

A Study Modelling of Fuzzy Activity-Based Cost Approach to Evaluate the Accuracy of Indirect Cost Allocation Under Data Uncertainty

Ali Noori Abdulzahra ¹, Sahar Mahede Jabir ²,
Murtadha Ibrahim Maki ³, Ahmed Maher Mohammad Ali ¹

¹ Faculty of Administration and Economics, University of Kufa, Najaf, Iraq

² Faculty of Engineering, University of Kufa, Najaf, Iraq

³ College of Excellence in Arabic Language and Literature, University of Kufa, Najaf, Iraq

Abstract – Technological developments such as digital transformation and artificial intelligence have affected the way manufacturing is done and therefore the way costs are calculated; this has led to changes in the structure and dynamics of costs compared to previous methods. The traditional approach to costing has resulted in inaccurate assessments of costs, consistently distorting the costs of products and services and providing misleading data to decision makers within organizations which rely upon it. Therefore, organizations are required to develop and implement cost systems and cost management practices to maintain their competitive advantage and meet the needs of their customers. Activity-based costing is one of the most effective cost management practices available today because it provides accurate data for allocating indirect costs to products and/or services. However, activity-based costing systems require continuous and comprehensive improvements in the collection and analysis of data.

As a result, there is often little value placed on the data collected from activity-based costing systems due to the variability and ambiguity inherent in all systems, especially those operating in today's rapidly changing automated industry. To address these problems and improve the accuracy of cost estimates and increase the reliability of the results, fuzzy logic was applied as a concept and methodology that reduces the ambiguity and uncertainty associated with estimating cost drivers using activity-based costing systems so that managers receive reliable and relevant information when assessing the cost of products and/or services.

Keywords - Activity-based costing, fuzzy logic, fuzzy activity-based costing, uncertain data.

1. Introduction

The corporate climate is swiftly adapting to technology advancements, providing organizations with benefits in consumer satisfaction and heightened demand for their products or services [1]. To adapt to these advancements and changes, organizations must enhance or establish their internal information systems, especially cost measuring systems [2]. This results from the evolving cost structure, heightened indirect expenses, and the necessity for precise data inputs to effectively assess production or service costs [3]. Conventional cost measuring systems operate on the idea of accuracy, wherein the information is deemed valid if the input data is accurate, and conversely [4]. Conventional systems are incapable of delivering precise information when confronted with unclear or ambiguous input [5]. Activity-Based Costing (ABC), in an advanced industrial environment, supports the strategic objectives of organizations. In this way it can provide managers with useful information about the consumption of independent and dependent energies through the processing of only quantitative data for decision-making purposes [6].

DOI: 10.18421/TEM153-26

<https://doi.org/10.18421/TEM153-26>

Corresponding author: Ahmed Maher Mohammad Ali,
Faculty of Administration and Economics, University of
Kufa, Najaf, Iraq

Email: ahmedm.fadhil@uokufa.edu.iq

Received: 09 August 2025.

Revised: 23 January 2026.

Accepted: 03 February 2026.

Published: 27 August 2026.

 © 2026 Ali Noori Abdulzahra et al.;
published by UIKTEN. This work is licensed under the
Creative Commons Attribution-NonCommercial-NoDeriv
4.0 License.

The article is published with Open Access at
<https://www.temjournal.com/>

The ABC approach forfeits its benefits when descriptive data is present rather than exact numerical values, impeding activity analysis and complicating precise cost estimation [7]. Fuzzy logic enables the management of uncertain and ambiguous data through the formulation of mathematical connections that emulate human cognition [8]. Fuzzy logic, with its degree of membership, facilitates the resolution of several intricate issues that classical logic fails to address, as it depends on explicit and precise quantitative principles within the range of (0,1) [9]. Transforming ambiguous data into quantitative values through the degree of membership in fuzzy logic facilitates the computation of the activity-based costing rate based on the fuzzy values of cost drivers, hence allowing for precise allocation of indirect costs [10]. The concept of Fuzzy Activity-Based Costing (FABC) facilitates a more precise allocation of indirect costs in contexts characterized by ambiguity and uncertainty [11]. A model is constructed utilizing membership functions, fuzzy logic, and defuzzification techniques [12]. Notwithstanding the intricacies of FABC, it mitigates financial inaccuracies and curtails the subjective judgment of decision-makers [13]. It assists management in identifying utilized and unutilized capacity, formulating strategic goals, and regulating expenditures to get more precise outcomes [14]. Prior study findings can no longer forecast the outcomes of implementing fuzzy activity-based costing (ABC) [5]. This facilitates a more precise distribution of indirect costs in contexts characterized by ambiguity and uncertainty within the sector; yet, it has not yielded any definitive answers for the future [15]. This groundbreaking finding will facilitate future studies that tackle the issues of strategically controlling additional expenses related to the organic degree of fuzzy logic. The initial segment to be discussed is the introduction. The subsequent part constitutes a literature review.

