JEAS, Vol. 31 No. 146 (2025) pp (197-216)
P-ISSN 2518-5764 - E-ISSN 2227-703X
DOI: https://doi.org/10.33095/9p0kjy98

Journal of Economics and Administrative Sciences

Literature Review of Fuzzy Set Theory: Applications and Methodologies

Mohammed Jasim Mohammed
Department of Statistics, College of Administration and Economics
University of Baghdad, Baghdad, Iraq.

Received:17/2/2025 **Accepted:26/3/2025** **Published: 1 /4/ 2025**

© 2025 The authors(s). This is an open-access article under the CC BY license (https:/creativecommons.org/licenses/by/4.0/).

Abstract:
This paper represents a comprehensive literature survey of the research published in the Journal of Economics and Administrative Sciences (JEAS) on applications and methodologies of fuzzy set theory. The review traced how fuzzy logic has been evolving in decision-making, optimization, and modeling uncertainties in published articles such as economics, management, and engineering. The categorization of fuzzy methodologies into various domains such as fuzzy linear programming, fuzzy regression, fuzzy control systems, and fuzzy multi-criteria decision-making relies heavily on the study of existing research. An analysis revealed an increasing trend of investigations highlighting the interplay of fuzzy logic with artificial intelligence, statistical modeling, and heuristic optimization methods. The developments in methodologies of fuzzy decision-making frameworks are again examined from the perspective of applicability in real-life problem situations involving imprecise and uncertain data. Findings that fuzzy logic, therefore, contributed considerably to the enhancement of problem-solving in economics and administrative sciences through more flexible and adaptive models. Therefore, this literature review will be an excellent guide for researchers in fuzzy set theory applications to grasp existing gaps and suggest future directions for improving fuzzy methodologies across industries.
Keywords: Fuzzy Sets; Fuzzy linear programming; Fuzzy linear regression; Fuzzy Analytic Hierarchy Process.

1. Introduction:

The fuzzy set theory was brought forth by Zadeh in 1965(Zadeh, 1965). Since then, it has taken a significant form in mathematics to deal with uncertainty and imprecision in several branches. The Classical set theory depends on binary logic, unlike fuzzy sets, which allow partial membership within the interval [0,1]. This flexibility makes fuzzy sets particularly useful in complex decision-making environments, especially when perfectly precise information is unavailable. Fuzzy logic has changed with the passing decades and found applications in artificial intelligence, optimization, control systems playback and data analysis nonparametric estimation as well as. This adaptability has enabled researchers to develop new methods of fuzzy linear programming(Zimmermann, 1978), fuzzy regression(Tanaka† et al., 1973), fuzzy decision-making models(Bellman & Zadeh, 1970), and developing solutions for real-world problems where ambiguity is a major factor. It has gained such vast applications in fuzzy set theory that grew into hybrid development approaches to couple it with statistical methods, machine learning, and heuristic optimization.

Fuzzy set theory gains additional significance when applied across various industries such as engineering, healthcare, supply chain, and economics. By fuzzy logic (Zadeh, 1965), control systems enable machines to automate systems handling imprecise inputs, which yields increasing efficiency in the overall operations of the industry. Fuzzy decision-making models help medical professionals in disease diagnosis due to non-specific symptoms, thus minimizing chances of misclassification. Moreover, fuzzy optimization techniques have been applied in supply chains for handling uncertainties in demand forecasting, inventory control, and transportation planning. Indeed, fuzzy set theory is a significant interdisciplinary application that sharply defines theory and practice, thus leading to proper decisions in uncertain situations.

Current fuzzy methodologies mainly focus on improving computational efficiency, robustness, and adaptability. New membership functions, defuzzification techniques, and hybrid models integrating fuzzy logic with artificial intelligence and deep learning have been the areas of research for scientists. Such progress recently increased the accuracy and scalability of solutions to complex problems in areas like data science, finance, and logistics. The growing number of publications within fuzzy set theory thus witnesses the continued and increased relevance of this domain in both research and industry. Therefore, this review of papers published in the Journal of economics and administrative sciences intends to provide an exhaustive of the most applications and methodology of fuzzy set theory with respect to its contributions, challenges, and future magnitudes concerning problems arising from uncertainty.

2. Publication Over Year:

A Survey of the number of papers published in the Journal of Economics and Administrative Sciences has shown a fluctuating trend over the years. It began in 2009 with one publication; however, a notable increase was seen in 2013 and 2014, which had two papers each. The year 2016 brought a significant increase with four papers published. This was followed by peaks in 2017 and 2018, which had five and six papers respectively. Thus, these figures indicate a progression in interest and research output in this field during these years. However, the number of publications reduced slightly in 2019 and 2020 with two and only one paper respectively. Both years 2021 and 2022 witnessed modest recovery with 2 and 3 publications respectively. The most striking increase happened in 2024, which showed 8 publications, suggesting fresh and increased research interest in fuzzy set theory. This proves the dynamic essence of research publication trends with levels of activity shifting from one time to another. Figer (1) shows the number of papers published over the year.

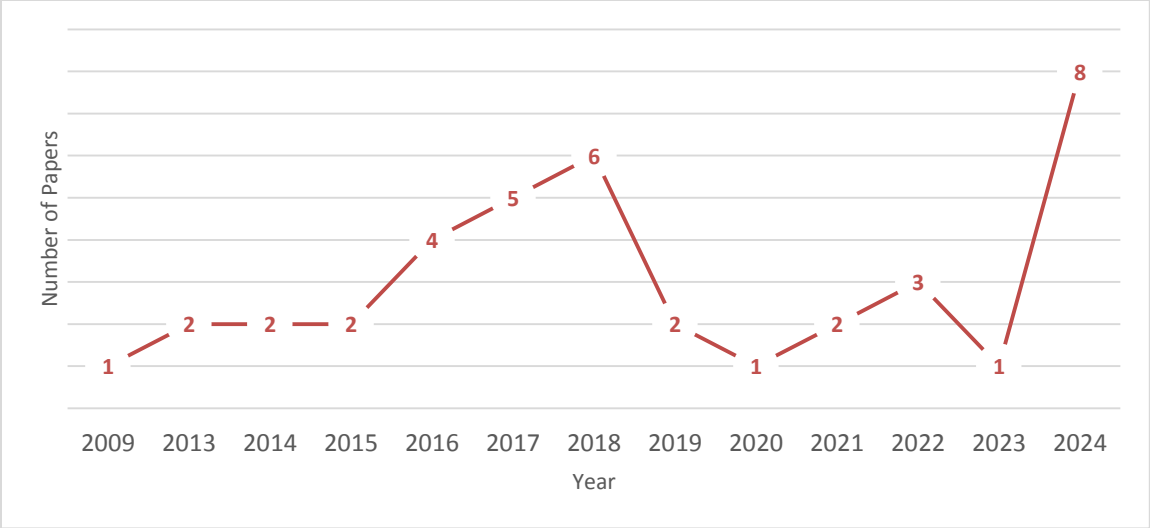

Figure (1): Number of papers published over the year
Source: Prepared by the researcher

3. Publication By topics:

Fuzzy set theory is the field in which the analysis of several papers published in the Journal of Economics and Administrative Sciences reports a diverse range of research topics. The most researched topic is 'Fuzzy linear regression', with 6 papers, indicating active work in this area. Next is 'Fuzzy linear programming' with 5 papers, representing its importance concerning optimization problems. Both 'fuzzy logic' and 'Fuzzy Analytic Hierarchy Process' count for 4 papers, suggesting their importance in decision-making processes. Other topics include 'Fuzzy reliability', 'Fuzzy Estimation', 'Fuzzy control charts', 'Fuzzy goal programming', and the 'Fuzzy assignment problem'. These topics each have 2 papers published, indicating moderate activity regarding research. Other topics include 'Fuzzy clustering', 'Fuzzy neural networks', 'Fuzzy classification', 'Fuzzy time series', 'Fuzzy game theory', and 'Fuzzy Dynamic Programming', with one paper each, suggesting the emergence of an area or one of niche interest. Therefore, the coverage of different topics within the Journal of Economics and Administrative Sciences showcases a fair diversity within fuzzy set theory: Focus has landed on certain aspects. Figer (1) shows the papers published by topics.

