concern the company in question, the Midland Refineries Company of the Ministry of Oil.

B. Time limits: Denotes the time frame during which the company collected, processed, and evaluated the data in order to provide the results for the period from January 1 to January 6, 2019.

6. The Theoretical Side

➢ Fuzzy Theory

One type of logic that has been applied in artificial intelligence applications and systems is fuzzy theory. Finding a solution to practical difficulties with this method is quite successful. Since it greatly affects decision-making, more precise solutions to the many difficulties faced by researchers and decision-makers are possible. Fuzzy logic was created by Iranian scientist Lotfi Zadeh and was found to be the most effective method for handling fuzzy data because it allows for the specific results to be drawn from false data, unlike traditional logic which depends on determining numerical values of values. In order to provide a mathematical system, he used statistical techniques after applying mathematical laws. Then he merged statistical principles, mathematical laws, and contemporary development. Fuzzy logic, which has been used in neural networks and manufacturing processes, has evolved into one of the techniques for creating contemporary systems. As it plays a crucial part in determining the best course of action when using fuzzy mathematical models to solve issues [6].

➢ Fuzzy Number

The classical group (crisp set) is a special, countable group that can take either of the two values (0,1) and is well-defined. When an element is a member of a group, it receives the value (1); when it is not, it receives the value (0); and when its degree of affiliation is equivalent to (0.9), it receives the value (0.8). This indicates that the element has a high degree of affiliation, however when the degree of affiliation is equal to (0.5), it indicates that the degree of affiliation is equivalent to the degree of non-affiliation. A weak affiliation between the element and the group is indicated if the degree of affiliation is less than (0.5), on the other hand. According to the figure below, the simple group.

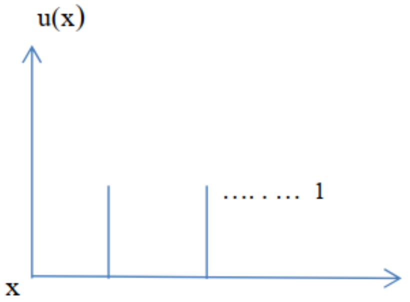

Fig 1: Shows the fuzzy group

The scientist (Zimmerman) defined in (1988) the fuzzy group: Let X have a group of elements and be denoted by the symbol x and let a group A be a fuzzy group in X is a group of arranged pairs, and let the fuzzy group be known as (A˜) where[5]:

…. (1) , i=1, 2,……, n xi), (xi)) }(n$_{A\sim}$ = { (A˜

So that $\mu_{\tilde{A}}$ (xi) ∈ [0 , 1]

- **Types of function membership liner**

A. the Triangular membership function is a linear membership function with three parameters that are of a straight line shape, so when they are:

A˜ = (a, b, c)

When it has been said that A˜ represents a fuzzy triangular number and the triangular membership function can be expressed in the following formula:

$$(x) = \begin{cases} \frac{x-a}{b-a} & \text{If } a \le x < b \\ 1 & \text{If } x = b \\ \frac{c-x}{c-b} & \text{If } b < x \le c \\ 0 & \text{If otherwise} \end{cases} \quad \text{……… (2)}$$

Whereas,
1. Represents the lower bound of the function
2. Represents the value of the centre
3. Represents the upper bound of the function

μA(x) Degree of affiliation (x) whose value ranges between (0, 1) The function can be illustrated as follows

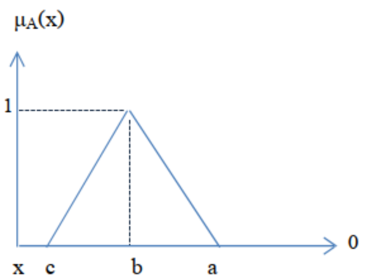

Fig 2: Shows the trigonometric affiliation function

A. Trapezoidal Function

Linear membership function with four parameters, where A˜ has four parameters for fuzzy number, where it represents [4]:

$\tilde{A}$ = (a, b, c, d)

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a} & \text{If } a \le x < b \\ 1 & \text{If } b \le x \le c \\ \frac{d-x}{d-c} & \text{If } b \le x < c \\ 0 & \text{If otherwise} \end{cases} \quad \text{……… (3)}$$

