Using Fuzzy Inference to Evaluation Suppliers in Diyala General Electric Industries Company

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Abstract

The research aims to evaluate the suppliers at Diyala general electric industries company conducted in an environment of uncertainty and fuzzy where there is no particular system followed by the company, and also aims to use the problem of travelling salesman problem in the process of transporting raw materials from suppliers to the company in a fuzzy environment. Therefore, a system based on mathematical methods and quantity was developed to evaluate the suppliers. Fuzzy inference system (FIS) and fuzzy set theory were used to solve this problem through (Matlab) and the problem of the travelling salesman in two stages was also solved by the first stage of eliminating the fuzzing of the environment using the rank function method, while the second stage used the method of the nearest neighbor to solve the travelling salesman problem (TSP) by drawing a path that facilitates the process of transporting raw materials in the least time where the programming (Winqsb) was used. The most important thing that was reached is the mechanism of evaluating the suppliers by giving a percentage to each supplier and also their ranking where the supplier (Japanese company) got the first place and it was (87.3) ... etc. The raw materials process was used in the least time and obtained at the lowest time of the transfer, which is 292 minutes.
Paper type: Research paper.

Key words: Supplier Evaluation, Fuzzy set theory, Fuzzy inference system(FIS), Traveling salesman problem(TSP), Triangular ranking function.

1-Introduction:

The process of evaluating and selecting suppliers is one of the critical challenges facing procurement management in the supply chain and because of the increase in the number of evaluation criteria, the process of evaluating suppliers is more complex and the other reason is the fuzzy environment that the country is experiencing, especially the economic and security situation. Therefore, there is a need to design a model for evaluating suppliers that will enable them to deal with large amounts of standards. Communicate with purchasing managers as decision makers in the process of evaluating suppliers whose evaluation is in linguistic terms rather than expressing answers in numerical form and to overcome the fuzzing and inaccuracy in their assessments. The application of fuzzy logic is an appropriate tool in the process of evaluating suppliers.

The traveling salesman problem (TSP) is one of the methods used that has attracted the attention of researchers over the past two centuries in the field of process research through the actual need of many productive sectors and companies that process or distribute their products. But sometimes we face problems in practice and the data are often inaccurate or uncertain, in which case uncertainty is an important factor in the decision-making of the problem in question, and often the human being is exposed to complex problems that require him to make the appropriate decision based on hypotheses and determinants that may be vague in nature. This has a significant impact on the process of making the right decision to solve any problem, and that is why we are studying fuzzy sets that have been addressed. This challenge is the most modern view in terms of application in various fields of application, theory and in various areas of life. The process of transferring raw materials from suppliers to the company is carried out through the use of the method of the TSP in the construction of a mathematical model that describes the problem as the method of the TSP in a fuzzy environment, which aims to address the problem.

Many researchers have addressed the process of evaluating suppliers in the fuzzy environment, including proposed (Ashtarinezhad, Sarfaraz and Navabakhsh,2018) suggested the evaluation of the suppliers in order to improve the total performance of supply chain and increase the power of competitiveness, satisfaction and profitability of the company that are considered important and significant issues at the organizations. The main objective of this research is to help oil and gas industry in order to evaluate and categorize the suppliers, using Fuzzy Inference System. The present research is empirical in terms of purpose and descriptive-survey in terms of data collection. Three outstanding managers of procurement department of the company under examination have been selected. With regard to the fact that the number of identified sub-indices to categorize the suppliers are too many in relevant literature, the fuzzy dematel method was used to determine the weight and importance of each of the sub-indices suppliers. In the present paper, to evaluate and categorize the suppliers using Fuzzy Inference System, with MATLAB Software.

(Agatz,Bouman and Schmidt, 2018) suggested fast and cost-effective delivery of goods delivered online is a logistical challenge, as many companies are looking for new ways to cross the last mile of their customers, and one of the most recently interesting technology-supported opportunities is the use of drones to support deliveries as the truck collaborates with a drone to make deliveries, leading to a new problem with the problem of a (TSP) vendor we call TSP with a drone, pilot. In this research, they programmed this problem as a valid number program and developed many rapid experimental methods based on approximate inference status ratios and tested their performance by comparing solutions to optimal solutions for small cases, in addition to the inference was applied to many artificial cases of different characteristics and sizes.

(Chaitanya, Thomas and Xavier,2019) suggested a new learning-based approach for approximately solving the travelling salesman problem on 2D euclidean graphs. We use deep Graph Convolutional Networks to build efficient TSP graph representations and output tours in a non-autoregressive manner via highly parallelized beam search. Our approach outperforms all recently proposed autoregressive deep learning techniques in terms of solution quality, inference speed and sample efficiency for problem instances of fixed graph sizes. In particular, we reduce the average optimality gap from 0:52% to 0:01% for 50 nodes, and from 2:26% to 1:39% for 100 nodes. Finally, despite improving upon other learning-based approaches for TSP, our approach falls short of standard Operations Research solvers.

(Herlina, Machfud, Anggraeni and Sukardi,2019) Shrimp agroindustry deals with processing raw shrimp into various frozen shrimp products. The production of frozen shrimp products are continuously produced based on consumer demand with uncertain pattern. To sustain this production, it is fundamental to enable supply of raw material to satisfy customer demand. Therefore, working integrated with suppliers to satisfy customer demand is a fundamental goal for shrimp agroindustry. A selection of suppliers in agroindustry is determined by three criteria, which are quality of raw materials, number of raw material arrival, and payment scheme. These criteria are used as a measurement to evaluate supplier performances by decision makers. To minimize uncertainty and subjectivity of decision makers when choosing suppliers, a fuzzy inference system method is proposed. The outcomes of the fuzzy inference system method are a set of rule base that is used to assess suppliers in shrimp agroindustry.

2- Methods and procedure:

2-1Fuzzy inference system(FIS):

After Zadeh's theory in 1965, scientist Ibrahim Mamdani presented the theory of the fuzzy set theory (1975), the most common and complex type, one of the first control systems built by fuzzy set theory. Mamdani's theory is based on converting certain inputs into outputs using fuzzy logic based on blurry rules (If-Then rules). The system refers to the calculations used to evaluate blurry language descriptions using concepts such as membership functions, fuzzy Logic operators and if-then rules. Since rule-based logic is based on the representation of qualitative knowledge, there is a need to identify

it and the logic of blur allows us to relation the quantitative approach to qualitative representation (Bai,2006).

The fuzzy inference system for a field consists of the following sections (Bai,2006) as follows: -

1-Fuzzifier: - The inputs of this stage are real values that fall within a certain range of (0-1) because the(FIs) suffers from a lack of understanding of linguistic variables; it deals with only the numbers that fall between (0-1), so the inputs must be converted into numbers understood by the system using the functions of belonging and the outputs of this stage are called fuzzy input, which is the degree of affiliation of the input values that fall between (1-0).

2-Fuzzy Rules: - The main part of the fuzzy inference system model is the rules and if- then fuzzy rules are used based on the knowledge of experts in each field.

3-Interface engine: - Is the process of entering fuzzy (i.e. degrees of belonging obtained from the previous stage) and the output is fuzzy by taking into account the fuzzy rule and evaluating the part of the results based on the type of system used, which is a field system.

4-Defuzzifier: - The input of this phase is the output of the previous phase, which is the fuzzy output, which is the result of the compilation of rule decisions into a single resolution, i.e. the fuzzy output is transformed into real value outputs.