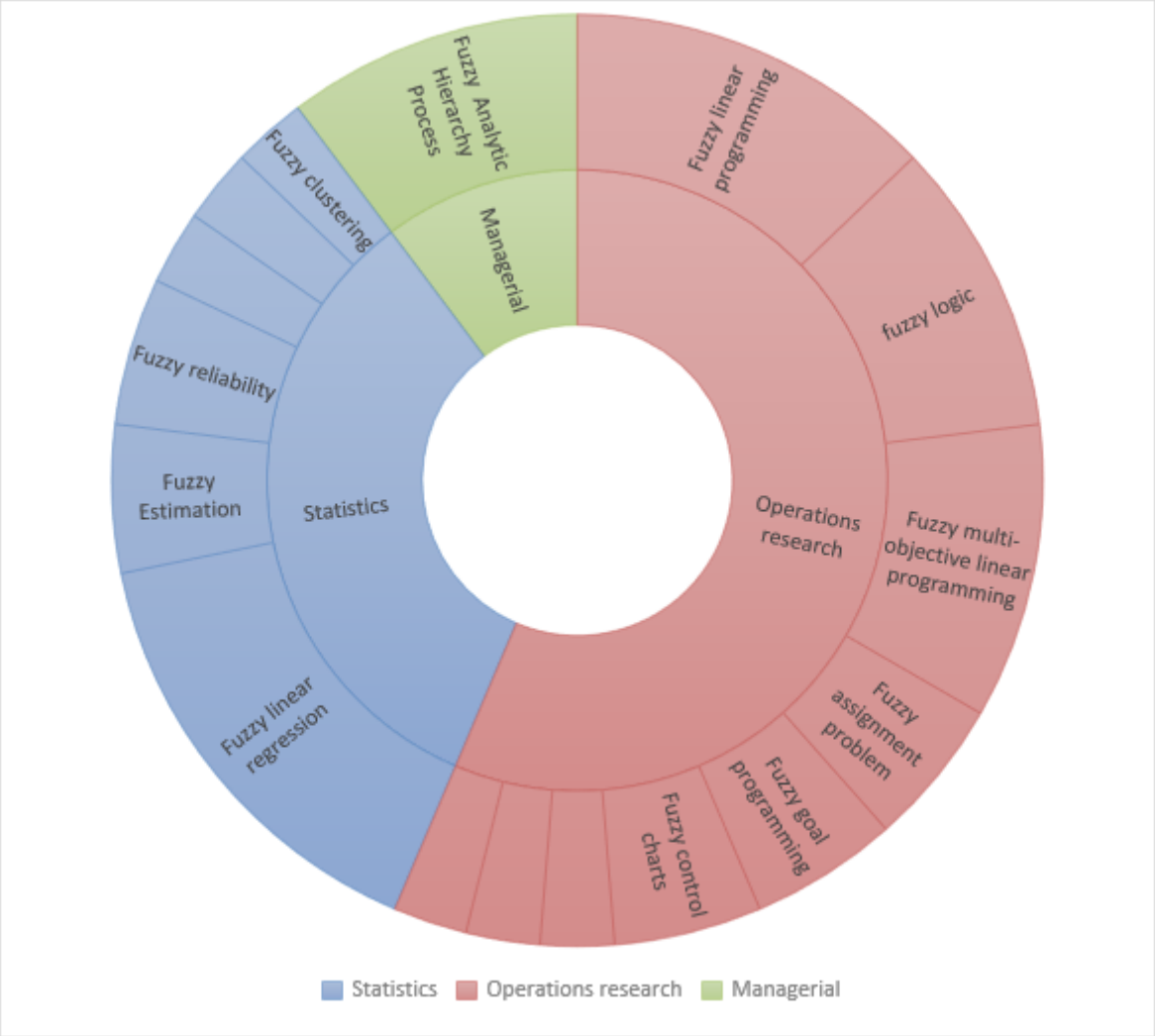

Figure (2): Publication by topics

Source: Prepared by the researcher

4. Publication By Sciences:

An inspection of published papers in the Journal of Economics and Administrative Sciences reveals distinct trends in different Sciences. Among them, research operations have been the most productive subject, with 22 papers written, indicating the emphasis on optimization, decision analysis, and analytical methods. In other words, this represents a great commitment from these researchers to develop methodologies in this area. Statistics ranked next, with 13 papers being published, showing its importance in the analysis and interpretation of the research findings and application of statistical methods. The managerial case is on 4 papers, indicating a relatively lower but still significant interest in research on management practices. Taken as a whole, the paper distribution indicates the journal's emphasis on quantitative and analytical modalities, whereas concentration remains on research operations and statistics with a passage to the managerial side.

4.1 Operations research Papers

(Ashour, 2009) Use Fuzzy linear programming (FLP) as a decision-making approach for environments where uncertainties prevail. The typical linear programming models suffer while they are applied to the uncertainties attached to the data and vagueness in the very practical sense. Fuzzy logic can be the immediate solution for such applications. This paper presents a method for solving FLPs by considering fuzzy numbers in constraints and objective functions. It employs various fuzzy set techniques such as triangular fuzzy numbers, trapezoidal fuzzy numbers, etc., for identifying uncertain parameters. This research utilizes fuzzy ranking methods with the application of which fuzzy constraints are converted into an equivalent deterministic representation in a highly structured as well as practical manner for optimization. It has been shown that fuzzy linear programming can create room for increased flexibility and adaptability in decision-making and offer great prospects for allocating resources in uncertain realizations. Application of defuzzification methods like that of a centroid to the determined model will help guarantee a closer approximation of its optimal solution with real-world descriptions than classical methods. The last results have been presented in order to represent the importance of embedding fuzzy logic optimization models for realizing better efficiency in intricate systems of the industry as well as economics. This kind of research will take fuzzy optimization methodologies even one step ahead, while it will also provide a practical approach for the industry in decision-making under uncertainty or non-precise data.

(W. S., Khalaf & Mohammed, 2013) Using fuzzy linear programming to treat the fuzzy maximal flow problem of vehicles in the Diwaniyah province, the study investigates a local road network with the highest congestion during peak hours. The traffic in this network is described as flows of trapezoidal fuzzy numbers during morning hours. This study aims to provide an optimal fuzzy solution for the maximal flow of vehicles through mathematical and quantitative measures. A fuzzy linear programming model was constructed, and a ranking function was used to defuzzify the results. The proposed method is good for traffic management as it reduces congestion by optimizing vehicle flow. The study is relevant and offers a wide range of insight into urban planning and transportation infrastructure decision-making purposes.

(Z. M. Mohammed, 2013) Investigate the capabilities of Process Control Charts (PC-Charts) and Fuzzy Multinomial Control Charts (FM-Charts) for the monitoring of quality production. Classical PC-Charts are employed with statistically predetermined thresholds for the identification of defects but may lack flexibility under changing production conditions. FM-Charts derived through fuzzy logic allow for adaptable control limits that accommodate variation between sample sizes and production environments. In this study, data was collected from a bottled water production plant to make comparisons between the two methods. The results show that FM-Charts are, in fact, quicker and more accurate in the identification of defective units, especially under inconsistent sample sizes. FM-Charts shorten inspection hours and costs and help operational decisions regarding quality control. The study indicates that FM-Charts become more advantageous within dynamically changing production settings where variations in samples impact the accuracy of control. The observations presented support the adoption of fuzzy control working methods in industries that require a high degree of precision in quality monitoring. Future studies may focus on improving fuzzy control models for better detection efficiency and their automation into production systems.

(Redha & Hassan, 2014) Optimized the allocation of medical supplies and pharmaceuticals by using Fuzzy goal programming. The foremost objective is to predict the annual demand for drugs and medical supplies by utilizing the real consumption data from hospitals and health establishments. The research centers on the General Company for Marketing Medicines and Medical Supplies as a case study. A goal programming model was developed with 15 decision variables and 19 constraints and with two objectives: (1) providing the rational allocation of the assigned budget for medicines and supplies, (2) providing medications and medical supplies for patient demands to promote public health.

The methodology utilized the WINQSB software to solve the developed fuzzy goal programming model and established that this approach does give an optimal allocation of resources. The findings indicate that the fuzzy-goal programming approach provides far better precision in determining the optimal quantities of pharmaceuticals and medical supplies, minimizing wastages such as shortages or excess inventory. The study demonstrates the applicability of fuzzy goal programming in medical supply chain management, which constitutes a workable solution to improve Nigeria's health sector budgetary allocations towards adequate provision of healthcare. The findings substantiate the wider applications of fuzzy optimization techniques for resource allocation problems in diverse sectors.