2. Literature Review

Some of the biggest obstacles include collecting accurate and reliable data to use in an ABC system, and dealing with uncertainty in the data that is collected. To develop an ABC system, managers must collect and analyze a large amount of data, including the time and resources required to complete each business process, the rate at which they consume each resource, and the rate at which they contribute to each cost driver. Collecting such data may be difficult because managers do not always know how much time and resources are being consumed, or how quickly they are being consumed. As a result, managers will often make estimates, which are likely to be inaccurate. In addition to inaccuracies in the data itself, the data may also be subject to other sources of error such as changes in processing times or equipment failure.

While some organizations have reported success in collecting data on resource utilization and activity characteristics, few have achieved high levels of accuracy in measuring the causal linkages between activities and resource consumption. One reason for this is that many of the factors that influence the rate at which resources are consumed during the performance of an activity cannot be controlled. For example, even if a company develops a highly effective method for estimating the amount of time and resources that are required to perform each business process, changes in processing volumes, or changes in the way in which processes are performed, can occur rapidly enough to render the estimates obsolete.

2.1. Activity-Based Costing and Non-Ambiguous Data

In reaction to changes in the economic business environment necessitating significant modifications to administrative and accounting unit information systems, the ABC system surfaced as a model aimed at advancing modern management accounting systems to enhance the requisite standards [16]. Robert Kaplan's introduction in 1987 transformed cost accounting methods [17]. One year later, Kaplan devised the methodology for assigning indirect expenses [18]. His principal objective was to develop accounting systems that might facilitate the strategic operations of economic entities within a swiftly changing industrial landscape, especially in American corporations [19]. The approach was later used in Europe, the United Kingdom, and Canada [13]. Activity-Based Costing (ABC) is a costing methodology predicated on the principle that goods utilize activities, which in turn utilize resources [20]. It is a technique predicated on activities, which constitute a series of operations that do not finalize the manufacturing process [21]. This system comprises four components: The first is resources, which denote the factors of production utilized by activities to generate outputs in the production process [22]. Resources consist of equipment, materials, or information, which are organized inside a particular activity to generate outputs [23]. Secondly, activities comprise a collection of procedures or processes that collectively constitute the work environment inside an economic unit [7]. An instance of this is the acquisition of raw materials utilized in the production of a certain product [6]. Third, activity drivers are determinants that affect cost accounting and represent the use of activities concerning items or services [24]. These variables provide improved allocation of expenses to activities. Ultimately, cost components that exhibit a shared cost driver are amalgamated into a singular cost factor [25]. The four elements of the ABC system fulfill two fundamental purposes for the company [26].

The initial step involves categorizing activities into value-adding and non-value-adding classifications [27]. This leads to the exclusion or diminishment of activities, particularly in the realm of inventory-free manufacturing [28]. The second aspect is the categorization of expenses, some of which are not associated with production volume but rather with the diversity of goods [22]. This is seen as a contributing element to the formation of cost, time, and quality measurements [16]. It is regarded as a management instrument that facilitates the formulation of the activity-based budget [17].

2.2. Membership Degree of Fuzzy Logic

Fuzzy logic constitutes an application of Artificial Intelligence [8]. It aims to codify thought when it is ambiguous [29]. It is more aligned with human cognition than classical logic and significantly aids decision-making in uncertain settings where information is limited or inadequate [9]. It addresses several factors, both quantitative and verbal, aiming to deliver unambiguous yet ambiguously defined outcomes [30]. Numerous studies suggest that the motives for employing fuzzy logic stem from its dependable terminology, which is widely recognized and comprehensible to the general populace, articulated in accessible language [31]. Fuzzy logic accommodates imperfect reasoning, which is crucial for enhanced decision-making accuracy [32]. Fuzzy systems may be readily constructed to correspond with any given set of input and output data owing to the existence of intricate nonlinear model functions [29]. Fuzzy logic is an effective instrument that simplifies the complexity of mathematical connections, serving as an alternative to classical mathematics, as human knowledge cannot be dichotomously categorized into two categories (0, 1) [33]. In classical logic, it determines the membership of an element inside a set, but fuzzy logic allows for the assignment of a score to this membership based on a fuzzy set [34]. Fuzzy logic fundamentally diverges from standard logic, as it encompasses various values and has several gray or uncertain areas [35]. Fuzzy logic has facilitated the resolution of several intricate issues that classical logic fails to handle, as it depends on precise and explicit quantitative principles within the range of (0,1) [36]. Fuzzy logic is employed across several domains and has numerous applications, particularly when data is ambiguous owing to unpredictability, vagueness, or a combination of both [29]. When the variables are fuzzy numbers rather than fixed variables, and these variables can be quantified over a designated timeframe, the primary instruments of fuzzy logic encompass the fuzzy function, which assigns a degree of membership [8], ranging from 0 to 1, to each element from a particular set, which may consist of symbols or numbers, thereby indicating the extent of its affiliation with a specific fuzzy set [30].