2-2 Membership Function

Fuzzy groups are sole in their specific relationship, classifying the element within the group as continuous or discontinuous, and relationship functions can be formulated using graphs of different shapes (Sivanandam ,2007).

And of types of relationship function (Ekel,2020).

Triangular Membership Function: This function has three parameters (a1, a2, a3) and is represented by the following equation (1) :-

$$\mu_A = \begin{cases} \frac{x-a_1}{a_2-a_1} & a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2} & a_2 \leq x \leq a_3 \\ 0 & otherwise \end{cases} \quad (1)$$

2-3 Methods to Defuzzifier:

1-Center of Gravity (COG) or Center of Area (COA)

Finds this method in the engineering center of the final decision COA in the V_i group of the external variable COA, i.e. the balance center of the z relationship function as a fuzzy value of the external variable COA as in equation (2) (kahraman, yavz,2010).

$$COA = \frac{\sum_{i=1}^{n} \mu_z(v_i) v_i}{\sum_{i=1}^{n} \mu_z(v_i)} \quad (2)$$

$$i = 1, 2, \dots, n$$

The outputs relationship to valuable functions represented.: $\mu_z(v_i)$

2- Ranking Function for triangular fuzzy numbers

The set of symbols used in the mathematical models expressed will first be defined as: a,b,c = numbers in a specific fuzzy group, we assume that A=(a.b.c) represents a triangular hazy number, the grade function for this fuzzy number is as in equation (3) (puri,2009):

$$\mathcal{R}(\tilde{A}) = \frac{1}{4} \ (a + 2 \ b + c) \qquad \qquad (3)$$

2-4 Concept supplier:

The supplier is defined as an organization that supplies goods and services for the rest of(Dahwa,2010); suppliers are keen to develop their own products and services to be selected by purchasing organizations but when suppliers do not know what is expected of buyers, it is difficult for them to know what they need, because it is not easy to develop their organizations, products, abilities and skills in the required way, and this can create obstacles among processors who have the experience and knowledge to meet the needs and those who do not have them (Holm&Vo,2015).

Choosing an effective supplier is the decision-making process and not only reduces the cost of materials but also increases the competitiveness of organizations, and the benefits of evaluating and selecting suppliers are: increased profitability, increased quality, increased overall performance and increased cooperative competitiveness (Nursal et al., 2016).

2-5 Evaluating suppliers process:

Organizations have tended to pay great attention to all types of supplying chains, which have prompted them to reconsider the role of their purchasing activities, as the process of selecting suppliers is a major influence on the purchasing results of organizations (Halldórsson, 2013). The first step in selecting suppliers is the process of evaluating suppliers, which is critical for the organization, affecting all processes of the supplying chain, and the process of selecting and evaluating suppliers is the process of finding suppliers to provide the buyer with goods and quality services. The right price, in the required quantity and on time (Khaled al et, 2011). The process of selecting suppliers is also part of the management of suppliers and includes all activities necessary to select a specific supplier of basic materials, goods or services in the long or short term and on the basis of the capacity and offers of the suppler in order to generate competitive advantages (Moser,2007), as well as the decision-making process for selecting multiple suppliers (Thiruchelvam & Tookey,2011). Traditional supplier's evaluation models, which need to be differentiated in choosing the best supplier, are based on financial metrics with less focus on other tangible and intangible criteria (Pateriya & Verma, 2013).

2-6 Steps to evaluate suppliers using the fog inference system:

The first step (determining the criteria for evaluating suppliers)
The standards of evaluation of suppliers over the years are affected by their impact on changes in the company from changes in the environment, political or security situation, economic and social situation (Singh& Sagar,2012). Each organization has different criteria than the other, depending on the requirements of each organization and its area (Ho et al.,2008), and the choice of criteria for each organization depends on the assessment of suppliers on the type of goods and services (Imeri,2013). The focus was on some of the criteria

that suit the company's research sample and the most prominent criteria identified by purchasing managers at Diyala General Electric Industries Company are (Imeri,2013):

1-Price 2-Quality 3-Delivery 4-Service 5- Similar Works 6-Country Origin 7- Use of Environmentally Friendly Materials 8-Ecosystem Management

       The second step (determining the fuzzy membership functions of the model) And to understand the model designed above answers taking into account some basic concepts:

1-Functions of the fuzzy membership of the model: the function of membership is determined according to the performance of the supplier with regard to the criteria based on the opinion of decision makers (purchasing managers) (Amindoust and Saghafina, 2014).

2-Membership functions to assess the performance of the suppliers: Five fuzzy variables representing the functions of membership in the first stage are applied to both the inputs and outputs of the fuzzy inference systems, namely (poor performance WP, low performance LMP, average MP performance, good GP performance, very good performance VGP) as in figure (1) through Matlab programming (Amindoust and Saghafina.2014).
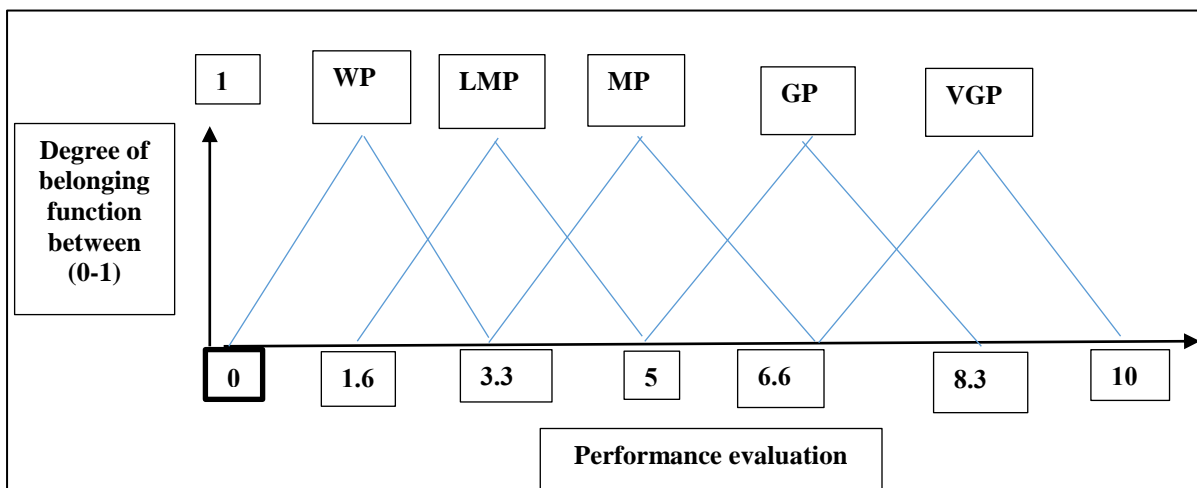

Figure (1) shows the form of membership functions for the performance of the suppliers in the first and second stage

       Then, in the second stage, five fuzzy variables are applied, representing the functions of membership to inputs, which are the same as the outputs of the first stage (Amindoust and Saghafina.2014).