(Battikh, 2014) Concentra on fuzzy multi-objective linear programming toward the resolution of the traveling salesman problem (TSP). TSP is the classical combinatorial optimization problem which is to be solved for the determination of a shortest possible tour for a salesman over several cities wherein every city cannot be visited more than once before returning to the starting point. Since decision making is very complicated and ambiguous, therefore a fuzzy approach is to be used to increase the accuracy and flexibility of the solution. The construction of mathematical models for single-objective optimization is done later into an extension embracing fuzzy logic into a multi-objective framework. The fuzzy method, therefore, accommodates multiple objectives such as reducing costs, minimizing travel distance, and minimizing that of time with imprecise data and decision-making constraints. The research work applies the model proposed to the real-case scenario of a pharmaceutical distribution company, optimizing the delivery route through several cities. The results show that the FMOLP provides an optimum travel path with reduced cost, reduced distances, and reduced travel times. The results are sufficient to prove efficient incorporation of fuzzy logic with TSP, providing a systematic decision-making process capable of handling multiple criteria. This methodology arises out of application in logistics, supply chain management, and transport planning, enhancing resource utilization and efficiency.

(Aseel Sameer Mohamed, 2015) Use fuzzy linear programming model to analyze fuel production at the Dura refinery. The model considers seven fuel products, each of which exerts a great influence on daily consumption. It consists of an objective function describing product selling prices, fuzzy constraints on production, fuzzy constraints on demand, and additional constraints concerning production needs. The program WIN QSB is used for determining the optimal solution. The method relies on fuzzy set theory, using trapezoidal fuzzy numbers and their algebraic operations. In the interest of improving decision-making under uncertainty, the model employs well-defined α-cut techniques and membership functions. Results show that fuzzy constraints allow flexibility and provide a more realistic method of fuel production optimization in terms of demand fluctuation and resource constraints. The model will prove its worth in enhancing the efficiency of advanced production planning approaches especially when confronting uncertain data. The suggesting model enhances operations research by giving a structure to deal with imprecise information, aiding refinery management in resource allocation and overall strategic plans. The results confirm the great importance of fuzzy linear programming for solving several complex industrial problems that cannot be handled by classical approaches.

(Bakhayt & Fayyad, 2015) Use the Fuzzy Multi-Objective Linear Salesman Model for Speed Up and Rationing in the Transport Mechanism Used in the General Company for Grain Processing" discussed the travel salesman problem in the context of minimizing the flour distribution from mills to various locations in Baghdad. The objective of this study is to run the fuzzy multi-objective linear programming (FMOLP) model for minimizing time, cost, and distance for transportation deficiencies, such as delays, high transport costs, and lack of effective planning. Thereafter, it proposes the optimized routing model using two fuzzy optimization methods, namely, FMOLP and Intuitionist Fuzzy Optimization (IFO) data on transport routes were obtained, including travel time, fuel consumption, and cost.

In the simulation results, it was shown that the use of fuzzy optimization models could outperform the existing transport mechanisms in terms of efficient distribution networking with reduced cost and shorter delivery windows. It was concluded from these results that transportation planning employing fuzzy logic can provide better decision-making, reduce uncertainty, and enhance efficiency. This study will contribute to demonstrating the applicability of fuzzy multi-objective optimization in addressing real-world problems in logistics, particularly supply chain and transportation management.

(Khalaf & Abd Ahmed, 2016)Examines the material requirements planning (MRP) of electric motor production in a fuzzy environment within the State Company for Electric Industries in Iraq. The study introduces fuzziness into demand, lead times, and inventory levels to take due consideration of the uncertainties that beset supply chains and production schedules. Therefore, to achieve the optimum for material planning in minimizing production costs and optimizing resource utilization, the study utilizes fuzzy mathematical modeling and ranking functions. The three parameters under consideration are demand forecast, supplier lead times, and inventory levels; these were analyzed according to fuzzy conditions. Optimal solutions using the fuzzy MRP model were derived with MATLAB and some statistical analysis software. Results confirm that the infusion of fuzzy logic into decision-making enhances control over material shortages and excess inventory. This study concludes that fuzzy-based MRP enhances operation efficiency and production reliability in electric motor manufacturing. These results are beneficial to industries with uncertain supply chain and production planning difficulties.

((Saleh, 2016) Presented a new way of working on symmetric fuzzy linear programming problems, involving two ranking functions. The methods proposed intend to provide better decision-making under uncertainty by converting fuzzy problems into crisp linear programming formulations. The research compares the efficiencies of the two ranking functions based on trapezoidal fuzzy numbers on cost optimization. A case study carried out on a general dairy distribution company demonstrates the application of the approach. The results show that the second proposed ranking function performs better and minimizes costs than the first method and conventional methods. The proposed methodology is a computationally efficient solution for applied real-world optimization problems where uncertainty about the data is heavily bound. It throws light on the role of the ranking functions in fuzzy linear programming and how they can be used to better decision-making in uncertain environments. Further, the implementation of the proposed approach using the Q.M. software corroborated its applicability and efficiency. The results indicate that, by incorporating advances in fuzzy optimization, industries that handle imprecise data are on their way toward achieving more accurate and robust solutions.

(Ashour & Jawad, 2017) Applied fuzzy game theory to determine the strategy that would be optimal for mobile phone network providers in Baghdad and Basra. It discusses the competitive behavior of telecom companies against the backdrop of uncertainty in decision-making and behavioral patterns in the market. In analyzing the effects of strategic decisions upon network expansion, pricing, and customer acquisition, the authors modeled the problem as one of fuzzy games. In this method, the players, strategies, and pay-offs of the game are first defined, taking into account the fuzzy logic for the imprecise arena of the market. The study examines different scenarios with a view to maximizing market share and profitability while minimizing competitive and regulatory risks. It therefore emerges that fuzzy game theory is a superior and more flexible framework with which to make decisions, affording telecom providers the chance to respond to changing market conditions. Results emphasize the importance of strategic flexibility in telecommunications and show that fuzzy decision-making tools can yield better business results. The study plays a vital role in the emerging field of fuzzy optimization for competitive industries and provides the insight that states and managers need as they navigate uncertainty in developing a market strategy.

(W. S. Khalaf & Jassim, 2017) Studies the Inventory issues in Iraqi manufacturing companies, especially related to stock level determination. Most firms follow soft personal judgments and simple mathematical methods, which have proved inefficient. The study centers on Baghdad Soft Drinks Company, investigating economic ordering and production quantities of 330ml Pepsi cans and essential components in an uncertain and fluctuating environment. To incorporate demand uncertainty and cost uncertainties, the fuzzy time series method has been used in demand forecasting, combined with fuzzy inference (If-Then Rules) for managing inventory holding costs. A production model without shortages is then utilized in eliminating uncertainties and determining optimal production quantities, while shortages are considered in the purchase model for the optimum ordering of components. MATLAB and Win-QSB software were used for mathematical and statistical analysis. The study results indicate that fuzzy set theory improves inventory management decision-making by accommodating uncertainty and the stock-level parameter. These two approaches would help companies to strengthen their position against the risks associated with fluctuating demand and cost, leading to better resource utilization and minimized waste of funds.

(Bakhayt & Kamel, 2017) Using Fuzzy Goal Programming to enhance the approach of aggregate production planning using fuzzy goal programming. This study focuses on the plastic factory of the General Company for Hydraulic Industries and attempts to optimize production planning by including uncertainties of cost and fluctuation in demand. The researchers propose two important strategies to achieve their goals: inventory management and workforce level changes. This will enable production to be adjusted to meet demand while minimizing other costs associated with storage and manpower. In a real production environment, cost factors are uncertain and imprecise. To accommodate this uncertainty and provide a much more flexible decision-making framework, the authors have used a fuzzy goal programming model. The basic idea behind considering fuzzy logic in optimization is to improve flexibility in reacting to production change and the constraints of resources. The results have shown that this approach does enhance production efficiency through the trade-off of various conflicting objectives, i.e., minimizing cost and attaining production targets within fuzzy demand conditions. It is hence concluded that fuzzy goal programming constitutes a practical and effective tool for tackling uncertainty in production planning and is highly relevant to industries facing demand fluctuation and resource constraints. The proposed model should also be adaptable to other manufacturing sectors to optimize their production processes.