It can be represented as follows [11]

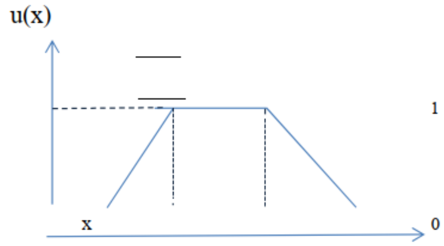

Fig 3: Shows the trapezoidal function

- **Operations on triangular intuitionistic fuzzy number**. Suppose we have A˜, B˜two sets of fuzzy numbers, which are known as [12]:

a2, a3), a1 = (A˜
B˜ = (b1, b2, b3)

Therefore, basic mathematical operations can be performed on fuzzy numbers (addition, subtraction and multiplication) as follows:

1. Addition of the fuzzy number to Ã, B˜ is defined by

Ã + B˜ = (a1, a2, a3) + (b1, b2, b3) = (a1 + b1, a2 + b2, a∈ + b3)

2. Subtraction the fuzzy numbers

Let the groups Ã and B˜ be the subtraction process for the two groups:

= (a1, a2, a3)*(b1, b2, b3) = (a1 − b3, a2 − b2, 3∈ − b1) Ã - B˜

3. Multiplication to the fuzzy numbers for the two sets A˜ ∗ B˜ = (a1, a2, a3) ∗ (b1, b2, b3) = (a1 b1, a1 b3, a∈ b1, a3 b3)
4. Scalar multiplication the fuzzy numbers

Stable k

(a1, a2, a3) = (ka1, ka2, ka3)

5. numbers are positive if A~>0 And zero if A ^ ~ = 0

And equivalent if A˜ = B˜

Where:

a_1. Represents the first number in the first set

a_2. Represents the second number in the first set a3. represents the third number in the first set b_1. represents the first number in the second set

b_2. Represents the second number in the second set

b3. Represent the third number in the second set

Fuzzy transport problem (FTP)

It is a linear programming problem with a structure that resembles the typical transportation problem, but whose variables have a fuzzy shape (its transactions are represented by the target function, the cost of transportation, the amount of demand, and the amount of supply), and which emphasizes the significance of transportation issues in distributing the product from production sources like factories to their requesting destinations like markets and stores with a specific absorptive cap In order to move the product between the locations of production and consumption, we need to figure out how to transfer and distribute materials as cheaply as possible. To do this, we represent the manufacturing centers as (m), and the number of demand points as (n).and the level of producing the product in each center with (ai) and (Xij) represents the amount of the product that will be transported from the production source (i) to the consumption point (j) in order to satisfy the needs of each asking point in (bj), where [10]:

The following table represents the fuzzy transport model:

				Supply
1	c11	…	c1n	a˜1
⋮	⋮		⋮	⋮
	cm1		cmn	a≤m
Demand	b˜1	…	b˜*n*	

The mathematical formula for the transfer model is as follows:

$$\text{Minimize} = \sum_{i=1}^{m}\sum_{j=1}^{n} \tilde{c}_{ij}\, x_{ij}$$

According to the restrictions below

$$\sum_{j=1} x_{ij} = \tilde{a}_i \quad , \text{for } i = 1,2,\dots,m$$

$$\sum^{m} x_{ij} = \tilde{b}_j \quad , \text{for } 2 = 1,2,\dots,n$$

Whereas:
M. The total number of sources
N. The total number of applicants
a˜i. Quantities displayed that are fuzzy for sources
˜b 2. Fuzzy quantities required for demand directions

c˜ij. The cost of the fuzzy unit transferred from the source (i) to the demanding entity (j)
xij. The optimum b amount that will transfer the source to the requesting side with the necessity that the transportation problem should be balanced that is:

$$\sum_{i=1}^{n} \tilde{a}_i = \sum_{m}^{i=j} \tilde{b}_j$$

A New Method for Obtaining an Initial Basic Feasible Solution to the Transportation Problem.
In contrast, the model's purpose is to develop a distribution plan with low transportation costs, which can be described as follows:

$$\text{Min } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}\, x_{ij}$$

❖ Methods to solve fuzzy transport problems

A number of solutions have demonstrated their effectiveness in resolving the fuzzy transport issue. The (Rank) function method is one of the most significant contemporary techniques for finding solutions to difficult transport problems since it was distinguished by being a function with particular requirements. This has led to the majority of research efforts to build a solution method for fuzzy transport problems. By making the issue non-fuzzy instead of fuzzy, it seeks to identify the best answer. Since most real-world problems have ambiguous conditions, which can make decision-making challenging, especially when defining the main objective in the context of a lack of precision and clarity, all of this has helped to make it a crucial tool for dealing with those conditions when attempting to solve the optimization problem.

➢ Rank Function Method

It is a method for dealing with uncertain numbers for specific integers by applying the formula. The rank function was used to achieve the outcome. As demonstrated [8]: Consequently, the set of fuzzy numbers is F(R).

(a, b, c, d) ∈ F(R)

Ƙ Ƙ: Ƒ(Ƙ) ⟶

Where F (R) is the rank function: the set of all the fuzzy numbers on the real number line
(R˜) = (a + b + c + d)/4
So to be the A˜, B˜ two set of a fuzzy number
a_2, a_3, a_4), a_1 = (A˜
B˜ = (b1, b2, b3, b4)

(i) A˜ ≥ B˜ ⟺ R(A˜) ≥ R(B˜)
(ii) A˜ ≤ B˜ ⟹ R(A˜) ≤ R(B˜)
(iii) A˜ = B˜ ⟹ R(A˜) = R(B˜)

➢ *Robust Ranking Method (RRM)*

It is one of the most important modern approaches for dealing with fuzzy transport problems, and the results it produces are in line with human intuition. The strategy is used in the decision-making process when the costs, quantities offered, and requests are uncertain. When this method was utilized in studies by the two researchers (R. Nagajajan and A. Solairaju) that were published in the year (2010), the function used in those studies has the following form [2]:Let Ã be: a group of ambiguous numbers for which the following definition of the Robust Ranking function applies:

$$R(\tilde{a}) = \int_0^1 (0.5)(a_\alpha^l \; a_\alpha^u)\,d\alpha$$

Where Ã = (a1, a2, a3, a4)

$$(a_\alpha^l \; a_\alpha^u) = (\{a_2 - a_1)\alpha + a_1, a_4 - (a_4 - a_3)\alpha$$

where $(a_{\propto}^{l}\ a_{\propto}^{u})$ represents the level of intersect α to the fuzzy number $\tilde{a}$

It can be extracted in the following mathematical formula Source 1:

$$(a_{\propto}^{l}\ a_{\propto}^{u}) = \{(b - a)\propto + a + c - (c - b)\propto$$

The robust function is one of the crucial components in the solution to the transport and allocation issue of a fuzzy nature [1].

➢ Algorithm of zero suffix method (M.Z.S.M)

According to a 2013 study by scholars Thiagarajan, Saravanan, *et al*. titled "Finding the best solution to the problem of transportation using the adjacent zero method"[13], the concept behind this approach is that it doesn't require many iterative processes. It was given that name because one of the suggested strategies that works well allocates the resources to cells that have received zeros and have the highest percentage of non-zero zero site cells. A summary of this method's solution steps can be found in the list below [14].

- Make a schedule to address the transportation issue, then check that it is balanced.
- Subtracting the lowest element from each row or column of the transfer matrix.
- After obtaining the cost reduction transfer schedule in the previous phase, we check to see that the reduced schedule has at least one zero in each row and column.
- At each zero in the table, we extract the non-zero nearby average. The non-zero rate is calculated by dividing the sum of the non-zero cells that are close to the zero location by the total number of those values.

By assigning the given offer and demand, we carry out the allocation procedure at the site of every zero, which has the highest non-zero rate, and the cell is allocated at that moment.

Repeating steps 1 to 5 will ensure that each process has at least one zero and each row or column is zero.

We begin figuring out the total cost of transportation after assigning all of the amounts indicated in the transfer schedule.