       In the third stage, five fuzzy variables, representing the functions of membership are applied, namely, the outputs of the second stage to show seven fuzzy variables representing the functions of membership, namely the outputs of the third stage in the fuzzy inference system. Fuzzy output groups are in the form of language variables (very poor performance VWP, poor WP performance, low LMP average performance, average MP performance, high HMP average performance, good GP performance, very good VGP performance) as in Figure (2) through Matlab programming, (Amindoust and Saghafina.2014).
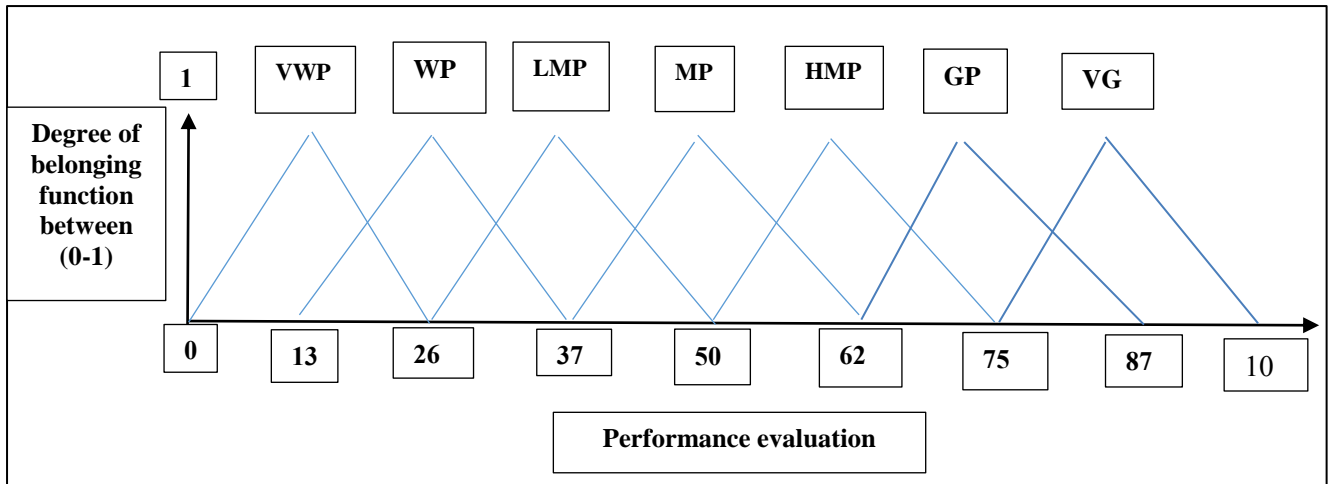
Figure (2) shows the form of membership functions for the performance of the suppliers in the third stage

The third step (determining matrices to assess the performance of fuzzy suppliers)

Is to use a set of fuzzy rules based on expert knowledge to implement the fuzzy classification method. The rules are amended based on the preference of decision makers for the appropriate classification of processors, and the rules are also designed on the basis of the average concept of each fuzzy inference system (Amindoust and Saghafina, 2014). We clarify the rules of the first, second and third stages in tables (1) and(2).

Table (1) Performance matrix equipped in the first and second stage

	The first stage				
	Performance	WP	LMP	MP	GP	VGP
The second stage	WP	WP	WP	LMP	LMP	MP
	LMP	WP	LMP	LMP	MP	MP
	MP	LMP	LMP	MP	MP	GP
	GP	LMP	MP	MP	GP	GP
	VGP	MP	MP	GP	GP	VGP

Source (Amindoust.et.: 2014,Supplire Evaluation Using fuzzy inference system)

Table (2) Performance matrix equipped in the third stage

	The second stage				
	Performance	WP	LMP	MP	GP	VGP
The Third stage	WP	VWP	WP	LMP	LMP	MP
	LMP	WP	LMP	LMP	MP	MP[j]
	MP	LMP	LMP	MP	HMP	GP
	GP	LMP	MP	HMP	GP	GP
	VGP	MP	HMP	GP	GP	VGP

Source (Amindoust.et.: 2014,Supplire Evaluation Using fuzzy inference system)

The Fourth Step (determining the data entry matrix for each supplier)
Consists of a number of sub-steps as follows:
1-Decision makers evaluate the performance of suppliers according to existing criteria, and to show decision makers' assessments to assess the performance of suppliers, language variables are used and converted into triangular fuzzy numbers, after which equation (4) (Amindoust and Saghafina,2014).
is used as follows:-
J= Represents criteria where (j=1.2,...,n)
s=Represents suppliers as (S=1.2,...,s)
K= Represents decision makers or decision makers (purchasing managers) as (K=1.2,...,n).
2- To compile the opinions of decision makers for each set of sustainability groups (economic and environmental); they can be found from the equation (5) average aggregated fuzzy numbers , and from the special equations to find each fuzzy number (a,b,c) to a limit in terms of finding the fog number The first (a) of equation (6), finding the second fuzzy number (b) of equation (7) and finding the third hazy number (c) of equation (8) (Amindoust and Saghafina,2014).

$$Rp = (a, b, c) \qquad (5)$$
$$a = 1/q \sum_{p=1}^{q} ap \qquad (6)$$
$$b = 1/q \sum_{p=1}^{q} bp \qquad (7)$$
$$c = 1/q \sum_{p=1}^{q} cp \qquad (8)$$

as follows:
P: The row in the matrix represents Rp
q: The number of rows represents
a: The first fuzzy number
b: Is the second fuzzy number
c:Is the third fuzzy number
3 - After finding the fuzzy numbers for each row of the matrix of equation (1) where we get the misty assembly matrix as in the equation (9) where the fuzzy numbers of each decision maker and each criterion are (ř11,ř12,…,ř1k). The average blurry numbers of decision makers per criterion are calculated as in 11Ř̄ in the equation (10) and the equation (11) represents entry variables for each standard (x1, x2, ...xn) as follows(Amindoust and Saghafina ,2014):

$$Sps = \begin{bmatrix} r11 & \cdots & r1k \\ \vdots & \ddots & \vdots \\ rn1 & \cdots & rnk \end{bmatrix} \qquad (9)$$

$$R11 = (r11 + r12 + \cdots + r1k)/k \qquad (10)$$

$$Rs = \begin{bmatrix} R11 \\ R12 \\ \cdot \\ \cdot \\ \cdot \\ Rn1 \end{bmatrix} \qquad (11)$$

2-7 The travelling salesman problem (TSP):

The method of the TSP is one of the methods used and that has attracted the attention of researchers over the past two centuries in the field of process research through the actual need of many productive sectors and companies that process or distribute their products; it is preferable to be processing or distribution of roads that have achieved better, less or more appropriate (cost, time, distance,... Etc.). From the 18th century to the present, researchers have increased interest in finding the perfect path through (n) cities so that the salesman visits each city only once before returning to the city from which he set off by determining the optimal path at the lowest time, cost, distance or everyone together(Jati, 2013).

2-8 Methods of solving of the TSP:

There are many methods to solve TSP varies in different entrances to solutions, efficiency of procedures, as well as results, but the solution method used in the current research is: - (Filip and Otakar, 2011,Bektas, 2006, Taha,2017)

Intuition and guesswork method: - is one of the ways to solve the TSP, which works to identify and find the lowest path among several paths in the number n of cities, and each city is visited only once, and then back to the city starting from it; this method has two branches (Filip and Otakar, 2011,Bektas, 2006, Taha,2017):

1- The reverse round method

2 - The Nearest Neighbor Method: A TSP method where it starts with the seller visiting a random city and then begins to visit the nearest city continuously until it completes the visit of all cities, and the nearest neighbor method is easy to implement and implemented quickly, but may sometimes pass shorter routes that can be easily observed and work as follows(Gutin et al,2002):

Create all points as un visited points and select a random point, and then set them as the current point, then point the point as a visited point, and select the shortest route from the adjacent points from another point visited by the shorter route. After finishing if the seller visits all the points this means the solution is over, and if the final stages are low points, the tour is comparable in length with the first rounds, it can be said that the trip is feasible and reasonable (Gutin et al,2002).