(W. S. Khalaf & Halim, 2018) The paper "Find the Fuzzy Maximum Flow of Imam Kadhim Visitors Using Fuzzy Dynamic Programming" aims to optimize the management of big crowds that visit the Imam Kadhim shrine. Considering the unpredictable and variable visitor flow from one point to another, the study employed fuzzy dynamic programming for a better model and analysis of maximum flow scenarios. The model creates a fuzzy dynamic programming solution to account for uncertainties surrounding visitor numbers, routes, and capacity constraints. Observing time schedules, chosen transportation routes, and environmental conditions influencing visitor flows; it uses fuzzy logic in the model to incorporate ambiguous and imprecise data. Compared with "traditional", deterministic methods, this provides a wider layer of analysis, one that is more flexible and realistic to observe. Simulation results examine the ability of the fuzzy dynamic programming model to optimize crowd distribution and transport organizations effectively. The study identifies major routes and time periods that are more likely to cause congestion, thus necessitating corrective measures to improve flow and limit bottlenecks. The contribution of this research toward operations research and management of transportation is in proposing a novel way to approach large-scale events characterized by variable parameters. This will ultimately enhance safety and timely movement while optimizing resource allocation in this type of high-density environment.

(Al-Douri & Hamdi, 2018) Describes the application of the Mehar method for the adjustment of fuzzy costs in a fuzzy linear programming model, with a case illustration involving Al-Hilal Industrial Company. Many production firms incur losses due to high production costs and variable profits, being affected by rising raw material prices, no taxation on imports, and poorly enforced consumer protection laws. In addition, companies also encounter uncertainties in production volume, sales, and availability of raw materials, which are subjected to seasonality. The study focused on fuzzy linear programming for production optimization of six types of cooler products in 2015. The fuzzy cost parameters are converted into a standard linear programming model based on the Mehar method. Finally, sensitivity analysis is conducted by changing fuzzy costs to determine the optimal production strategy. The results suggest that the process of conducting uniform production in all seasons, storing surplus stock in low-demand periods (first and fourth quarters) and selling it during high-demand periods (second and third quarters), is a cost-advantaged action. This mode of operation helps stabilize production costs and thus maximizes profit through synchronization of production with seasonal demand fluctuations.

(Jawad & Hassan, 2018) Proposes a multi-model fuzzy assignment approach aimed at optimizing Internet line usage in a government institution. It applies integer programming techniques to allocate Internet resources with maximum efficiency in uncertain demand and supply environments. The research used three assignment models: 3AP, 3PAP, and MAP to compare different optimization strategies and evaluate their effectiveness. The real-life case data analyzed demonstrate that embedding fuzzy logic into assignment problems significantly improves the correctness and flexibility of decision-making. Constraints regarding the allocation of bandwidth, cost minimization, and service-level quality improvements are incorporated within the models. The findings of this research indicate that the proposed fuzzy allocation mechanism performs considerably better than traditional ones in handling uncertain data and optimizing resource usage. The results also emphasize the need to effectively distribute Internet resources across several departments with fairness and efficiency using robust optimization techniques. The study concludes with the affirmation that the fuzzy assignment model provides a practical and adaptable avenue for network resource management in dynamic systems.

(Saffawi & warttan, 2018) Compare the P chart under traditional theory and the multinomial fuzzy configuration control chart (FM), which conveys the monitoring effectiveness of process quality between two methodologies. The work is focused toward identifying the shortcomings of the conventional control charts in treating uncertainties and imprecise data, which characterize many situations in industrial applications. On the other hand, the multinomial fuzzy quality control chart applies concepts and vocabularies from fuzzy set theory to make decisions under uncertainty with a varying degree of flexibility and accuracy in assessment of process variations. The two methods are applied to real-time production data, and their performance is evaluated regarding shifts and anomalies in quality characteristics. Results indicate that the fuzzy quality control chart is more sensitive to variations during the handling of linguistic or imprecise data, thus reducing the number of false alarms and stabilizing the process. Also, the fuzzy approach provides a broader view for assessing quality deviations as it adds expert judgment along with modeling uncertainty. These findings substantiate that the multinomial fuzzy quality control chart would serve as a more efficacious tool for monitoring quality in dynamic and uncertain manufacturing surroundings. This study further aids quality control methodology through the capitalization of fuzzy logic in statistical process control.

(Jeter, 2018) Use of fuzzy set theory addresses uncertainties in transportation costs, administrative expenses, and prices for goods to best allocate resources in logistics. Three different membership functions-linear, exponential, and hyperbolic-are used in assessing the efficiency of the transportation problem under different possible conditions. The proposed fuzzy model enables the decision-makers to work with imprecise and ambiguous data to achieve a flexible planning approach for transportation. This model is used for a real case in the General Company for the Manufacture of Grain, where it was proven effective in minimizing transportation costs subject to several operational constraints. The results indicate that decision-making is facilitated by fuzzy logic as it embraces the uncertainty, which in turn optimizes the transportation plan. In contrast to the conventional optimization method, this imposition of fuzzy logic gives flexibility to the results, thus enabling organizations to effectively balance and pursue different conflicting objectives. The study shows the importance of fuzzy multi-objective programming in solving complex logistics and supply chain management issues, with consequences for more widespread application in sectors where dynamic and uncertain decision environment is of high significance.

(Albadri & Ali, 2019) Apply the fuzzy multi-goal programming approach to determine the critical path under project management. Traditional project planning techniques often fail when faced with imprecise data, leading to wrong decisions. This research brings together fuzzy logic and decision-making, allowing for flexible constraints and uncertainty modeling. This method expresses uncertain durations and costs of the project in terms of fuzzy numbers and, thus, gives a more realistic review of project time considerations. The fuzzy multi-goal programming model develops upon competing objectives such as minimizing total cost of project operation and maximizing time allocation for activities balancing resource constraints. A case is given to describe its application on a large infrastructure project, which demonstrates how effective this method is in improving project scheduling. The analysis demonstrates that a fuzzy approach proposes a flexible and robust framework in management of projects allowing a decrease in risk, while at the same time increasing efficiency. Through this study, we can understand the relevance of fuzzy logic in managing complex projects and suggest a methodology to deal with ambiguity in planning and execution. Future research might look at a way to combine fuzzy methods with artificial intelligence for advanced project scheduling predictability.

(Mihnatan & Khalaf, 2019) investigate the time-cost tradeoff in project management under fuzzy environments. Fuzzy logic in project scheduling processes helps resolve lacks of certainty with respect to activity durations and costs. Herein-a fuzzy logic approach-is used to represent imprecise data to enhance the accuracy of decisions. The study uses fuzzy ranking functions to convert uncertain data into structured evaluations that couple CPM and fuzzy time-cost tradeoff analysis. The method maintains lead-lag relationships between project activities for better optimization within scheduling and cost efficiency. A real construction project provides an application of this technique and provides an example of how fuzzy techniques may assist with project planning. The results demonstrate that using fuzzy logic optimally reduces the duration of a project while minimizing additional costs. The study emphasizes fuzzy logic's role in handling uncertainties inherent in project scheduling, hence giving project managers an invaluable tool for dealing with complex decision-making environments. Future work can see greater refinement of fuzzy models for precision and integration into autonomous project management software.

(Ibrahim & Hadi, 2024) They deal with the globally recognized issue of assignment optimization under imprecision or uncertainties, which come under consideration in industries for the effective allocation of resources such as machines, jobs, or workers. Traditional assignment models assume data is precise; this work looks at the use of a fuzzy assignment model to better handle ambiguities in the real world. The method adopted by the authors for solving this fuzzy assignment problem involves transforming it into a fractional assignment model that mainly maximizes performance and minimizes cost, using the labeling method.

They apply it to a practical case with data from the Diwaniya Tire Factory, emphasizing the two factors of efficiency and cost. The human approach goes through an iteration until the optimal solution with an efficiency ratio of 0.49 and total cost reaching from 3,432,000 million dinars is reached. This demonstrates effectively the labeling method can handle fuzzy data and has given an optimal solution to maximize performance and control costs. The conclusion drawn by the authors is that fuzzy programming and the labeling method represent a powerful tool for decision-makers handling uncertain data in assignment problems, which inevitably leads to more rational and efficient resource allocation strategies.