Fuzzy numbers are a subset of fuzzy sets associated with natural numbers, real numbers, or integers, distinguished by their convexity and modularity [36]. Analyzing the issue and identifying its variables is fundamental for constructing a fuzzy system that converts issues articulated in descriptive variables into actions guided by a set of inference rules that emulate human reasoning in three stages [33]. The initial process is fuzzification, which is transforming real-world values into fuzzy values that reflect imprecise descriptive expert assessments [9]. The second component comprises the fuzzification rules, which are divided into two pieces [30]. The initial segment is referred to as the logical statement, while the subsequent segment is termed the logical outcome [35]. This regulation facilitates the development of a complicated system dependent on human knowledge or a database involves the application of fuzzy logical linkages (such as not, or, and) to elucidate the connections between system inputs [32]. Defuzzification is the process of transforming fuzzy values into exact numerical values [8]. The results can be achieved by performing a single fuzzy operation on two or more fuzzy operations [29].

2.3. Fuzzy Activity-Based Costing Modeling

Fuzzy Activity-Based Costing (FABC) is the most efficacious method for addressing imprecise data, with the objective of enhancing the precision of cost allocation in uncertain contexts [29]. This approach employs language variables such as “high,” “low,” and “average” in lieu of exact numerical values, facilitating the analysis of activities with costs that are challenging to determine properly [11]. The FABC paradigm facilitates enhanced cost allocation in contexts characterized by ambiguity and uncertainty [37]. FABC is executed by membership functions, fuzzy logic, and defuzzification [38]. Notwithstanding its intricacy, it enhances decision-making and mitigates financial inaccuracies [39]. It diminishes the personal discretion of decision-makers and assists management in identifying used and unutilized capacity, formulating planning budgets, and regulating expenses for more precise and objective outcomes [40]. Assessing the behavior of resources derived from costs is a critical concern of the FABC model, including the duration and amount of raw materials alongside other elements associated with flexible and committed resources [4]. To improve the resource identification process, the cost-related flexible resource identification phase is considered an ambiguous process for each activity [10]. To enable the assessment of resource behavior, three phases have been delineated: the minimum necessary resources, the most likely resources, and the maximum available flexible resources [41].

FABC enhances cost efficiency in its economic unit activities, encompassing manufacturing, procurement, warehousing, marketing, and sales - by implementing fuzzy control systems to regulate machine speed and equipment temperature during the production process [12]. It effectively lowers inventory expenses by minimizing waste and curtailing surplus inventory [42]. FABC augments the enhancement and escalation of sales in marketing and sales endeavors by offering solutions through programs using fuzzy classifications (continuous customer, intermittent client, regular customer), alongside categorizing market demand state (high, low, medium) [34]. These categories facilitate more precise decision-making in cost reduction under ambiguity or fluctuating situations [43]. To attain precise outcomes in cost reduction for activities with challenging cost estimations owing to ambiguity and uncertainty, five fundamental phases are implemented to fulfill the objectives of the FABC model [11]. The initial phase involves identifying resource-consuming activities that impact costs, such as production [4]. Warehousing and distribution in ambiguous contexts [32]. Fuzzy linguistic values are employed to characterize resource usage [30]. The subsequent stage involves use membership functions to ascertain the extent to which each expense is associated with a certain category [13]. For instance, the expenses associated with building maintenance or machinery upkeep can be modeled using a trigonometric or Gaussian function, classified as low, medium, or high [8]. The third phase involves identifying the cost factors that influence resource consumption, such the quantity of manufacturing orders or the duration of operation hours. Rather of employing fixed values, these drivers are depicted by fuzzy sets [9]. The fourth phase involves converting ambiguous input into quantifiable values through a defuzzification procedure [25]. An activity-based cost rate is determined using the ambiguous values of the cost drivers [1]. The last phase involves assigning costs to each product according to the outcomes of the fuzzy analysis of the cost drivers. Implementing the FABC model necessitates addressing several challenges associated with computational complexity [4], which demands the utilization of sophisticated analytical tools such as MATLAB or Python; the intricacy of defining membership functions [39], as this model necessitates proficiency in selecting suitable functions; and ultimately, the requirement for data availability, which entails adequate historical data to evaluate components such as the knowledge base, the inference module, and the user interface [12].