2-9 Mathematical model of the fuzzy TSP:

The fuzzy TSP can be formulated as follows: (puri, 2009)

$$Min \ \check{Z} =_{\Re} \sum_{i=1}^{m} \sum_{j=1}^{n} \check{c}_{ij} x_{ij}$$

$$s.t.$$

$$\sum_{i=1}^{m} x_{ij} \ = 1 \qquad\qquad i = 1, 2, \dots, n \qquad i \neq j$$

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad\qquad j = 1, 2, \dots, n \qquad i \neq j$$

$$x_{ij} = 0 \text{ or } 1$$

The fuzzy traveler's salesman matrix can be represented on seven cities as in table 3 (puri, 2009).

Table (3) matrix of the fuzzy TSP

	x_0	x_1	x_2	x_3	x_4	x_5	x_6
x_0	0	$\tilde{c}_{01}x_{01}$	$\tilde{c}_{02}x_{02}$	$\tilde{c}_{03}x_{03}$	$\tilde{c}_{04}x_{04}$	$\tilde{c}_{05}x_{05}$	$\tilde{c}_{06}x_{06}$
x_1	$\tilde{c}_{10}x_{10}$	0	$\tilde{c}_{12}x_{12}$	$\tilde{c}_{13}x_{13}$	$\tilde{c}_{14}x_{14}$	$\tilde{c}_{15}x_{15}$	$\tilde{c}_{16}x_{16}$
x_2	$\tilde{c}_{20}x_{20}$	$\tilde{c}_{21}x_{21}$	0	$\tilde{c}_{23}x_{23}$	$\tilde{c}_{24}x_{24}$	$\tilde{c}_{25}x_{25}$	$\tilde{c}_{26}x_{26}$
x_3	$\tilde{c}_{30}x_{30}$	$\tilde{c}_{31}x_{31}$	$\tilde{c}_{32}x_{32}$	0	$\tilde{c}_{34}x_{34}$	$\tilde{c}_{35}x_{35}$	$\tilde{c}_{36}x_{36}$
x_4	$\tilde{c}_{40}x_{40}$	$\tilde{c}_{41}x_{41}$	$\tilde{c}_{42}x_{42}$	$\tilde{c}_{43}x_{43}$	0	$\tilde{c}_{45}x_{45}$	$\tilde{c}_{46}x_{46}$
x_5	$\tilde{c}_{50}x_{40}$	$\tilde{c}_{51}x_{41}$	$\tilde{c}_{52}x_{42}$	$\tilde{c}_{53}x_{53}$	$\tilde{c}_{54}x_{54}$	0	$\tilde{c}_{56}x_{56}$
x_6	$\tilde{c}_{60}x_{60}$	$\tilde{c}_{61}x_{61}$	$\tilde{c}_{62}x_{62}$	$\tilde{c}_{63}x_{63}$	$\tilde{c}_{64}x_{64}$	$\tilde{c}_{65}x_{65}$	0

3. A real practical example

Diyala general company's electrical distribution converter production plant (400Kv/11) evaluates the suppliers in a random manner and without scientific methods studied according to an environmental controlled by fuzzy and uncertainties that affect the company in general. The decision-making process of hiring the supplier is one of the difficult and complex decisions, as the performance of the supplier is a critical factor in the success or failure of any organization and its impact on all activities of the organization, specifically with regard to the production costs and quality of the product and thus affects the volume of demand and the reputation of the organization. The modern orientation of international organizations is the adoption of a single supplier selected according to several criteria, where many criteria have been introduced in the trade-off between suppliers, which has made the evaluation process more complex and needs to be carefully narrated, examined, analysed and evaluated for each supplier and adopted high quality standards for evaluation and preference and building long-term relationships with the best supplier. The working methods used by the company in the process of transporting raw materials suffer many problems, including delays in the process of transporting raw materials due to the congestion and difficulties they face during the transportation process on the roads taken by the truck's driver, and also the fuzzy environment of the entire Iraqi environment makes the transportation process fuzzy in nature and the process of transporting materials to the company affects the production process and thus causes delays in the delivery of orders to customers. The goal of the study is to use fuzzy inference systems in the process of evaluating the company's suppliers in the fuzzy environment where the evaluation criteria based on existing conditions and situations were combined from a sustainable point of view to two groups (economic and environmental) for each evaluation decision in the proposed method as well as the method of the nearest neighbour to solve the problem of the travelling salesman to identify and find the best path from the suppliers to the factory in a fuzzy environment. The data was collected from the procurement department, which consists of three sections: -

1 - Local Procurement Management Department.
2- Department of Foreign Procurement Management.
3- Management of the warehouse department

That is, it consists of three managers, namely decision makers (i.e. opinion makers) who are responsible for the purchases at the factory. The data collection was carried out through interviews by the researcher with experts and procurement staff. The process of transporting raw materials from the suppliers to the factory is carried out to begin the production process of the electrical distribution converter (400Kv/11) and to complete the supplying of orders on them, which are subject to controls and laws, i.e. there are contracts and agreements between the suppliers and the company on the basis of which the goods are transported for delivery to the company. A group of suppliers were taken in Baghdad to check the transfer on the terms of the fuzzy traveling salesman to improve the transport mechanism. The data was obtained from Diyala Public Company and the areas of presence of the suppliers were identified, and we faced the problem of time where time cannot be precisely determined due to traffic conditions and therefore these times can be described as fuzzy numbers, so that the decision maker can find the shortest route (the least time) to transport raw materials from the supplier to the company, and the prevailing working time data for transportation work by transport companies was collected i.e. from 6 a.m. until 2:00 p.m.

3-1 Application of the Fuzzy Inference System (FIS) to evaluate the suppliers in the fuzzy environment:

to simplify the modus operable, we take one of the suppliers, for example, the supplier Aaqriquf, a local supplier, and after applying the steps of the fuzzy inference system to evaluate the suppliers, we got table (4) for the suppliers (Aaqriquf). The following stages will be applied based on Matlab to obtain the evaluation of the suppliers.

Table (4) The Linguistic variables to measure the opinions of decision makers and average decision-makers for the supplier (Aaqriquf) for each standard average decision-maker

Aaqriquf	Decision maker (1)	Decision maker (2)	Decision-maker (3)	Average decision
Cost	Very high	Medium	Very high	High
Quality	Very good	Very good	Very good	Very good
Service	Not satisfied with land	Not satisfied with land	Not satisfied to some extent	Not satisfied to some extent
Delivery	Medium	Medium	Medium	Medium
Similar orks	Very strong	Very strong	Very strong	Very strong
Country of origin	Very good	Very good	Very good	Very good
Use of environmentally friendly materials	Harmless	Harmless	Harmless	Harmless
Management ecosystem	Very good	Very good	Very good	Very good

The first Stage

 1- We enter Linguistic variables in the form of fuzzy numbers that the program understands for each criterion as well as for outputs as well as in figure (3) where this figure shows the five functions levels to evaluate each supplier according to the cost standard, which we coded by code (C) and is limited between (3-9).
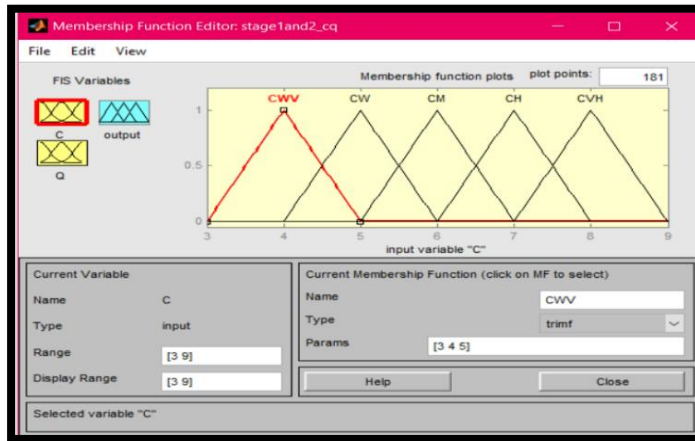