(S. B. Ayed & Khalaf, 2021) Focuses on evaluating suppliers for Diyala General Electric Industries Company using a fuzzy inference system (FIS) in an environment characterized by uncertainty. The company lacks a structured supplier evaluation system, leading to inefficiencies in selecting reliable suppliers and optimizing the transportation of raw materials. To address this, the research integrates fuzzy logic and the Traveling Salesman Problem (TSP) to improve supplier evaluation and material transportation. The study applies a two-stage approach: first, the fuzzy inference system assigns performance scores to suppliers based on multiple criteria, ranking them accordingly. The Japanese company ranked highest with a performance score of 87.3. In the second stage, the TSP method is used to optimize transportation routes, reducing material delivery time to 292 minutes. The research highlights the effectiveness of using fuzzy logic in decision-making, ensuring efficient supplier selection and reducing transportation inefficiencies. The proposed model provides a systematic and quantitative approach to supplier evaluation, benefiting procurement strategies and logistics management.

(B. S. Ayed & Khalaf, 2022) Explores the planning of production activities with respect to electrical distribution converters (400KV/11) at the Diyala Public Company within a fuzzy environment. The research combines forecasting using time series with goal programming to optimize production planning by considering uncertain demand and lead time for production. The fuzzy time series model is used to predict fuzzy demand, while a fuzzy inference system estimates the lead time for raw materials. Also, the goal programming mathematical model is applied with the objectives of minimizing the total production costs and maximizing the number of units produced. It is solved using the Lingo program, achieving both objectives of reducing total production costs to less than 4,464,254,500 Iraqi dinars and increasing monthly production levels to more than 17,000 units. The results establish the efficacy of integrating fuzzy logic with goal programming to manage industrial production uncertainty. This provides a structured framework for decision making, thus enabling improvement in production planning efficiency. The study also establishes the applicability of fuzzy-based optimization techniques in real-time manufacturing, consequently benefiting the industrial organizations by providing insight regarding uncertain demand and production constraints.

4.2 Statistical Papers:

(Yawiz, 2015) Use the fuzzy reliability to estimated reliability of Mosul Dam, taking into account fuzzy failure times and a free distribution approach. The reason for the choice of fuzzy logic is that the authors could not collect reliable failure time data and there was no probabilistic distribution to model the data directly. Here, the three considered periods are 1986-2013, 2013-2033, and 2033-2066. Failure times were preferably chosen by geologists and engineers, and those four failure times define a trapezoidal fuzzy membership function among them. An in-house software package was developed using MATLAB for estimating fuzzy reliability for these periods. Accordingly, low fuzzy reliability values were computed, indicating an approximate fuzzy reliability of 0.5 for the current Dam situation, which signifies certain structural integrity. In contrast, the estimate was anticipated to drop down by 2033 to 0.1, meaning a near-critical condition for collapse. The emphasis of the research is therefore on immediate provision for a new dam, located in a geologically stable area, to mitigate possible threat situations.

The research findings validate the need for an urgent construction program, since it will sensitize policymakers, engineers, and urban planners to the due need for dam safety and long-term sustainability.

(Al-doori & Laith Fadhil S. H, 2016) Use fuzzy logic for system reliability assessment that encompasses multiple components. The bulk of reliability evaluation requires exact data that may not exist in some complex cases; therefore, this very limitation was worked around using fuzzy logic which can handle the uncertainty and imprecision present in reliability estimation. The focus of the authors was to identify suitable membership functions in the domain of fuzzy modeling to represent the uncertainty concerning the performance of system components in a better way. The integration of fuzzy system, fuzzy logic, and Beta distribution is proposed in a composite framework for estimating k-component systems' reliability function. This new environment enhances the analysis to address imprecision and ambiguity that are contained in the real-life scenarios. Therefore, the outcome shows that the fuzzy reliability model can estimate the system reliability in a more flexible and realistic manner, particularly when data are scarce or not precise. The contribution of the research is to offer a new insight into reliability estimation and thus emphasizes the incorporation of fuzzy logic to cope with the uncertainty in complex systems.

(Al-Kazaz & Al-Saadi, 2017) Aim to estimate the parameters of the Generalized Inverted Exponential (GIE) distribution when fuzzy data is present. Traditionally, estimation procedures cannot cope well with the uncertainty and impreciseness in data, and thus fuzzy logic has been adopted for this work to greatly improve accuracy. The study will employ a centroid approach to transform triangular fuzzy data into crisp values, thus allowing both MLE and Bayesian estimation methods. The MLE approach uses the Newton-Raphson algorithm to estimate shape and scale parameters, while the Bayesian method adopts the Metropolis-Hastings algorithm with a gamma prior distribution under quadratic loss function. A simulation-based study is also done to assess the performance of those two MLE and Bayesian estimation methods, through their mean squared errors (MSE) value. The study launched concludes that MLE is accurate with regards to parameter estimation after defuzzification compared to Bayesian estimation, irrespective of how big or small the sample is. However, even this fails to diminish the efficiency of using fuzzy based Bayesian approach as far as dealing with uncertainty and unresolved complex data structures are concerned. This gives a clear insight into the importance of fuzzy logic in statistical estimation having immense value for decision making under uncertainty. The research thus provides a significant contribution towards more advanced and novel methodologies of estimation in lifetime distributions with imprecise data.

(M. J. Mohammed & Abbas, 2018) Use Fuzzy membership and entropy functions for adaptive fuzzy linear regression models. uncertainty in statistical modeling is caused by a lot of sources which are usually not well addressed by traditional approaches. This created a need for researchers to refine the methods already being used by establishing new approaches within old theories. The studies are still taking new hypotheses and methods towards further enhancement of statistical models under uncertainty. The adaptive fuzzy linear regression model developed in this study can address the uncertainties embedded in the imprecise data. It differs from the traditional fuzzy regression approaches that are based on membership functions for fuzzification. This novel approach uses position and entropy functions. The mean absolute difference serves as a measure of performance for accuracy in models. Results show that position and entropy functions are better in representing fuzzy numbers compared to the old membership functions. In addition, the new adaptive model outperforms existing models developed on LR membership functions, showing more accuracy and better efficiency. This reveals the significance of entropy-based techniques in fuzzy regression for better handling of imprecision. It offers a better alternative to handle uncertainties and thus adds further dimension for future improvement toward the application of fuzzy regression in the development of statistical models.

(M. J. Mohammed, 2020) Use tow fuzzy robust estimators to estimate the location parameter in statistical data analysis. In evaluating various estimators (fuzzy median, fuzzy trimmed mean) and their performance relative to each other concerning the variance of fuzzy numbers as a criterion, it was found that, of all estimators considered, the fuzzy Median performs best for smaller and medium sample sizes, whereas the fuzzy trimmed mean is better for larger sample sizes. The present work adds value in that it discusses the operating characteristics of different fuzzy robust estimation techniques for data having varying sample sizes and intrinsic uncertainty. The outcome suggests that the efficiency and reliability of fuzzy data statistical analysis can be improved if the user selects an appropriate estimator depending on the sample size. The findings are significant for statisticians and researchers handling uncertain or imprecise data, serving as a guide in choosing appropriate estimation methods that improve analytical results.

(Shemail & Mohammed, 2022) Use the semi-parametric logistic regression with trapezoidal intuitionistic fuzzy numbers for output representation in medical application. Classic logistic regression models would treat the response variable, the y-axis multitude, as a crisply defined, dichotomous decision: either this or that, success or failure. In the medical realm, however, the imprecision-vagueness of the very concepts themselves would be applicable in the response variable. Thus, we are going through a fuzzy regression framework whereby the dependent variable becomes a trapezoidal intuitionistic fuzzy number. The model is asymmetrically estimated using simulation data where sample size differences were employed: 25, 50, and 100. Two alternative approaches have been used to estimate the parametric part of the model: the fuzzy ordinary least squares estimator (FOLSE) and the suggested fuzzy weighted least squares estimator (SFWLSE). The non-parametric section was estimated using Nadaraya-Watson and nearest neighbor methods. According to the findings, the FOLSE outperforms SFWLSE for parametric estimation while Nadaraya-Watson estimates better than the nearest neighbor method for the non-parametric part. Probability alleviates constraint modelling in the statistical world with respect to constituting robust logistic regression. It can be stated here that fuzzy logic in conducting Logistic regression contributes to better prediction or classification performance and a better representation of uncertain outcomes in applications, especially in healthcare and decision-making.

(Abd Al-Razzaq & Mohammed, 2022) Use discusses methodologies on fuzzy regression discontinuity design (FRDD) to estimate the causal impact of treatments in different social science experiments. They have discussed elevation measurement issues for treatment effects imposed on individuals, in that one will not be able to run experiments and situations concurrently to observe treated and untreated outcomes for an individual. Thus, the analysis proceeds to estimate the local average treatment effect for the population. The paper focuses on the importance of robust local polynomial regression estimators and coverage error optimality for the FRDD model. It reviews various estimators for the local causal effect of treatment, both left and right of the cutoff point, emphasizing kernel functions in making these estimations. The analysis is done using the R programming language to practically implement the proposed methods.