➢ Fuzzy Zero Point Method (IFZPM)

It is a contemporary and efficient approach to solving the fuzzy transport problem that was put forth by the researcher (Edward Samuel) in 2012. It was distinguished by being straightforward and regarded as a crucial tool for decision-makers in taking and analyzing actions as well as the administrative and economic decisions that they must make in order to solve the transport problem of a fuzzy nature [9] the algorithm method of the modified genetic algorithm.

The actions we take to use the aforementioned technique are as follows:

First step is to make sure that the transfer schedule is balanced for the fuzzy transport problem, and that it is balanced in the event that it is not.

The second step is to identify the schedule's highest fuzzy transportation cost.

Third step: Instead of using zero costs, we make up the cost of the column or fictional ghost row with the highest transport cost in the table.

Fourth step: The lowest transport cost is found in each row of the transfer table's columns, and it is then subtracted from all the cells in that column and row's transport.

Fifth step: The Table of Fuzzy Costs is the result of the preceding processes, which brings us to step five.

Sixth Step: Verify that the sum of each component of the bid and the sum of each component of the demand is less than or equal to the sum of the fuzzy supply.

Seven step: If there is a cell that costs at least zero in every row or column, we move to step (the tenth), but if the contrary is true, we advance to step (eight).

Eighth step: Draw as few vertical and horizontal lines as you can to completely encircle all of the zeros in the reduced fuzzy transfer schedule you created in step (the fifth).

Ninth step: We begin creating the solution schedule as

A. We choose the option with the lowest cost, letting (c) be the case in all cells when no lines are covered by it.
B. All cells that have no lines covering them are subtracted from.
C. Each cell below the junction of two lines receives an additional cost.
D. All cell components below the first line are left alone.

➢ Allocation table method (ATM)

Due to the volatility of the oil economy, it is one of the contemporary methods for achieving the best answer to the transportation issues, and it is distinguished by its straightforward implementation and sporting activities. The research seeks to determine the lowest transportation costs under conditions of fluctuating oil prices. Through the results, it is demonstrated that the method was effective and accurate in its application in predicting the future of transportation costs, whereas the procedures used in the method are [3].

- ➢ Scheduling the transportation issue within the constraints of a certain supply and demand.
- ➢ The transfer schedule should be balanced if it is out of balance after being checked for balance.
- ➢ Whether they are individual integer, decimal, or fractional costs, we specify the lowest individual costs within the costs of the schedule.
- ➢ We keep this particular cost the same while deducting all table expenses from it, and then we multiply the reduced schedule by its values to obtain the final cost.
- ➢ After assigning the lowest individual cost in the table within the cell's defined supply and demand, we delete the row or column that was allotted.
- ➢ After all amounts have been distributed to the parties making requests in the transportation matrix, we start figuring out the total cost of transportation.

Figure [7] further explains what will be used from the algorithms to address the fuzzy transport problem.

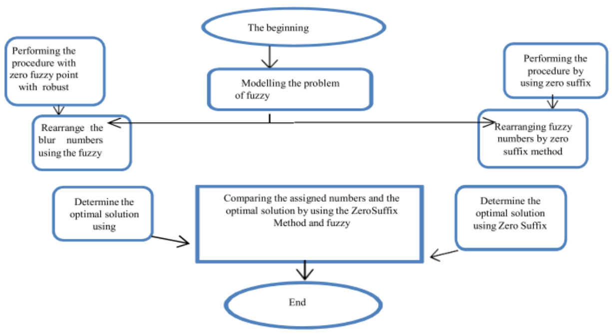

Fig 4: Flowchart of Transportation Problem Solving

The applied side

We have used the modern algorithm to show that it is a modern and significant way to arrive at the optimal solution, which has a substantial impact "on reducing transportation costs to national institutions of a productive nature. This is done in order to apply the theoretical part of the research. The Central Refineries Company, one of the departments under the Ministry of Oil, was selected to provide black oil (fuel oil) to the country's governorates for the time period (1/1/2019 – 1/6/2019). Black oil is a crucial resource for brick factories and electrical generators, and the cost of transporting them has a significant impact on the country's economy. Using the method below (1), which was determined by calculating the cost of shipping black oil at the Midland Refineries Company, one can find the lowest overall cost for transporting black oil from the major warehouses to the governorates seeking this material.