Figure (3) shows the membership functions of the cost standard

Figure 4 shows the five levels of membership functions to evaluate each supplier according to the quality standard, which we coded with the code (Q) and is limited to (0-10).
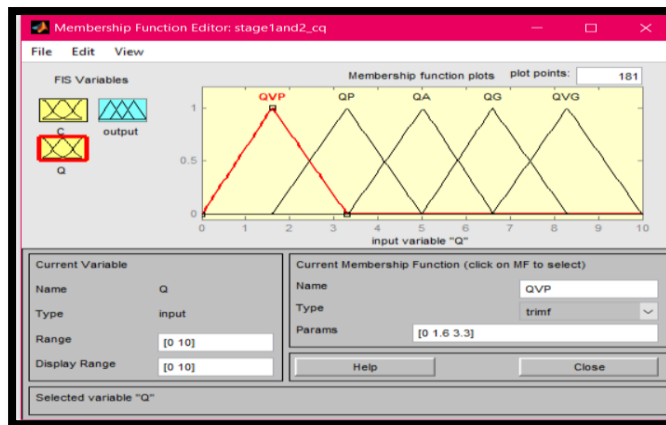
Figure (4) shows the shape of the functions of Membership to the quality standard

Figure 5 also shows the five levels of membership functions to assess the performance of each supplier and represents the outputs of the first economic group and is limited to (0-10).
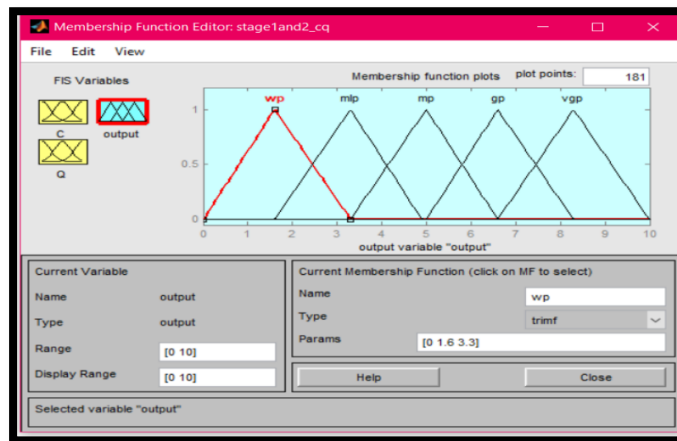
Figure (5) shows the functions of Membership to female directors

2-We make the if-then fuzzy rules for the first stage of the quality and cost criteria, which we have 25 bases, and figure (6) shows the rules (IF-THEN) which is (25) the fuzzy rule.
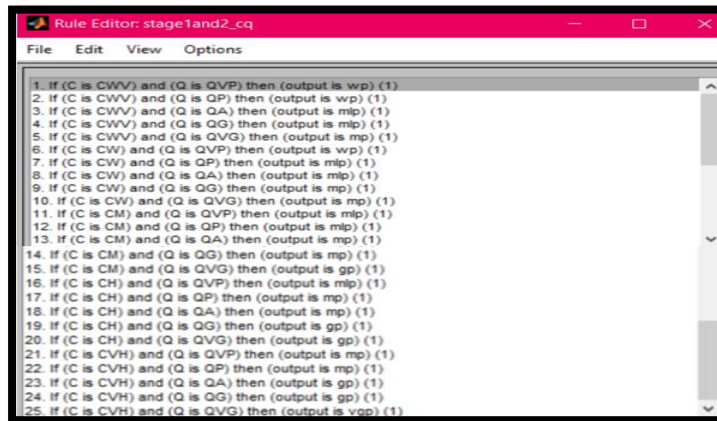

Figure (6) shows the fuzzy rules IF-THEN and is (25) a base for cost and quality standards.

3-Then we got the results of the first stage of the cost, quality and output criteria as described in the form (7), and that the results that appeared for the cost and quality criteria are (4.97), which means that the output of the first stage of the two criteria is average performance
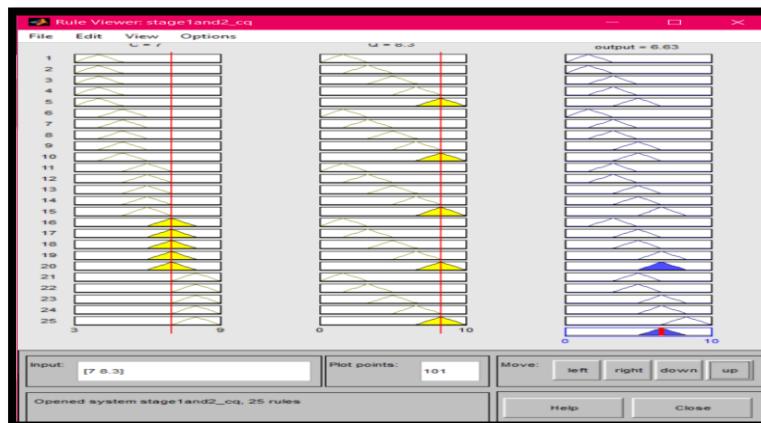

Figure (7) Results of the first stage of the cost and quality criteria

4-We repeat the previous steps in accordance with the service and delivery criteria and show the outputs representing the Second Economic Community where the results for the service and delivery criteria were (4.97), i.e. average performance. We repeat the same steps to the criteria for similar works and origin and show the outputs representing the third economic group where the results were for the two similar business standards and the origin is (8.3) i.e. very high performance. We repeat the same steps to the criteria for the use of environmentally friendly materials and ecosystem management and the outputs representing the environmental group show that the results of the environmentally friendly materials and ecosystem management standards were (4.97), i.e. average performance

The second stage

1-We start with the second stage and each of the four groups that were produced in the first stage will be grouped together to represent the inputs of the second stage. That is, the criteria (cost and quality) will be grouped and C.Q is the first economic group with (service and delivery) and (S.D) represents the second economic group to show one group (n1) and compile standards (similar business and origin) and represents the SW.CO) economic group third with (use of environmentally friendly materials and ecosystem management) and represents (U.M) the environmental group to appear as one group (n2).