(Kareem & Mohammed, 2023)Use the Fuzzy Bridge Regression Model Estimating to targets the issue of estimating fuzzy regression models in the presence of data having multicollinearity. The traditional Fuzzy Least Squares Estimator (FLSE) method faces difficulties in such cases, resulting in unreliable estimates of the parameters. The current study thus proposes the Fuzzy Bridge Regression Estimator (FBRE) Method, which affords better estimation by allowing triangular fuzzy numbers. In detecting multicollinearity, the VIF works well for the models when the input variables are crisp but where the output and parameters are fuzzy. The performance evaluation was done through simulation experiments conducted for various sample sizes (20, 40, 80, and 160) for FBRE and compared with the aptitude of the FLSE.

The study noted that FBRE tends to give a lower level of Mean Squared Error (MSE), thus, a better estimator. It was also realized that model performance improves with an increase in sample size, but, with increased correlation among the independent variables, an increase in MSE results. In conclusion, it states that FBRE is more efficient than FLSE in fuzzy regression models, especially in the presence of multicollinearity.

(Baha Alwan & Abdulmohsin Ali, 2024) organized the many fuzzy quantile regression analysis methodologies and their enhancements, generalizations, and modifications. Furthermore, they had gathered several proposed studies based on fuzzy regression modeling. They presented some ideas, such as substituting the weight function presented by previous studies with a new weight function, entropy input with semi-parametric model using alternative functions for kernel functions, and the possibility of using neural network systems instead of the used regression model and comparing the results.

(A. H. Mohammed & Ashour, 2024) Introduce novel hybrid fuzzy approach to smoothing high-dimensional highly nonlinear data in environmental analysis has been proposed. The study combined Kernel Principal Component Analysis (KPCA) and Fuzzy C-Means (FCM) clustering to understand the hydrodynamics of several physical and chemical water quality variables. The KPCA method reduces the dimensionality of the problem by using a Gaussian kernel function to extract the most effective and influential variables, while the FCM part will allow efficient classification of this multidimensional data by assigning degrees of membership for each cluster. In the application part of the work, the hybrid model is used for the water quality investigation stations monitoring 15 environmental variables for a number of years. The results confirm that fuzzy clustering is successful in identifying overlapping stations as well as refining classification assignment accuracy. The optimal fuzziness of m = 3.6 and number of clusters of k = 3 were finally deduced, whereupon significant patterns of water contamination levels emerged. The results emphasize the applicability of fuzzy logic in environmental monitoring where it can handle uncertainties and imprecision in water quality assessment more appropriately. This study supports the advancement of an intelligent information system-oriented framework for environmental decision-making by applying fuzzy optimization strategies to enhance data interpretation and management of productive resources.

(Qusay Alshebly * & Najm Abdullah, 2024) Present the new optimization methodology for bioinformatics high dimensional gene expression classification problems. With this rapid increase in biological data, automatic classification becomes a very necessary means. The new conjugate gradient method, PNCG, improves the learning process of the fuzzy neural networks following the Takagi-Sugeno model. The main design goal is to improve the performance of convergence methods such as Polak-Ribière Polyak (PRP) and Liu-Storey (LS) concerning delayed convergence. The method has been evaluated on several simulated and real datasets by comparing results with findings of three public available cancer gene expression datasets. The performance results show that PNCG outperforms conventional methods in terms of accuracy, computational efficiency, and error reduction. The improvements include average training time, accuracy rates, and mean square error in both training and testing datasets. Thus, it is shown that the method can be the potential success tool for optimization classification problems in the bioinformatics sector with possible applications- cancer diagnosis and beyond into the biomedical fields. Future investigations may include further improvements and integration within automated classification systems.

(Hasan & Mohammed, 2024) Use a fuzzy classification system for assessing the nutritional status of Iraqi children younger than five years using fuzzy logic and the Mamdani method. Such classification of nutrition is important in medicine because of the existing uncertain conditions in variables like weight and height, affecting diagnoses of malnutrition. The goal of the study is to bring about a higher accuracy in classification to prevent the possibility of wrong diagnoses for treatment choices. A total of 16,487 children were analyzed (8,427 males and 8,060 females), grouped into a total of 12 age categories.

The fuzzy classification system classified the children into malnourished, underweight, normal, overweight, and obese. Results show that malnourished individuals less than eight months of age are underweight at a rate of about 30% while those eight months to two years are overweight at about 30%. And children aged 3 to 5 years generally have normal nutritional status. By the use of fuzzy inference rules and defuzzification methodologies, this study proved that fuzzy logic is an appropriate means of coping with uncertainties pertinent to nutritional assessments. The proposed model offers a sound framework for the classification of child nutrition status and will therefore contribute to the development of health strategies in Iraq.

(Ibrahim Tawfeeq* & Hazim Aboudi, 2024)) Proposes a novel outlier treatment in fuzzy data by fuzzy least squares estimation considering various kernel functions. The study aims to provide better parameter estimation for fuzzy regression models with crisp explanatory variables, fuzzy parameters, and response variables of which outliers are present. Different distance measures between fuzzy numbers based on different kernel functions are introduced to improve estimation. The proposed method is verified against the traditional fuzzy least squares (FLS) method and evaluated with respect to the Mean Square Error (MSE). The simulation experiments were conducted with different sample sizes (25, 50, 100, 150) and two different degrees of outliers (0%, 10%, 20%, and 30%). The results have shown that the proposed method of fuzzy least squares estimation with kernel-based distance is relatively more outlier robust compared to the classical FLS method. The study shows that using kernel functions enhances the efficiency of fuzzy regression models, thus providing better estimations under uncertain data. This provides a step toward developing more reliable regression methods for the analysis of fuzzy and imprecise data.

4.3 Managerial Papers:

(Al-Maadidi & Alsammak, 2016) Explore employing fuzzy logic to develop a knowledge chain model's membership level for various vital activities in a knowledge-driven organization. Often, knowledge management models face the constraints of uncertainty and imprecise data; hence fuzzy logic promises a great deal for more efficient decision-making in complex environments. Integrating fuzzy set theory into the analysis of fundamental activities serves to make knowledge management of activities more flexible and adaptive. Further, it uses fuzzy membership functions to evaluate knowledge-based processes while dealing with uncertainty and variability issues in knowledge flow within organizations. Analytical and empirical methods have been used to exercise the applicability of fuzzy logic in optimizing knowledge chains-increasing accuracy and reliability in decision sizes or even reaching a structured framework in which dynamic, uncertain knowledge settings can be managed. Such a model holds promise in resource allocation optimization, improved collaboration, and enhanced innovation in knowledge-intensive organizations. It shows that fuzzy methodologies can serve much further in knowledge management strategies and possibly much wider applications in organizational intelligence and decision-support systems.

(N. Basheer & Y. Maan, 2020) Utilize the Fuzzy Extended Analytic Hierarchy Process (FEAHP) for the prioritization and evaluation of the main and subsidiary criteria in B2B industrial marketplaces. Classical decision-making methods have a problem handling uncertainty and imprecision in market evaluation, making the usage of a fuzzy approach quite justified. The research applies fuzzy set theory to improve the accuracy of the weighting of criteria and make better decisions in uncertain business settings. The study uses a more flexible triangular fuzzy number-based refinement of prioritization of industrial market criteria into an adaptable and flexible assessment model. The methods transform expert opinions from qualitative assessments into quantifiable fuzzy values, which lowers ambiguity in decision-making. This leads to the very interesting outcome of establishing the viability of FEAHP in the structuring and analyzing of very complex decision frameworks ensuring strategic planning is more reliable for the industrial markets.

Fuzzy logic has emerged as a very important tool in the ability to prioritize those criteria for market evaluations that allow companies to access the best-informed decisions basing their structures on data. This study fosters the development of fuzzy decision-making models that are indeed very important for improving the business-to-business market strategies, with practical implications for firms that seek to enhance their competitiveness in dynamic industrial sectors.