The transportation costs are calculated according to Table (3-1) after documenting the fuzzy data.

Transport cost = load (tons) * distance (km) * transport price (dinar per ton) …….(1)

Governera	Baghdad	Basra	Karbal A	Babylon	Al-Kut	Al-Naiaf	Al-Diwani	Al-Samaw	Offer
warehouse	,20 3	80	45	35	40,45	56	35,40	50,53	4600,5000
Najaf refinery warehouse	34,45	50,55, ,63	10,16, ,35	10,15, ,25	25,30 45	10,15, ,33	15,20, ,35	30,40, 45	2100,2500, ,2555
Diwanyiah refinery warehouse	35,40, 55	48,50, 65	20,28, ,40	25,33,4 0	18, 25,30	15,20, ,35	15,20, 25	33, 39,42	1250, 1550,1600
Samawa refinery warehouse	40,50, 60	40,42, ,53	30,36, ,40	36, ,40,45	30,36, 50	32,35, ,46	20,21, 30	9,15, 30	2000, 2500,2550
Demand	3100, 3500 ,4000	3800, 3999, ,4398	1500, ,2500,2 900	800,850 , ,955	600, 750,950	500, 650,700	445,800 , 910,	400, 550,600	

Following the creation of a table for the fuzzy cost, fuzzy offer, and fuzzy demand in the problem of fuzzy transport, the robust ranking function is used to transform the fuzzy numbers into particular numbers in accordance with the robust ranking function shown below:

$$R(\tilde{a}) = \int_0^1 (0.5)(a_\propto^l \; a_\propto^u) d\alpha$$

Where $\tilde{A}$ = (a1, a2, a3, a4)

$(a_\propto^l \; a_\propto^u) = (\{a_2 - a_1)\propto + a_1, a_4 - (a_4 - a_3)\propto$

where $(a_\propto^l \; a_\propto^u)$ represents the level of intersect α to the fuzzy number $\tilde{a}$

It is extracted according to the mathematical equation where:

$(a_\propto^l \; a_\propto^u) = \{(b - a)\propto + a + c - (c - b)\propto$

Thus, after applying the fuzzy ranking function to the parameters of the fuzzy trans

R(10,15,20) = 15, 3(50,60,80) = 62.5, 3(10,30,45) = 30, 3(10,15,35) = 18.75, 3(30,40,45) = 40, 3(32,50,60) = 48, 3(20,35,40) = 32.5, 3(35,50,53) = 47, 3(30,34,45) = 35.75, 3(50,55,63) = 55.75, 3(10,16,35) = 19.25, 3(10,15,25) = 16.25, 3(25,30,45) = 32.5, 3(10,15,33) = 18.25, 3(15,20,35) = 22.5, 3(30,40,45) = 38.75, 3(35,40,55) = 42.5, 3(48,50,65) = 53.25, 3(20,28,40) = 29, 3(25,33,40) = 32.75, 3(18,25,30) = 24.5, 3(15,20,35) = 22.5, 3(15,20,25) = 20, 3(33,39,42) = 38.25, 3(40,50,60) = 50, 3(40,42,53) = 44.25, 3(30,36,40) = 35.5, 3(36,40,45) = 40.45, 3(30,36,50) = 38, 3(32,35,46) = 37, 3(20,21,30) = 23, 3(9,15,30) = 17.25

Port schedule, the results appear as follows:

As for the fuzzy offer amounts after the Robust function is applied, they are as follows:

R(4000,4600,5000) = 4550, 3(2100,2500,2555) = 2413.75, 3(1250,1550,1600) = 1487.5, 3(2000,2500,2550) = 2387.5

As from the demand directions

3(3100,3500,4000) = 3525, 3(3800,3999,4398) = 4049, 3(1500,2500,2900) = 2350, 3(800,850,955) = 863.75, 3(600,750,950) = 762.5, 3(500,650,700) = 625, 3(445,800,910) = 738.75, 3(400,550,600) = 525

- **Application of modern transportation methods to solve fuzzy transportation problems**

The three methods for finding a solution will be used on the transport matrix; they are the (zero fuzzy point, zero suffix method, and method (ATM)) on the black oil product model (fuel oil) in the Midland refineries company to transfer it from the main warehouses to the provinces requesting the product. The results of these methods will be compared with those of a method called linear programming to determine which of the above methods is most likely to produce the best results. Following the data's documentation, the transport schedule will be determined by the features (supply, demand, and cost) for the product's fuzzy transportation problem, as shown in table (3-2) below.