2-We then introduce language variables in the form of fuzzy numbers understood by the program for the group (C.Q) as well as for outputs as well as in figure (8) where this figure shows the five levels of functions to evaluate each supplier by group (C.Q) and confined between (0-10)
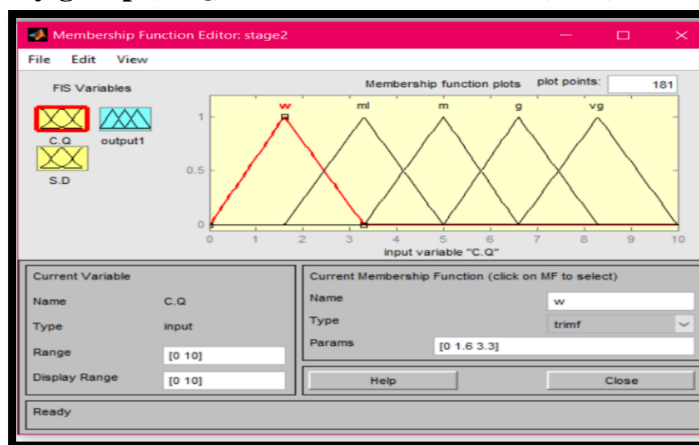
Figure(8) The functions of membership to a group standard (C.Q)
Figure 9 shows the five levels of membership functions for evaluating each supplier by group (S.D) and confined between (0-10).
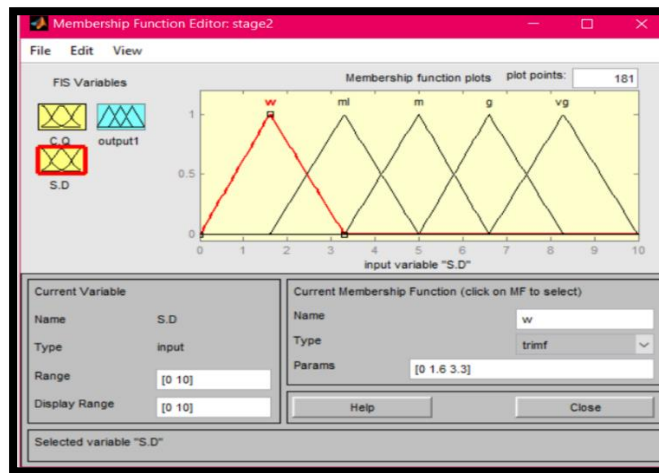
Figure (9) showing the form of group membership functions (S.D)
Also, figure (10) shows the five levels of membership functions to assess the performance of each supplier and represents the outputs of the group (n1) and is limited between (0-10)
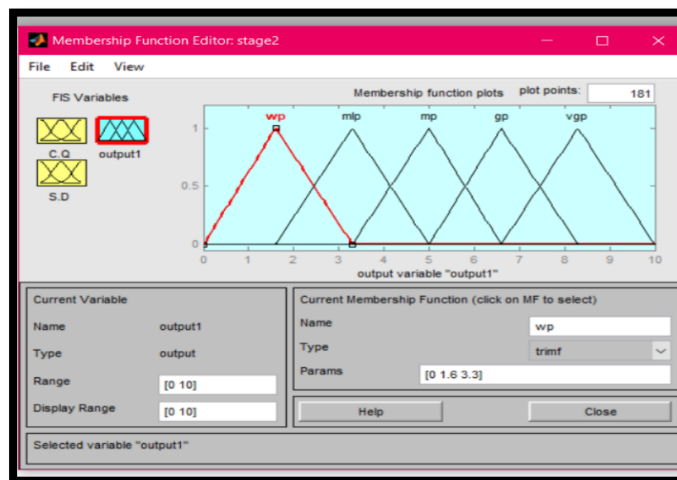

Figure (10) shows the functions of membership to the group outputs (n1)

3-Now we make the if-then fuzzy rules for the second stage of the group (C.Q) and group (S.D) in which we have 25 bases, and then we got the results of the first stage of the group (C.Q), the group (S.D) and the group outputs (n1) as described in the figure (11), and the results that emerged for the group (C.Q) and the group (S.D) are (5.01). This means that the output of the first group (n1) is an average performance.
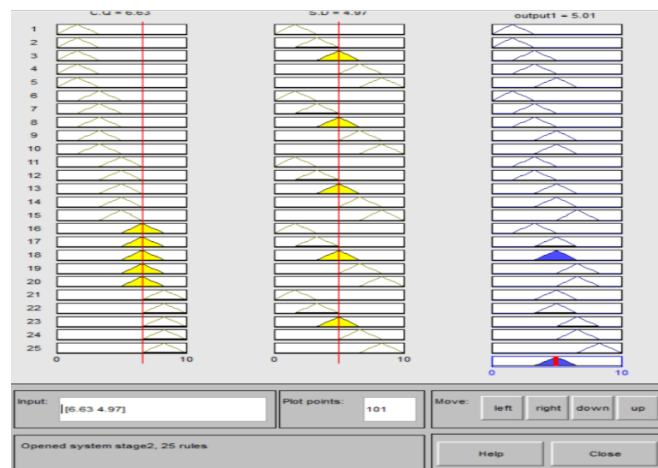
Figure (11) show group second stage Results (C.Q) and Group (S.D)
4-We do the same steps that we did in the second stage of the group groups (C.Q) an group (S.D) we also return to the group, groups (SW.CO) and the group (U.M) to show the second group (n2) whose results were (6.59) which means that the performance of this group (n2) in the second stage is good.

The third stage

 1- The outputs of the second stage, which consist of two groups group (n1) (economic) and the second group (n2) (economic and environmental) are grouped and introduced in the third stage where we enter the functions of membership for each group resulting from the outputs of the second stage and consist of five functions as in figure (12), (13) and (14) that illustrate the five end functions of the group (n1) and represent the inputs of the third stage limited to me (0-10).
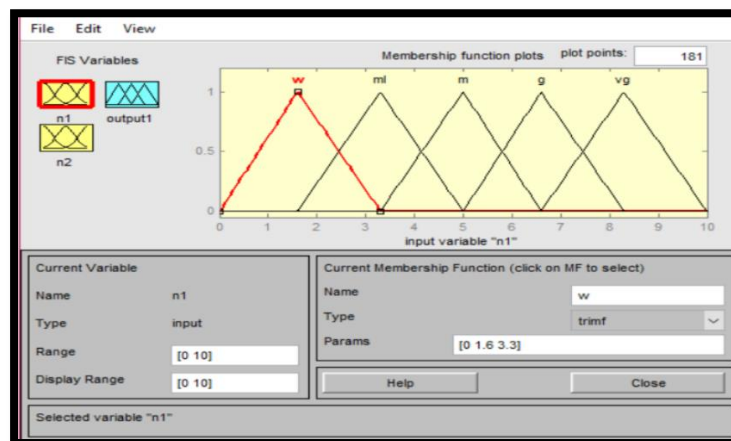

Figure (12) show the functions of membership of the group (n1)

Figure (13) shows the five functions of membership to the group (n2) and represents the inputs of the third stage and the limited (0-10)
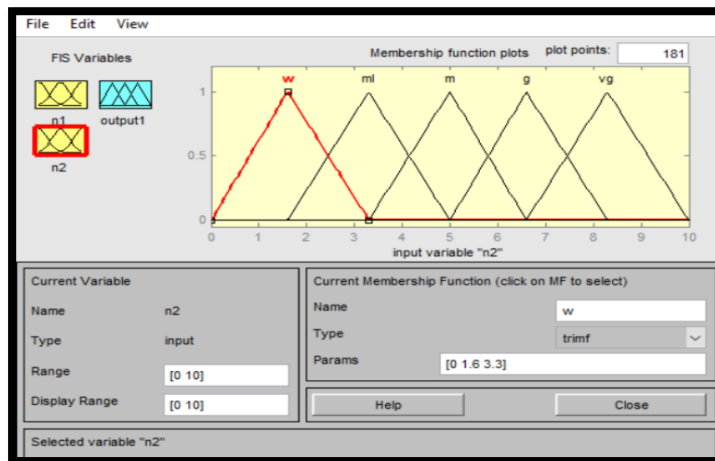
figure (13) shows the functions of membership of the group (n2)