3. Data and Method

This study relies on a literature evaluation, employing theoretical analysis and theory-building methodologies for instructional materials. Theoretical textbooks are essential resources for scholars to assess and generate new knowledge. This study emphasizes the necessity of examining the literature about the extent of fuzzy logic and the efficacy of activity-based costing, as well as seeking pertinent articles using keywords such as “fuzzy logic,” “fuzzy activity-based costing,” and “Uncertainty data” to identify relevant research. The study findings indicate the overall quantity of papers published in scientific journals. Nonetheless, the author’s idea, which corroborates and encapsulates his first observations, is articulated. This research explicitly seeks to reveal previously overlooked connections between cost accounting and data and activity uncertainty, which have been disregarded in other studies.

4. Results

The ABC approach offers a framework that allows managers to precisely assess the cost elements of all goods or services, facilitating the identification or elimination of unproductive offerings. Additionally, it provides valuable insights for identifying and eliminating inefficient manufacturing processes or services. The ABC system is regarded as a strategic cost management tool, facilitating the comprehension of cost behavior and the reallocation of substantial indirect costs in accordance with modern technology advancements, executed through three fundamental processes, as seen in Figure 1. The ABC system enhances product returns in commercial enterprises and service returns in service-oriented firms by delivering precise and dependable information on value-adding resources. The execution of ABC encounters several challenges, notably the necessity for a cohesive, adaptable, and unequivocal database that can serve as input to the system for precise cost allocation. The uncertainty over the data accuracy utilized in the system, along with the changing business conditions due to technical improvements and industrial process automation, presents more hurdles. Adhering to conventional logic will result in managers receiving information in the decision-making process categorized into two levels of accuracy: Either accurate information or inaccurate information derived from the outputs of the ABC system.



Figure 1. Stages of implementing the ABC system

Fuzzy logic does not yield definitive true or false values like conventional logic does. A membership function calculates the degree of membership for each input value on a scale from 0 to 1, where 0 signifies non-membership and 1 indicates complete participation. Furthermore, it offers a membership value that is both half true and partially false. Figure 2 depicts the extent of diversity in membership.

Fuzzy logic is defined by its clarity and simplicity, since it accommodates several sorts of inputs, including exact, ambiguous, or uncertain data. The membership value may be deduced by a series of mathematical principles that emulate human cognition, aiding in the resolution of complicated situations and enhancing the decision-making process.

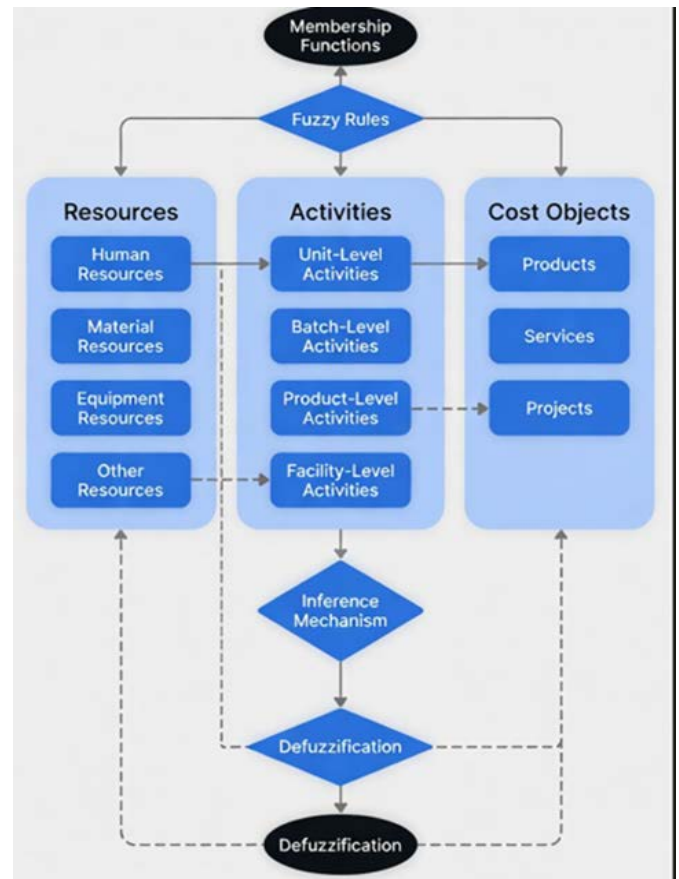


Figure 2. Fuzzy activity-based costing technology

The FABC approach was developed to furnish reasonably precise information that facilitates the appropriate estimate of indirect costs amongst confusing and unclear data. This work employed fuzzy logic inside the ABC model to address inherent ambiguity and uncertainty, therefore identifying optimal values for cost parameters, activities, and cost drivers, which enhances the accuracy of cost.