(Nori Al-Hakeem & Dawood, 2021) The researchers combined Quality Function Deployment (QFD) and the Fuzzy Analytic Hierarchy Process (FAHP) in evaluating suppliers in industrial projects. For high-quality procurement processes, supplier selection is essential, especially when critical materials are involved, such as medical equipment. This emphasizes the need for objective supplier evaluation criteria to be efficient and minimize risks, both administrative and economic. In the research work, QFD translates customer requirements into measurable attributes for suppliers. FAHP is employed to handle uncertainty and prioritize these attributes effectively. Thus, the capability for systematic and data-driven supplier assessment is enabled. This is presented as a case study for an industrial project about its procurement of medical equipment. Empirical results show that combining QFD and FAHP improves supplier selection decisions by presenting a structured process of evaluation aligning supplier abilities to the needs of organizations. Further studies should be directed to the refinement of the metric constituents for evaluating suppliers and to the adoption of more advanced decision-support tools for evaluation methodologies. Overall, as much as the study is significant for evaluating and improving supplier selection processes, it provides value propositions in terms of how supplier optimization strategies can lead to operational efficiency and, eventually, better procurement results in industrial and commercial applications.

(Jassim Nassir & Yousef Abdul Redha, 2024) develop of an integrated approach that integrates Theory of Constraints (TOC) and Fuzzy-AHP (FAHP) techniques to streamline decision-making in construction project management. Construction industries grapple with resource constraints, scheduling conflicts, and other complex issues with multiple criteria and uncertainties. Using the TOC framework helps in identifying and managing constraints limiting the performance of a project. The TOC predominantly focuses on the identification of the highest critical limiting factors and their systematic improvements to enhance project outcomes overall. Once the constraints are identified, the prioritization of these factors is done by FAHP, which helps accommodate uncertainties and subjective judgments related to the decision-making process. FAHP extends the classical Analytical Hierarchy Process with fuzzy logic analysis making it more flexible and realistic when precise data are absent. A case study is used to demonstrate the real-life application of the integrated approach. Findings reveal that this structured integration of TOC and FAHP offers a reasonable framework for the identification of critical constraints and their priority ranking, thus enhancing allocation of resources, scheduling, and ultimately project performance.

(Abdulqader Mansoor & Yarub Maan, 2024) Use Fuzzy Analytic Hierarchy Process (FAHP) in Sustainable supply chain management practices as applied in the food industry. Indeed, sustainability in a decision often has complexities and uncertainties, thus helping with fuzzy logic to refine the evaluation of sustainability criteria. The research identified three fundamental sustainability dimensions—economic, environmental, and social, with 13 sub-criteria included. A fuzzy pairwise comparison approach was utilized, and experts considered the relative importance of these criteria. The results indicate that economic criteria hold the highest priority (73%), followed by environmental (16.2%) and social (10.8%) considerations. It permitted the handling of imprecise judgments, resolving ambiguities in decision-making, and offering a structured framework in evaluating sustainable supply chains. This research underscores that fuzzy logic enhances the logic of sustainability prioritization in dense decision environments such as supply chain management. The model improves reliability and adaptability of decision making through fuzzy numbers incorporated in the assessments by experts. The findings indicate the dire need for fuzzy integration in sustainability assessments that shows a

practical approach for organizations on sustainable supply chain strategies while balancing economic, environmental, and social objectives.

5. Conclusion:

Fuzzy set theory applications and methods are studied extensively in papers published in the Journal of Economics and Administrative Sciences (JEAS). While only a youthful theory that has been around for only about 60 years, fuzzy sets contribute so extensively to almost all fields: agnosticism notwithstanding, many contributions have earned their merits in the number of rare and great additions that have come into being, making its present status widely accepted in application ranging from engineering to social sciences, decision sciences to computer sciences, and physical sciences to life sciences. The findings here are indicative of the main role that fuzzy logic plays in the definition of uncertainty, imprecision, and complex decision making, with a few key applications such as optimization and regression analysis and multi-criteria decision making.
It shows the exploding number of publications as regards fuzzy set theory nowadays. The research gap identified in the paper includes areas that need to be further refined such as advancing hybrid fuzzy models, real-time fuzzy decision-making systems, and improved computational techniques for large-scale applications. Future research should recommend rigorous analysis into the various subject areas. Such a field, for instance, would be management where fuzzy set theory would be comprehensively reviewed both as a theoretical construction and practical applications to understand more about its usefulness and effect. It would also entail a future study that considers investigating the hybridization between fuzzy logic and emerging technologies like machine learning and big data analytics to further improve decision-making under uncertainty. In conclusion, this review affirms the role of fuzzy methodologies in providing theoretical as well as practical resolutions to multifaceted problems in changing environments.

Authors Declaration:

Conflicts of Interest: None

-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.

- Ethical Clearance: The Research Was Approved by The Local Ethical Committee in The University.

References

Abd Al-Razzaq, S. S., & Mohammed, J. M. (2022). Estimation of Causal Effect of treatment via Fuzzy Regression Discontinuity Designs. *Journal of Economics and Administrative Sciences*, *28*(134), 110–117. https://doi.org/10.33095/jeas.v28i134.2424

Abdulqader Mansoor, S., & Yarub Maan, H. (2024). Evaluating and Prioritizing the Sustainable Supply Chain Management Practices in Food Industry. *Journal of Economics and Administrative Sciences*, *30*(141), 264–280. https://doi.org/10.33095/zwgmg912

Albadri, F. F., & Ali, Y. A. (2019). Use multi-goal fuzzy programming to find the critical path. *Journal of Economics and Administrative Sciences*, *25*(112), 428–443. https://doi.org/10.33095/jeas.v25i112.1672

Al-doori, E. A., & Laith Fadhil S. H. (2016). Fuzzy logic in the estimate of reliability function for k - components systems. *Journal of Economics and Administrative Sciences*, *22*(87), 391. https://doi.org/10.33095/jeas.v22i87.717

Al-Douri, M. S., & Hamdi, I. M. (2018). Using Mehar method to change fuzzy cost of fuzzy linear model with practical application. *Journal of Economics and Administrative Sciences*, *24*(104), 314. https://doi.org/10.33095/jeas.v24i104.87

Al-Kazaz, Q. N., & Al-Saadi, H. J. K. (2017). Comparing Bayes estimation with Maximum Likelihood Estimation of Generalized Inverted Exponential Distribution in Case of Fuzzy

Data. *Journal of Economics and Administrative Sciences*, *23*(101). https://doi.org/10.33095/jeas.v23i101.199

Al-Maadidi, M. W. A., & Alsammak, M. A. J. (2016). Adoption of Membership Level for Critical Activities In Knowledge Chain Model Building An Investigation Analytical Study Depending on Fuzzy Logic Architecture for Organizations Pushed by Knowledge. *Journal of Economics and Administrative Sciences*, *22*(93), 242. https://doi.org/10.33095/jeas.v22i93.433

Aseel Sameer Mohamed. (2015). Constructing fuzzy linear programming model with practical application. *Journal of Economics and Administrative Sciences*, *21*(83), 328. https://doi.org/10.33095/jeas.v21i83.656

Ashour, M. A. H. (2009). Fuzzy Linear Programming problems. *Journal of Economics and Administrative Sciences*, *15*(56), 181. https://doi.org/10.33095/jeas.v15i56.1271

Ashour, M. A. H., & Jawad, M. A. (2017). Using Fuzzy Games Theory to Determine the optimal Strategy for The Mobile Phone Networks in The Baghdad and Basra governorates. *Journal of Economics and Administrative Sciences*, *23*(95), 399. https://doi.org/10.33095/jeas.v23i95.394

Ayed, B. S., & Khalaf, S. W. (2022). Planning the Production of the Electrical Distribution Converter (400KV/11) Using Time Series Methods and Goal Programming in the Fuzzy Environment. In *Journal of Economics and Administrative Sciences* (Vol. 28, Issue 131). https://doi.org/10.33095/jeas.v28i131.2231

Ayed, S. B., & Khalaf, W. S. (2021). Using Fuzzy Inference to Evaluation Suppliers in Diyala General Electric Industries Company. *Journal of Economics and Administrative Sciences*, *27*(130), 1–24. https://doi.org/10.33095/jeas.v27i130.2188

Baha Alwan, E., & Abdulmohsin Ali, O. (2024). About Semi-parametric Methodology for Fuzzy Quantile Regression Model Estimation: A Review. *Journal of Economics and Administrative Sciences*, *29*(138), 127–146. https://doi.org/10.33095/jeas.v29i138.3044