Figure (14) shows the seven membership functions of the third stage outputs, which are limited between (0-100).
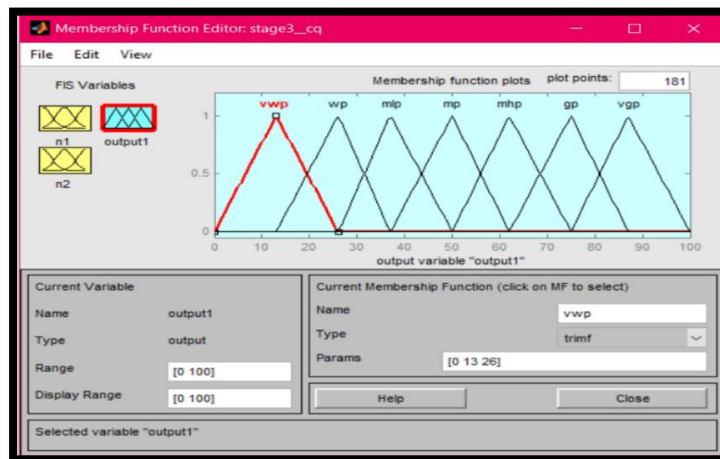
Figure (14) show the special membership functions of the outputs of the third stage

2- We make the if-then fuzzy rules for the second stage of the group, groups (n1) and group (n2) which we have 25 rules and after the application of the rules we get the results of the third stage of the group (n1) and the group (n2) and the outputs represent the evaluation of the order of the supplier Aaqriquf and as described as (15), and the results that emerged (62.3) mean that the performance of the supplier (Aaqriquf) is a high average performance.

Figure 15 shows the results of the third stage

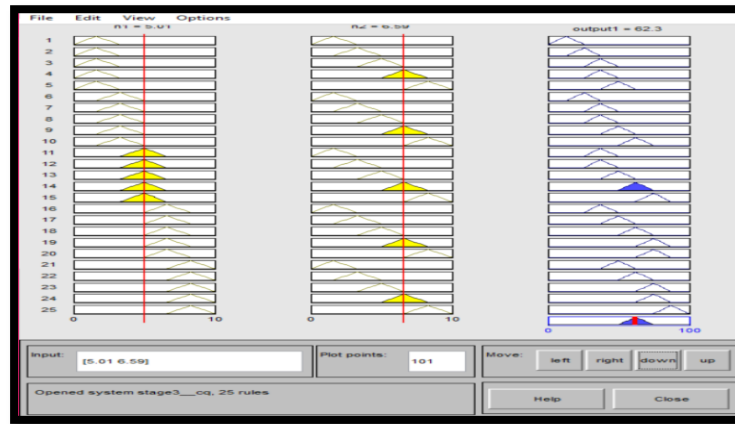## 3-2 Application of the approach of the nearest neighbor to the method of TSP in the fuzzy environment:

the decision variables of the matrix of the traveling salesman has been clarified basic variables as in table (5) according to a specific matrix

Table (5) shows the resolution variables on which the matrix will be built

	x_0	x_1	x_2	x_3	x_4	x_5	x_6
x_0	0	$\tilde{c}_{01}x_{01}$	$\tilde{c}_{02}x_{02}$	$\tilde{c}_{03}x_{03}$	$\tilde{c}_{04}x_{04}$	$\tilde{c}_{05}x_{05}$	$\tilde{c}_{06}x_{06}$
x_1	$\tilde{c}_{10}x_{10}$	0	$\tilde{c}_{12}x_{12}$	$\tilde{c}_{13}x_{13}$	$\tilde{c}_{14}x_{14}$	$\tilde{c}_{15}x_{15}$	$\tilde{c}_{16}x_{16}$
x_2	$\tilde{c}_{20}x_{20}$	$\tilde{c}_{21}x_{21}$	0	$\tilde{c}_{23}x_{23}$	$\tilde{c}_{24}x_{24}$	$\tilde{c}_{25}x_{25}$	$\tilde{c}_{26}x_{26}$
x_3	$\tilde{c}_{30}x_{30}$	$\tilde{c}_{31}x_{31}$	$\tilde{c}_{32}x_{32}$	0	$\tilde{c}_{34}x_{34}$	$\tilde{c}_{35}x_{35}$	$\tilde{c}_{36}x_{36}$
x_4	$\tilde{c}_{40}x_{40}$	$\tilde{c}_{41}x_{41}$	$\tilde{c}_{42}x_{42}$	$\tilde{c}_{43}x_{43}$	0	$\tilde{c}_{45}x_{45}$	$\tilde{c}_{46}x_{46}$
x_5	$\tilde{c}_{50}x_{40}$	$\tilde{c}_{51}x_{41}$	$\tilde{c}_{52}x_{42}$	$\tilde{c}_{53}x_{53}$	$\tilde{c}_{54}x_{54}$	0	$\tilde{c}_{56}x_{56}$
x_6	$\tilde{c}_{60}x_{60}$	$\tilde{c}_{61}x_{61}$	$\tilde{c}_{62}x_{62}$	$\tilde{c}_{63}x_{63}$	$\tilde{c}_{64}x_{64}$	$\tilde{c}_{65}x_{65}$	0

where each of:

X0: factory site (Diyala General Electric Industries Company) Hadid in Diyala

X1: the site of the first supplier (Wadi Al Rahma) 62nd Street in Baghdad.

X2: The site of the second supplier (Aird najm alearab Company) Karadat Dakhil in Baghdad.

X3: The site of the third supplier (Al-Nassif Company) Hayu Alwahda in Baghdad

X4: The site of the fourth supplier (Mushtal aleiraq Company) Karadat Dakhil in Baghdad.

X5: The site of the fifth supplier (Maktab alaindimaj alshaamil) Earasat Alhindih in Baghdad.

X6: Location of the sixth supplier (Aaqriquf office) Sank in Baghdad.

The resolution variables are defined as: - Xij: refers to the decision variable from the site (i) to the source (j) for example: -

(x_{01}): - refers to the decision variable from the company to the site of the supplier (Wadi Al Rahma) and so on for all variables from the company to the supplier or vice versa from the supplier to the company.

C_{IJ}:: Refers to the fuzzy time, which is a measured and calculated amount per minute that separates the knot (i) from the knot (j)

3-3 Building the matrix of the fuzzy TSP:

The matrix is fuzzy numbers processing i.e. three fuzzy numbers that have been processed and defuzziness using the triangular ranking function according to the equation (10) as well as depending on the time of exit of the truck three times, which is (morning, noon, evening) i.e. time is limited between A=(a,b,c) each represents the time of exit in the sense of:

A= If the truck exits between (7am to 9am)
b= if the truck goes out between the period (9am to 11pm)
c= if the truck exits between the period (11pm to 2pm)

And that the data on the time taken to transport raw materials were taken per minute for the transfer from the suppliers to the company as well as the time it took to go from one area to another as in table (6) obtained through interviews as well as to see the reality of the workflow and record the data.