The FABC approach minimizes the human discretion of decision-makers, aiding management in formulating planning budgets and controlling expenses, hence yielding more precise and objective outcomes.

The FABC model facilitates the detection of resource and activity behavior influenced by costs by offering an average membership value, which is both partially accurate and partially inaccurate, alongside values assigned a score of (1,0). Consequently, the system's inputs will be sufficiently precise to provide proper cost allocation despite the considerable uncertainty and ambiguity in the data. allocation information. Fuzzy logic mitigates data inaccuracies in the ABC system while assessing value-adding and non-value-adding operations, yielding precise and intended outcomes through the use of membership functions, fuzzy logic, and defuzzification. Notwithstanding its intricacy, it enhances the decision-making process and mitigates financial inaccuracies, as seen in Figure 3.

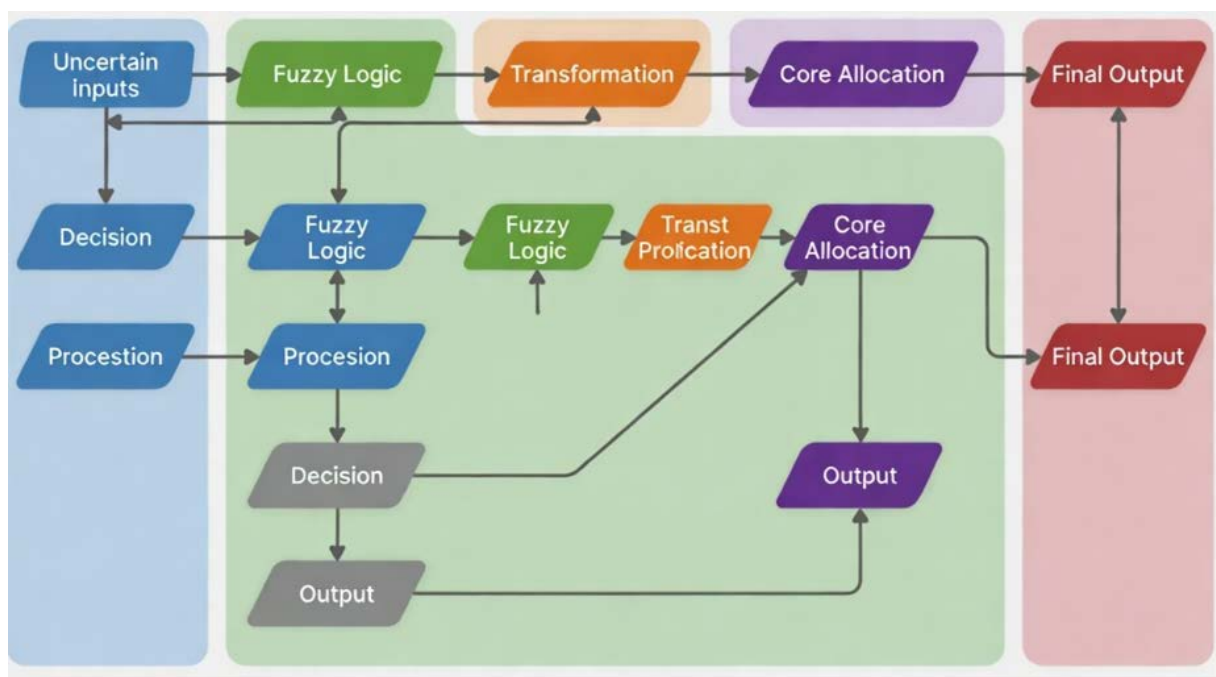


Figure 3. Costing system based on fuzzy activities and uncertain data

5. Discussion

Cost and time management is a critical strategic objective that an economic entity aims to attain while preserving the company's market position. Management implements ways to assign indirect expenses in accordance with the unit's production characteristics while maintaining product quality. Due to contemporary production systems that utilize computer-based automation for managing processes, manual labor has diminished in significance, and conventional cost-reduction tactics have been inadequate in keeping up with the advancement of production systems. This has required the necessity to remain abreast of contemporary advancements. One of these tactics is the FABC strategy for minimizing the cost of products or services.