Province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery	15	62.5	30	18.75	40	48	32.5	47	4550
Najaf refinery warehouse	35.75	55.75	19.25	16.25	32.5	18.25	22.5	38.75	2413.75
Diwanyiah refinery warehouse	42.5	53.25	29	32.75	24.5	22.5	20	38.25	1487.5
Samawa refinery warehouses	50	44.25	35.5	40.25	38	37	23	17.25	2387.5
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

The supply amount is (2600.25) tons of black oil as shown in Table (3-3) after balancing the transportation schedule by introducing a fictitious row with costing its cells equal to zero.

Province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery warehouse	15	62.5	30	18.75	40	48	32.5	47	4550
Najaf refinery warehouse	35.75	55.75	19.25	16.25	32.5	18.25	22.5	38.75	2413.75
Diwanyiah warehouse	42.5	53.25	29	32.75	24.5	22.5	20	38.25	1487.5
Samawa refinery warehouses	50	44.25	35.5	40.25	38	37	23	17.25	2387.5
Imaginary row	0	0	0	0	0	0	0	0	2600.25
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

3.2 Applying the zero fuzzy point method on the transport schedule with its procedures. The assigned transport schedule is as follows according to Table (3-4) below:

Province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery 15 62.5	30			18.75					
Najaf refinery 35.75 warehouse 55.75	19.2	16		863.75					
Diwanyiah 42.5 53.25	29	2188.		32.75	24.5 76	625	20 738.	38.25	1487.5
Samawa refinery 50 warehouse 44.25	35.5			40.25	38	37	2[3]	17.25 52	2387.5
Imaginary row	0	0 40	0	0	0	0	0	0	2600.25
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

After measuring the total cost of transporting the product from the main warehouses to the provinces requesting the black oil product, it was as follow:

MIN(Z)= 240908.4375

MIN(Z) = 247878.75

Applying the zero suffix method to the transport schedule after balancing the schedule, so the assigned schedule will be as in Table (3-5):

Province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
			19.25						
Al Dora refinery	15	62.5	30	18.75	40	48	32.5	47	4550
Najaf refinery warehouse	3 352	5.75	1025 925	16.25 863.75	32.5	18.25 625	22.5	38.75	2413.75
Diwanyiah refinery warehouse	42.5	53.25			4.5 748.75		20 738.75	38.25	1487.5
Samawa refinery warehouses	50	44.25	35.5	40.25	38	37	23	17.25	2387.5
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

Then we calculate the final cost of transportation in a zero suffix method with its previously mentioned procedures as follows:

MIN(Z) = 247878.75

Applying the ATM method to the transport schedule after balancing the schedule, so the assigned schedule will be as in Table (3-6)

Province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery	15	62.5	30	18.75	40	48	32.5	47	4550
Najaf refinery warehouse	35.75	55.75	19.25	16.25	32.5	18.25	22.5	38.75	2413.75
Diwanyiah warehouse	42.5	53.25	29	32.75	24.5	22.5	20	38.25	1487.5
Samawa refinery warehouses	50	44.25	35.5	40.25	38	37	23	17.25	2387.5
Imaginary row	0	0	0	0	0	0	0	0	2600.25
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

Determining the lowest individual costs from the costs of the transportation schedule, which is (15) from the costs of the schedule, then this cost is subtracted from the individual costs of the schedule, which are found in Table (3-7) as shown below.

province / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery warehouse	7.5	31.25	15	9.375	20	24	16.25	23.5	4550
Najaf refinery warehouse	17.875	27.875	9.625	8.125	16.25	9.125	11.25	19.375	2413.75
Diwanyiah refinery	21.25	26.625	14.5	16.375	12.25	11.25	10	19.125	1487.5
Samawa refinery warehouses	25	22.125	17.75	20.125	19	18.5	11.5	8.625	2387.5
Imaginary row	0	0	0	0	0	0	0	0	2600.25
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

The next step is to obtain the reduced schedule. The lowest individual cost is allocated in the transport matrix within the specified demand and supply limits, and then we start allocating the lowest cost of the schedule in succession until all the quantities required for this product are exhausted, as shown in Table No. (3-8).