Bakhayt, A.-G. K., & Fayyad, A. H. (2015). Use of model sales man fuzzy multi-objective linear for speed up and rationing in the transport mechanism used in the General Company for grain Processing. *Journal of Economics and Administrative Sciences*, *21*(81), 299. https://doi.org/10.33095/jeas.v21i81.579

Bakhayt, A.-G. K., & Kamel, R. D. (2017). Fuzzy aggregate production planning by using fuzzy Goal programming with practical application. *Journal of Economics and Administrative Sciences*, *23*(99), 355. https://doi.org/10.33095/jeas.v23i99.260

Battikh, A. H. (2014). Solve travelling sales man problem by using fuzzy multi-objective linear programming. *Journal of Economics and Administrative Sciences*, *20*(75), 432. https://doi.org/10.33095/jeas.v20i75.599

Bellman, R. E., & Zadeh, L. A. (1970). Decision-Making in a Fuzzy Environment. *Management Science*, *17*(4), B-141-B-164. https://doi.org/10.1287/mnsc.17.4.B141

Hasan, H. A., & Mohammed, M. J. (2024). Classification of Iraqi Children According to Their Nutritional Status Using Fuzzy Logic. *Journal of Economics and Administrative Sciences*, *29*(138), 161–171. https://doi.org/10.33095/jeas.v29i138.3046

Ibrahim, S. K., & Hadi, A. A. (2024). Solve the fuzzy Assignment problem by using the Labeling method. *Journal of Economics and Administrative Sciences*, *24*(106), 446. https://doi.org/10.33095/jeas.v24i106.34

Ibrahim Tawfeeq*, A., & Hazim Aboudi, E. (2024). Some Fuzzy Least Squares Estimators for Regression Model Using Different Kernel Functions. *Journal of Economics and Administrative Sciences*, *30*(142), 465–375. https://doi.org/10.33095/7qdnc433

Jassim Nassir, M., & Yousef Abdul Redha, N. (2024). An Integrated Approach to Constraints Theory and Fuzzy Analytical Hierarchy Process (FAHP) in Construction Projects (Case Study). *Journal of Economics and Administrative Sciences*, *30*(143), 68–85. https://doi.org/10.33095/4bgyes38

Jawad, L. B., & Hassan, Z. F. (2018). Adoption of multi – model Assignment Fuzzy to find Optimizing for the use of internet line in the Ministry of Science and Technlogy . *Journal of Economics and Administrative Sciences*, *21*(84), 357. https://doi.org/10.33095/jeas.v21i84.708

Jeter, A. S. (2018). Fuzzy Multi-Objective Capacitated Transportation Problem with Mixed Constraints using different forms of membership functions. *Journal of Economics and Administrative Sciences*, *24*(107), 614. https://doi.org/10.33095/jeas.v24i107.1315

Kareem, R. E., & Mohammed, M. J. (2023). Fuzzy Bridge Regression Model Estimating via Simulation. *Journal of Economics and Administrative Sciences*, *29*(136), 60–69. https://doi.org/10.33095/jeas.v29i136.2607

Khalaf, W. S. , & Mohammed, A. H. (2013). Solution of Fuzzy Maximal Flow Problems of Vehicles in Province of Diwaniyah Using the Ranking Function for Fuzzy Linear Programming Model. *Journal of Economics And Administrative Sciences*, *19(73)., 430-450.*, *19*(73), 430–450.

Khalaf, W. S., & Abd Ahmed, M. (2016). Material Requirements Planning for the Electric Motor in Fuzzy Environment for State Company for Electric Industries. *Journal of Economics and Administrative Sciences*, *22*(90), 170. https://doi.org/10.33095/jeas.v22i90.504

Khalaf, W. S., & Halim, H. D. (2018). Find the fuzzy maximum flow of Imam Kadhimen visitors using fuzzy dynamic programming University of Baghdad - Faculty of Administration and Economics. *Journal of Economics and Administrative Sciences*, *24*(103), 102. https://doi.org/10.33095/jeas.v24i103.106

Khalaf, W. S., & Jassim, A. B. (2017). Inventory control by using Fuzzy set theory An Applied Research at the Baghdad Soft Drinks Company. *Journal of Economics and Administrative Sciences*, *23*(101), 72. https://doi.org/10.33095/jeas.v23i101.170

Mihnatan, R. S., & Khalaf, W. S. (2019). The Time-Cost Trade-off to Manage A Project in a Fuzzy Environment. *Journal of Economics and Administrative Sciences*, *25*(114), 498–522. https://doi.org/10.33095/jeas.v25i114.1748

Mohammed, A. H., & Ashour, M. A. H. (2024). Constructing a Hybrid Algorithm to Model the Physical and Chemical Inspection Station Data of the Shatt Al-Arab Waters*. *Journal of Economics and Administrative Sciences*, *30*(141), 457–478. https://doi.org/10.33095/qe4m1z69

Mohammed, M. J. (2020). Fuzzy Robust Estimation For Location Parameter. *Journal of Economics and Administrative Sciences*, *26*(117), 480–491. https://doi.org/10.33095/jeas.v26i117.1825

Mohammed, M. J., & Abbas, A. F. (2018). A Comparision Between Membership function And Entropy Function In Fuzzy Adaptive Linear Regression. *Journal of Economics and Administrative Sciences*, *24*(103), 453. https://doi.org/10.33095/jeas.v24i103.123

Mohammed, Z. M. (2013). Comparison between Process Control Charts and Fuzzy Multinomial Control Charts with Practical Appliance. *Journal of Economics and Administrative Sciences*, *19*(73), 471. https://doi.org/10.33095/jeas.v19i73.1076

N. Basheer, Y., & Y. Maan, H. (2020). Fuzzy Analytic Hierarchy Process FEAHP to Prioritize The Evaluation of The Main and Subsidiary Criteria in B2B Industrial Market Sectors – Applied Research. *Journal of Economics and Administrative Sciences*, *26*(124), 460–480. https://doi.org/10.33095/jeas.v26i124.2052

Nori Al-Hakeem, A. A. H., & Dawood, F. S. (2021). Evaluation suppliers according to the integration of the Quality Function Deployment and the Fuzzy Analytic Hierarchy Process. *Journal of Economics and Administrative Sciences*, *27*(125), 170–192. https://doi.org/10.33095/jeas.v27i125.2071

Qusay Alshebly *, O., & Najm Abdullah, S. (2024). The Fuzziness Models with The Proposed New Conjugate Gradient Method for The Classification of High-Dimensional Data in Bioinformatics. *Journal of Economics and Administrative Sciences*, *30*(142), 425–448. https://doi.org/10.33095/ahnw8r72

Redha, S. M., & Hassan, N. A. K. (2014). Employment programming fuzzy goal in medical field. *Journal of Economics and Administrative Sciences*, *20*(76), 363. https://doi.org/10.33095/jeas.v20i76.682

Saffawi, S. Y., & warttan, H. A. (2018). Comparative study of between P chart and Multinomial Fuzzy quality control chart (FM). *Journal of Economics and Administrative Sciences*, *24*(104), 329. https://doi.org/10.33095/jeas.v24i104.88

Saleh, S. A. (2016). New Approach for Solving Symmetric Fuzzy Linear Programming Problem. *Journal of Economics and Administrative Sciences*, *22*(91), 1. https://doi.org/10.33095/jeas.v22i91.495

Shemail, A. H., & Mohammed, M. J. (2022). Semi Parametric Logistic Regression Model with the Outputs Representing Trapezoidal Intuitionistic Fuzzy Number. *Journal of Economics and Administrative Sciences*, *28*(133), 70–81. https://doi.org/10.33095/jeas.v28i133.2350

Tanaka†, H., Okuda, T., & Asai, K. (1973). On Fuzzy-Mathematical Programming. *Journal of Cybernetics*, *3*(4), 37–46. https://doi.org/10.1080/01969727308545912

Yawiz, Z. (2015). Reliability Estimation Of Fuzzy Failure Times Of Free Distribution And It Use To Estimate The Fuzzy Reliability Of Mosul Dam. *Journal of Economics and Administrative Sciences*, *21*(81), 348. https://doi.org/10.33095/jeas.v21i81.583

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, *8*(3), 338–353. https://doi.org/10.1016/S0019-9958(65)90241-X

Zimmermann, H.-J. (1978). Fuzzy programming and linear programming with several objective functions. *Fuzzy Sets and Systems*, *1*(1), 45–55. https://doi.org/10.1016/0165-0114(78)90031-3