The FABC model is an advancement of the ABC approach, integrating activity-based analysis with fuzzy logic to mitigate ambiguity and uncertainty in the computation of activity-related costs. This approach prioritizes organic states as the principal criterion for resource allocation, including unknown situations that may influence cost escalations and the duration necessary to execute tasks. Activities are determined by resource consumption levels, with costs assigned to activities according to the ambiguous activities of each process. Fuzzy logic is employed to manage uncertainty in activity data, including delays and fluctuating production. The concept seeks to decrease complexity relative to conventional ABC methods and tackles scenarios with partial or erroneous data. The FABC model's applications aim to furnish management with precise information.

This information is comprehensive and crucial to the manufacturing process, offering greater accuracy than conventional costing systems by assigning costs logically and equitably, utilizing fuzziness vectors for the distribution of joint costs across many cost objectives.

6. Conclusion

The integration of fuzzy logic into the Activity-Based Costing (ABC) system creates a new costing method called Fuzzy Activity-Based Costing (FABC). FABC is an improvement over the old costing methods because it addresses many of the deficiencies of the old costing methods in today's manufacturing and service-based environment. In recent years technological advancements, digital transformations and increased automation in many manufacturing and service environments have increased the amount of indirect cost that companies incur. Additionally, technology has introduced additional amounts of uncertainty and ambiguity in the data provided to costing systems regarding cost driver, resource usage and activity-based analysis. The traditional ABC systems rely heavily on exact quantifiable input data which can lead to distorted and/or unreliable cost allocations when dealing with data that contains large amounts of uncertainty or ambiguity. This can result in decision-making errors at the manager level concerning the pricing of products, the assessment of profit, the improvement of processes and strategic planning.

This paper demonstrates how the use of fuzzy logic (membership functions, linguistic variables (e.g., low, medium, high), fuzzification, fuzzy inference rules and defuzzification) in a FABC system can effectively address these issues. By representing ambiguous data as degrees of membership (from 0 to 1), FABC provides a more realistic representation of real-world cost dynamics than does the traditional ABC system. That is, instead of the data being either exactly true or false, FABC allows the data to be represented as existing on a continuum. Therefore, FABC produces more accurate and reliable indirect cost allocations than do the deterministic ABC methods used traditionally. These more accurate and reliable indirect cost allocations will reduce the financial inaccuracies associated with costing decisions made using traditional ABC methods. Additionally, they will eliminate the need for subjective judgment from decision-makers regarding the reliability of the cost allocations produced by the FABC system. Finally, they will provide decision-makers with an unbiased view of which activities add value and which activities do not add value to the organization, which resources are being utilized and which are not being utilized (i.e., idle capacity), and how the total costs of an organization behave.

Therefore, the results indicate that the use of fuzzy activity-based costing systems will enhance the accuracy of cost estimates regardless of whether the organization is operating in a highly automated and data-uncertainty environment. As such, FABC supports more informed decisions relative to cost control, budgeting, pricing and performance measurement. While the fuzzy activity-based costing system is computationally complex and requires the user to possess technical knowledge in order to define membership functions and implement the necessary tools. For example, in the context of increasingly dynamic and flexible production systems, FABC is a method of producing cost estimates that can support decision-making more accurately than traditional costing methods. In conclusion, the proposed fuzzy activity-based costing model represents a viable means of resolving the long-standing issue of inaccurate indirect cost allocation in uncertain environments. FABC will provide managers with reliable, relevant and useful cost information that will enhance their ability to compete in the marketplace, improve the efficiency of their use of resources, and facilitate strategic cost management in the current uncertain environment. Potential areas of future research include the development of empirical studies examining the application of FABC models in specific industries, the examination of the feasibility of integrating FABC models with emerging technologies such as artificial intelligence (AI)-driven data analytics, and the comparison of the feasibility of using fuzzy logic to handle uncertainty in costing models with other uncertainty-handling techniques (e.g. Monte Carlo simulations) in order to further test and develop the practical application of FABC models.

References:

- [1]. Ali, R. S., et al. (2024). Impact of Climate Change Policies on Sustainable Development. *The Global Conference on Entrepreneurship and the Economy in an Era of Uncertainty*, 609-624. Springer Nature Singapore.
- [2]. Al-Matari, A. S., et al. (2022). The impact of dynamic accounting information system on organizational resilience: the mediating role of business processes capabilities. *Sustainability*, 14(9), 4967.
- [3]. Liang, H. (2025). Modern Technology's role in accounting cost calculation of industrial enterprises: Informatization as a key strategy to improve management efficiency. *Heliyon*, 11(1).
- [4]. Adetayo, A. R., et al. (2025). A Comparative Study of Traditional and Activity-Based Costing Methods for Cost Allocation in Business Practices. *International Journal of Innovative Scientific Research*, 3(2), 14-18.
- [5]. Ali, A. M. M., et al. (2023). Using Time-Driven Benchmarking for Measuring Health Services Performance Under COVID-19 Pandemic. *International Journal of Professional Business Review: Int. J. Prof. Bus. Rev.*, 8(2), 9.