Governorate / warehouse	Baghdad	Basra	Karbala	Babylon	Al-Kut	Al-Najaf	Al-Diwaniya	Al-Samawa	Offer
Al Dora refinery warehouse	7.5 35	31.25	15 161.	9.375 863.	20	24	16.25	23.5	4550
Najaf refinery warehouse	17.875	27.875	9.625 218	8.125	16.25	9.125 22	11.25	19.375	2413.75
Diwanyiah refinery	21.25	26.625 325	14.5	16.375	12.25 76	40	10	19.125	1487.5
Samawa refinery warehouses	25	22.125 112	17.75	20.125	19	18.5	11.5 738	8.625 52	2387.5
Imaginary row	0	0 2600.25	0	0	0	0	0	0	600.25
Demand	3525	4049	2350	863.75	762.5	625	738.75	525	

After measuring the total cost of transporting the product from the main warehouses to the provinces requesting the black oil product, it was as follow:

MIN(Z) = 240908.4375

3.5. Apply linear programming method

(Win Q.S.B) program is one of the ready-made applications for computer systems, the importance comes from that it collects operations research applications and administrative applications to solve mathematical models with accuracy and efficiency, in this research we used the program to find the optimal solution to the problem to compare and 15nalyse the results. The final results by applying the methods above on the fuzzy transportation problem with the linear programming method of the (WINQSP) program. The methods above are the results of the solution as follows:

	Method	Result solution
1.	Zero point method	247878.75
2.	Zero suffix method	247878.75
3.	ATM method	240908.4375
4.	Linear programming method (optimal solution)	237008.4000

3. The researcher reached to

1. Unlike the linear programming approach, which provides a "optimal" solution to handle fuzzy transport issues, the ATM method was first, and it is a contemporary method that is mathematically simple to apply and provides a solution that is close to

optimization.
2. The researchers' dependence on current techniques in the future to resolve fuzzy transportation issues since they provide accurate solutions quickly.

4. Recommendations
1. In order to make the ideal answer for fuzzy transport difficulties simpler, we advise exploring the application of the ATM approach.
2. Focusing on oil goods and expanding their warehouse storage, as this is a key economic resource for the nation and has a significant influence on the expansion of its economy.
3. It is advisable to apply contemporary tools and software to address any transportation issues that hamper the operations of commercial, industrial, and financial institutions.
4. Creating a database for each productive facility, as this will have a significant impact on how much future research will rely on it.