Table (6) shows the triple-minute fog time between the plant (Diyala General Electric Industries Company) and the suppliers' areas of presence

Location	Company	Wadi Al Rahma	Aird najm alearab	Al-Nassif	Mushtal aleiraq	Maktab alaindimaj alshaamil	Aaqriquf
Company	(0,0,0)	(90,115,120)	(60,75,98)	(100,130,140)	(80,95,110)	(80,95,102)	(50,70,90)
Wadi Al Rahma	(60,80,100)	(0,0,0)	(30,50,62)	(95,105,120)	(55,65,75)	(40,50,64)	(60,75,82)
Aird najm alearab	(90,110,120)	(60,85,94)	(0,0,0)	(35,45,55)	(18,20,30)	(9,12,15)	(70,80,102)
Al-Nassif	(115,120,129)	(20,25,34)	(67,75,95)	(0,0,0)	(10,15,20)	(25,35,41)	(35,45,71)
Mushtal aleiraq	(100,120,136)	(18,20,26)	(20,30,36)	(22,27,32)	(0,0,0)	(15,25,35)	(50,60,70)
Maktab alaindimaj alshaamil	(90,120,130)	(15,18,25)	(12,14,16)	(40,50,60)	(12,16,20)	(0,0,0)	(19,24,33)
Aaqriquf	(110,115,120)	(30,40,46)	(55,66,81)	(7,10,17)	(29,37,45)	(25,35,61)	(0,0,0)

For example, we will take the first fuzzy time from the company to the supplier Wadi Al Rahma, where the fuzzy time for it is (90,115,120) minutes; now, we apply the equation of the triangular ranking function (3) as follows

$$X_{01} = \frac{(90 + 2 * 115 + 120)}{4} = 110 \ (دقيقة)$$

Where the top of the triangular ranking function (110) minutes appeared, which is the time it takes for the salesman to leave the company to the office of Wadi Al Rahma, and we remove the fuzzy data of other supplier and that the data of the matrix after the removal of the fuzziness is shown in table(7).

Table (7) shows the time after processing the minute-long fuzzy between the company and the suppliers' areas of presence

Location	X_0	X_1	X_2	X_3	X_4	X_5	X_6
X_0	0	110	77	125	95	93	70
X_1	80	0	48	106	65	51	73
X_2	91	81	0	45	22	12	83
X_3	121	26	78	0	15	34	49
X_4	119	21	29	27	0	25	60
X_5	115	19	14	50	16	0	25
X_6	115	39	67	11	37	39	0

4- Discussion of Results

This section will discuss the two stages: evaluating the suppliers and equipping the company with the raw materials.

Stage 1: We repeat the three stages of each supplier according to the data of each supplier and according to the fuzzy inference system and use the method of de-fuzziness (COA) as in equation (2) where we prepare table (8), which represents the final results of all the suppliers who are (16) equipped and explains the final results we have obtained for each supplier as well as the order of each supplier from the best to the least performing. Table (8) shows the evaluation of the performance of each supplier as well as the order of each supplier for the rest of the supplier according to the specified criteria where the supplier (Japanese company) received the first place and the percentage of its performance towards the company according to all standards is (87.3) followed by the supplier (Aird Najm Alearab) in second place and in third place equipped (German MR company), ... etc.

Table 8 shows the performance evaluation of each suppliers and the performance arrangement of each supplier

Suppliers	Suppliers performance ratio	Suppliers Arrangement
Aird Najm Alearab	75.5	2
Maktab Alaindimaj aAshaamil	61.8	7
Coz Hao Chinese	50.2	9
Mushtal Aleiraq	63.1	5
Aaqriquf	62.3	6
Wadi Al Rahma	38.1	14
German MR	74.7	3
L.A.E Italian	73.9	4
System Ticked	49.1	12
Turkish Kyler	50.5	8
Al-Nassif	49.0	13
Sharikat Zad Alkhalij	37.7	16
Saudi Factory	37.8	15
Japanese	87.3	1
Flash Steel	49.5	11
Italian Sudsby	50.0	10

Stage 2: After the de-fuzziness as in table (7) the optimal solution to the problem of the travelling salesman (TSP) was found in a closer to-neighbor way through winqsb as shown in table (9).

Table (9) shows the value of the time reduction function and the contribution values of each decision variable to the function after applying the nearest ongoing method of solving the TSP in Winqsb

The type of function	Z	the contribution values of decision variables
reduces the time	292 minutes	$X_{06} \rightarrow X_{63} \rightarrow X_{34} \rightarrow X_{41} \rightarrow X_{12} \rightarrow -X_{25} \rightarrow X_{50}$ $70 - 11 - 15 - 21 - 48 - 12 - 115$

The value (Z=292) minutes or the equivalent (four hours and 52 minutes) represents the optimal path, which is the lowest time for the TSP from the company to the supplier Aaqriquf, then the supplier company Al-Nasif and then the supplier company Mushtal Aleiraq was equipped with the office of Wadi Al Rahma, then equipped with the company Aird Najm Alearab and then Maktab Alaindimaj Alshaamil and then return to the company as described in table (9) and on this basis the path will be as follows:-

$$0 \rightarrow 6 \rightarrow 3 \rightarrow 4 \rightarrow 1 \rightarrow 2 \rightarrow 5 \rightarrow 0$$

5- Conclusion:

Fuzzy logic and fuzzy numbers helped to explain the fuzzy Iraqi production environment, which in nature lacks certainty and solutions that are accepted in a short time. Fuzzy logic and the permanence of membership helped evaluate the suppliers according to the standards of each supplier as well as the order of each supplier from the best to the least performed where the supplier (Japanese company) got the first place and the percentage of its performance towards the company according to all standards is (87.3) followed by the supplier (Land Company Star Of Arabs) in second place and in third place supplier (German MR),... etc. Also, the fuzzy traveling salesman's method helped and using the nearest neighbor's method to get as little time as possible to transport raw materials from the suppliers to the company, representing the minimum that the driver reaches the company after passing all the suppliers as (292) minutes.

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استخدام الاستدلال الضبابي لتقييم المجهزين في شركة ديالى العامة للصناعات الكهربائية

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مستخلص البحث:

يهدف البحث لتقييم المجهزين في شركة ديالى العامة للصناعات الكهربائية تجري في بيئة يسودها الغموض والضبابية (Fuzzy) حيث لا يوجد نظام معين تتبعه الشركة وأيضا يهدف الى استخدام مشكلة رجل البيع المسافر (Travelling Salesman problem) في عملية نقل المواد الأولية من المجهزين الى الشركة في بيئة ضبابية لذلك تم وضع نظام يستند الى أساليب رياضية وكمية لتقييم المجهزين، حيث تم استخدام نظام الاستدلال الضبابي ((Fuzzy inference system(FIS)) ونظرية الاعداد الضبابية (Fuzzy set theory) في حل هذه المشكلة من خلال برنامج (Matlab) وأيضا تم حل مشكلة رجل البيع المسافر بمرحلتين بالمرحلة الأولى التخلص من ضبابية البيئة باستخدام أسلوب دالة الرتب (Ranking function) ، اما المرحلة الثانية فتم استخدام طريقة أقرب جار لحل مشكلة رجل البيع المسافر وذلك من خلال رسم مسار يُسَهِل عملية نقل المواد الأولية بأقل وقت حيث تم استعمال برنامج (WinQsb). اهم ما تم التوصل الية ن ناحية تقييم المجهزين باعطاء نسبة لكل مجهز وأيضا ترتيبهم حيث حصل المجهز (الشركة اليابانية) على المرتبة الأولى وكانت نسبته (87.3) و...الخ. اما عملية المواد الأولية بأقل وقت حيث تم استعمال برنامج تم الحصول على اقل وقت لعملية النقل وهو (292) دقيقة .

المصطلحات الرئيسة للبحث: تقييم المجهزين، نظرية المجموعة الضبابية، نظام الاستدلال الضبابي، مشكلة رجل البيع المسافر، دالة الرتب المثلثية

*البحث مستل من رسالة ماجستير