- [6]. Dipya, I. N. T., & Martadinata, I. P. H. (2024). Penentuan harga pokok produksi dengan metode activitybased costing produk minyak kemiri bakar pada umkm oemah uncle b di kabupaten buleleng: Harga Pokok Produksi, Activity Based Costing. *Jurnal Ilmiah Akuntansi dan Humanika*, 14(1), 43-54.
- [7]. Zavrbska, M., & Besta, P. (2024). Logistics cost management in foundry production using the Activity-Based Costing method. *Acta Logistica (AL)*, 11(4).
- [8]. Kumar Podder, S., & Podder, S. (2025). Cost Overrun Prediction in Road Construction: A Fuzzy Logic and Clustering Approach. *International Conference on Transportation and Development 2025*, 691-700.
- [9]. Senić, A., Dobrodolac, M., & Stojadinović, Z. (2024). Predicting extension of time and increasing contract price in road infrastructure projects using a sugeno fuzzy logic model. *Mathematics*, 12.
- [10]. Ariche, S., et al. (2025). Enhancing energy management in battery electric vehicles: A novel approach based on fuzzy Q-learning controller. *Engineering Science and Technology, an International Journal*, 67, 102070.
- [11]. Esmalifalak, H., Albin, M. S., & Behzadpoor, M. (2015). A comparative study on the activity based costing systems: Traditional, fuzzy and Monte Carlo approaches. *Health Policy and Technology*, 4(1), 58-67.
- [12]. Zhang, Q. (2025). The Green Productivity Improvements in Manufacturing and the Geographical Impact of the Digital Economy Using a Fuzzy Rule-Based Approach. *International Journal of Fuzzy Systems*, 1-16.
- [13]. Etges, A. P. B. D. S., et al. (2024). Improvements in technology and the expanding role of time-driven, activity-based costing to increase value in healthcare provider organizations: a literature review. *Frontiers in Pharmacology*, 15, 1345842.
- [14]. Biadacz, R. (2022). The use of modern varieties of cost accounting as a cost management strategic tool by SMEs in Poland. *Polish Journal of Management Studies*, 26(2), 42-59.
- [15]. Arend, R. J. (2022). The costs of ambiguity in strategic contexts. *Administrative Sciences*, 12(3), 108.
- [16]. Varani, M., et al. (2025). Automated activity-based costing for large tractor fleets: A scalable CANBUS framework for farm economics. *Smart Agricultural Technology*, 12, 101171.
- [17]. Sauder, N., et al. (2025). What Patient, Surgical, and Hospital Factors Are Associated With Increased Value in Primary Total Hip Arthroplasty? A Patient-Level Value Analysis of 2,203 Procedures With Time-Driven Activity-Based Costing. *The Journal of Arthroplasty*.
- [18]. Chan, T. K., et al. (2025). Comparison of Incremental Costs and Medicare Reimbursement for Intra-Versus Extra-Articular Distal Radius Fracture Surgery Using Time-Driven Activity-Based Costing. *The Journal of Hand Surgery*.
- [19]. Amrih, G. G., & Mulya, A. S. (2024). Analysis of Calculating the Cost of Goods Produced by a Car Body Companyi Using the Activity-Based Costing Method in Determining Selling Prices (case study at PT. XYZ Company). *International Journal of Finance Research*.
- [20]. Yasin, V., & Sianipar, A. Z. (2025). Design of a Printing Production Cost Information System Using the Activity Based Costing Method. *Jurnal Teknologi Informatika dan Komputer*, 11(2), 584-593.
- [21]. Nardi-Hiebl, S., et al. (2025). The resource requirements of perioperative patient warming in German hospitals—the results of a prospective, multicenter activity-based costing study. *BMC anesthesiology*, 25(1), 349.
- [22]. Esmalikia, G., Sabzalipour, F., & Moradian, Z. (2025). The perspective of the implementation of activity based costing in public sector institutions: Investigating the impact of the current state of deployment of the costing system. *Journal of Accounting and Social Interests*, 14(4), 25–58.
- [23]. Rexhepi, B. R., et al. (2024). The Cost Calculation Method Based on Activity Is Known as The Activity-Based Costing (ABC) Method. *International Journal of Religion*. 2024. 5, 2054-2069.
- [24]. Constantinescu, D. S., et al. (2022). Time-driven activity-based costing in preoperative tasks for total hip and knee arthroplasty. *The Journal of arthroplasty*, 37(5), 809-813.
- [25]. Ali, A. M. M., Jabir, S. M., Kadhim, A. A., & Almagtome, A. (2022). Nanotechnology Practices and Cost Restructure for Effective Cost Management under Industry 4.0 Based Manufacturing Systems. *TEM Journal*, 11(3).
- [26]. Hajj, C. E., Jawad, D., & Montes, G. M. (2021). Analysis of a construction innovative solution from the perspective of an information system theory. *Journal of construction engineering and management*, 147(9), 03121003.
- [27]. Stončiuvienė, N., Ūsaitė-Duonielienė, R., & Zinkevičienė, D. (2020). Integration of Activity-Based Costing Modifications and LEAN Accounting into Full Cost Calculation: ABC and LEAN accounting. *Engineering Economics*, 31(1), 50-60.
- [28]. Almeida, A., & Cunha, J. (2017). The implementation of an Activity-Based Costing (ABC) system in a manufacturing company. *Procedia manufacturing*, 13, 932-939.
- [29]. Zhao, J., & Yang, G. H. (2024). Event-triggered-based adaptive fuzzy finite-time resilient output feedback control for MIMO stochastic nonlinear system subject to deception attacks. *IEEE Transactions on Fuzzy Systems*.
- [30]. Islam, M. S., Salem, M., Tantawy, M., & Salah, M. (2024). Cost overrun risk assessment for healthcare projects: A modified fuzzy group decision-making approach. *Journal of Construction Engineering and Management*, 150(12), 04024168.
- [31]. Ouifak, H., & Idri, A. (2025). A Comprehensive Review of Fuzzy Logic based Interpretability and Explainability of Machine Learning Techniques Across Domains. *Neurocomputing*, 130602.
- [32]. Xu, H., Ouyang, X., & Zhao, N. (2025). Dynamic Event-Triggered Low-Computation Neural Adaptive Output-Feedback Control for Strict-Feedback Nonlinear Systems with Prescribed Performance. *Engineering Letters*, 33(4).
- [33]. Dong, S., et al. (2025). Cooperative Quantized Event-Based Fuzzy Tracking Control of Nonlinear Autonomous Surface Vehicles With Prescribed Performance. *IEEE Transactions on Automation Science and Engineering*, 22, 17594-17605.