References

1. Shaker MM, Fakhri ZH, Globe KZ. Using the robust ranking method to solve the issue of allocation with triple fuzzy numbers in the industrial sector in Baghdad. Journal of the City of Science College. 2014;6(2):1-12.
2. Bateeq AH. Using the robust method to solve fuzzy transport problems to make the best decision to reduce transportation costs in the health sector using quantitative methods. Journal of the City College of Science University. 2014;6(2):13-28.
3. Ahmed MM, Khan AR, Ahmed F. New approach to solve transportation problems. Open Journal of Optimization. 2016;5:22-30.
4. Srinivas B, Ganesan G. Optimal solution for degeneracy fuzzy transportation problem using zero termination and robust ranking methods. International Journal of Science and Research. 2013;2(7):929-33.
5. Ebrahimnejad A. On solving transportation problems with triangular fuzzy numbers: review with some extensions. In: Iranian Conference on Fuzzy Systems (IFSC). IEEE; c2013.
6. Fegade MR, Jadhav VA, Muley AA. Solving fuzzy transportation problem using zero suffix and robust ranking methodology. JOSR Journal of Engineering. 2012;2(3):36-39.
7. Darunee H, Poom K. A method for solving a fuzzy transportation problem via robust ranking technique and ATM. Cogent Mathematics. 2017;4:1283730.
8. Monalisha. Applying robust ranking method in two-phase fuzzy optimization linear programming problems (FOLPP). LogForum Scientific Journal of Logistics. 2014;10(4):399-408.
9. Ngastiti P, Bayu S. Zero point and suffix methods with robust ranking for solving fully fuzzy transportation problems. Journal of Physics. 2018;1022(1):012005. doi: 10.1088/1742-6596/1022/1/012005.
10. Pramila K, Uthra G. Optimal solution of intuitionistic fuzzy transportation problem. Annals of Pure and Applied Mathematics. 2014;8(2):67-73.
11. Nagaraja R, Solairaju A. Computing improved fuzzy optimal Hungarian assignment problems with fuzzy costs under robust ranking techniques. International Journal of Computer Applications. 2010;6(4):0975-8887.
12. Krishna PS, Vimala S. ATM for solving fuzzy transportation problem using method of magnitude. IAETSD Journal for Advanced Research in Applied Sciences. 2018;5(3):406-12. doi: 2394-8442.
13. Shambhu S, Rama S, Ravi. Modified zero suffix method for finding an optimal solution for transportation problems. European Journal of Scientific Research. 2013;104(4):673-676.
14. Thiagarajan K, Saravanan H, Natarajan P. Finding an optimal solution for transportation problem using zero neighbouring method. Ultra Scientist. 2013;2(A):281-284.
15. Adukia KL, Agrawal B. Optimal solution of assignment problem with the help of least value algorithm. International Journal of Research and Analytical Reviews. 2022;9(4):335-41. Available from: http://ijrar.org/viewfull.php?&p_id=IJRAR22D2981. DOI: http://doi.one/10.1729/Journal.32536.
16. Adukia KL, Agrawal B. Optimal solution of fuzzy linear programming problems for trapezoidal number by using method of matrix inversion. International Journal of Engineering Development and Research (IJEDR). 2022;10(4):80-4. Available from: http://doi.one/10.1729/Journal.32593. https://www.ijedr.org/archive.php?vol=10&issue=4#IJEDR2204012.
17. Agrawal B, Kumar S, Sharma G. Optimum solution of a transportation problem with an Excel solver. International Journal of Research and Analytical Reviews. 2022;9(3):892-901. Available from: http://ijrar.org/viewfull.php?&p_id=IJRAR22C1598. DOI: http://doi.one/10.1729/Journal.33184. https://www.researchgate.net/publication/362344463_OPTIMUM_SOLUTION_OF_A_TRANSPORTATION_PROBLEM_WITH_AN_EXCEL_SOLVER.
18. Agrawal B, Kumar P. An approach of L.P.P method-game problem using simplex method. International Journal of Research and Analytical Reviews. 2022;9(4):927-35. Available from: http://ijrar.org/viewfull.php?&p_id=IJRAR22D2939. DOI: http://doi.one/10.1729/Journal.33185.
19. Agrawal B, Singh P. Linear programming in operation research for optimum best solution in real-world problems using Excel solver. International Journal of Research and Analytical Reviews. 2022;9(4):34-40. Available from: http://ijrar.org/viewfull.php?&p_id=IJRAR22D1602. DOI: http://doi.one/10.1729/Journal.33183.
20. Shrivastava B, Agrawal B, Kumar S. Fuzzy linear programming problem with α-cut and robust ranking methods. International Journal of Statistics and Applied Mathematics. 2022;7(2):57-62. doi: 10.22271/maths.2022.v7.i2a.797.
21. Tewari P, Agrawal B. A study of linear programming technique. International Journal of Statistics and Applied Mathematics. 2022;7(2):54-56. doi: 10.22271/maths.2022.v7.i2a.796.
22. Agrawal B, Bhat SM. Optimal mix of two or more products to maximize the contribution of linear programming problem. IOSR Journal of Mathematics (IOSR-JM). 2023;19(2):53-61. Available from: https://www.iosrjournals.org/iosr-jm/pages/v19(2)Series-1.html. DOI: http://doi.one/10.1729/Journal.33183.