- [34]. Xu, B., & Li, Y. X. (2024). Switching fuzzy adaptive finite-time control of nonlinear systems via event-triggered output feedback strategy. *International Journal of Fuzzy Systems*, 26(1), 304-319.
- [35]. Zhou, S., et al. (2023). Coding-Decoding-Based Sliding Mode Control for Markovian Jump Systems Under Constrained Bit Rate: An Adaptive Quantizer Approach. *IEEE Transactions on Control of Network Systems*, 11(1), 257-270.
- [36]. Yang, Y., Niu, Y., & Li, J. (2025). Fuzzy modeling and event-triggered control of offshore platforms under constrained bandwidth: an encoding-decoding scheme. *Nonlinear Dynamics*, 1-24.
- [37]. Li, K., et al. (2025). A memetic algorithm based on feasible solutions with local search for fuzzy unrelated parallel machine scheduling with fuzzy cost constraint. *Applied Soft Computing*, 113545.
- [38]. Ostadi, B., Daloie, R. M., & Sepehri, M. M. (2019). A combined modelling of fuzzy logic and Time-Driven Activity-based Costing (TDABC) for hospital services costing under uncertainty. *Journal of biomedical informatics*, 89, 11-28.
- [39]. Ibrahim, O., et al. (2025). Comparative Evaluation of Different Fuzzy Tuning Rules on Energy Management Systems Cost Savings. *Results in Engineering*, 105107.
- [40]. Daas, S., & Innal, F. (2025). Uncertainty assessment of improved multistate reliability in the sociotechnical systems based on the polymorphic fuzzy entropy fault tree analysis and triptych cost-benefit-safety analysis. *Journal of Loss Prevention in the Process Industries*, 94, 105570.
- [41]. Subramanian, B., et al. (2025). Big data and fuzzy logic for demand forecasting in supply chain management: a data-driven approach. *Journal of fuzzy extension and applications*, 6(2), 260-283.
- [42]. Kouki, M., Vidal, P. E., & El-Sehiemy, R. A. (2025). Generic fuzzy-based optimal energy management strategy for efficient performance of realistic micro-grids with battery lifetime enhancement under climate changes. *Journal of Energy Storage*, 128, 116977.
- [43]. Onyedikachi, C. (2025). Cost volume profit analysis and activity based costing techniques on performance of nigerian champion brewery PLC. *Research Journal of Accounting and Finance (RJAF)*, 13(1).