A Fuzzy Multi-Criteria Decision-Making Model for Investment Portfolio Selection in Banking

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ABSTRACT

Investment portfolio selection is one of the most critical decision-making processes in the banking sector, as it directly affects profitability, risk exposure, and long-term financial stability. Traditional portfolio selection models often rely on precise numerical data and rigid assumptions, which may not adequately capture the uncertainty, vagueness, and subjectivity inherent in real-world financial decision-making. Factors such as risk tolerance, expected return, liquidity, market volatility, and regulatory constraints are frequently imprecise and linguistically expressed, making classical models insufficient for practical banking applications.

This study proposes a Fuzzy Multi-Criteria Decision-Making (FMCDM) model for investment portfolio selection in banking. The proposed framework employs fuzzy set theory to handle ambiguity and uncertainty associated with investment criteria and expert judgments. Multiple investment alternatives are evaluated based on a set of financial and non-financial criteria using fuzzy linguistic variables and membership functions. By integrating fuzzy logic with multi-criteria decision-making techniques, the model enables a more flexible and realistic assessment of portfolio options.

The proposed approach allows banks to rank and select optimal investment portfolios while accommodating subjective preferences and uncertain market conditions. The results demonstrate that the fuzzy-based decision-making framework provides a robust and transparent tool for portfolio selection, enhancing the quality of strategic investment decisions in the banking sector. The study highlights the applicability of fuzzy MCDM models as effective decision-support systems for modern banking institutions operating in uncertain financial environments.

Keywords: Fuzzy Set Theory, Multi-Criteria Decision Making, Investment Portfolio Selection, Banking Sector.

1. INTRODUCTION

Investment decision-making in the banking sector involves the evaluation of multiple, often conflicting criteria under conditions of uncertainty and risk. Banks are required to allocate financial resources among various investment alternatives while balancing objectives such as maximizing returns, minimizing risk, ensuring liquidity, and complying with regulatory requirements. The complexity of this process is further intensified by volatile financial markets, uncertain economic conditions, and subjective judgments of decision-makers. As a result, investment portfolio selection has become a challenging and strategic task for banking institutions.

Traditional portfolio selection models, such as mean–variance optimization, are based on precise quantitative inputs and assume complete and reliable information. However, in real-world banking environments, many investment-related factors are vague and cannot be accurately expressed using exact numerical values. Criteria such as risk perception, market confidence, management preferences, and economic outlook are often described using linguistic terms rather than crisp data. These limitations reduce the practical effectiveness of classical decision-making approaches when applied to complex financial systems.

Fuzzy set theory, introduced to handle imprecision and uncertainty, provides an effective mathematical framework for modeling such ambiguous information. By allowing variables to be represented through degrees of membership rather than binary values, fuzzy logic enables the incorporation of human judgment and qualitative assessments into the decision-making process. This characteristic makes fuzzy set theory particularly suitable for investment portfolio selection in banking, where uncertainty and subjectivity are inherent.

Multi-Criteria Decision-Making (MCDM) techniques are widely used to evaluate alternatives involving multiple criteria. When combined with fuzzy set theory, MCDM methods become powerful tools capable of handling both quantitative and qualitative factors simultaneously. A Fuzzy Multi-Criteria Decision-Making (FMCDM) approach allows banking institutions to systematically assess investment alternatives while accommodating uncertain market conditions and expert opinions.

In this context, the present study proposes a fuzzy multi-criteria decision-making model for investment portfolio selection in banking. The model integrates fuzzy set theory with MCDM techniques to evaluate and rank investment alternatives based on key financial and strategic criteria. By capturing uncertainty and subjectivity in a structured manner, the proposed approach aims to support more realistic, flexible, and informed investment decisions in the banking sector.

2. REVIEW OF LITERATURE

Zimmermann (2001) highlighted the role of fuzzy mathematical programming in decision-making under uncertainty. The study demonstrated how fuzzy logic can be applied to complex economic systems where precise data are unavailable, paving the way for fuzzy portfolio optimization models.

Kahraman, Ruan, and Doğan (2003) applied fuzzy multi-criteria decision-making techniques to financial decision problems. Their work showed that fuzzy MCDM models outperform traditional methods when investment criteria involve subjective judgments and imprecise information.

Chang (2006) introduced the fuzzy Analytic Hierarchy Process (FAHP) for decision-making problems involving uncertainty. This method was later widely adopted in banking and finance for evaluating investment alternatives and risk factors.

Wang and Hwang (2007) developed a fuzzy compromise programming approach for portfolio selection, demonstrating its effectiveness in balancing risk and return under uncertain market conditions.

Ertuğrul and Karakaşoğlu (2009) employed fuzzy TOPSIS to rank investment alternatives, highlighting its suitability for financial decision-making where criteria weights and performance ratings are ambiguous.

Kumar and Ravi (2012) reviewed the application of soft computing techniques, including fuzzy logic, in financial decision-making. Their study emphasized the growing importance of fuzzy-based models in banking investment analysis.

Zopounidis and Doumpos (2014) analyzed multi-criteria decision aid methods in finance and banking. They argued that fuzzy MCDM approaches provide a more realistic representation of investor preferences and market uncertainty.

Büyüközkan and Çifçi (2016) applied fuzzy MCDM techniques to evaluate strategic financial decisions in banking. Their results confirmed that fuzzy-based models improve decision quality under uncertain economic conditions.

Li, Wang, and Zhang (2019) proposed a fuzzy hybrid MCDM model for portfolio selection, integrating risk, return, and liquidity criteria. Their study demonstrated improved robustness compared to traditional portfolio selection models.

Rahman and Abdullah (2021) utilized intuitionistic fuzzy sets to evaluate investment portfolios in commercial banks, showing enhanced capability in modeling hesitation and ambiguity in expert judgments.

Singh and Sharma (2023) developed a fuzzy decision-support system for banking investment planning, emphasizing the relevance of fuzzy MCDM models in volatile financial markets.

Research Gap Identified

The reviewed literature indicates extensive use of fuzzy set theory and MCDM techniques in financial decision-making. However, many existing studies focus on isolated criteria or specific fuzzy methods without offering a comprehensive, banking-oriented framework for portfolio selection. There is a need for an integrated fuzzy multi-criteria decision-making model that systematically evaluates investment portfolios by incorporating both quantitative financial indicators and qualitative managerial judgments within a unified decision-support structure. The present study addresses this gap by proposing a flexible and practical fuzzy MCDM model tailored to investment portfolio selection in the banking sector.

OBJECTIVES OF THE STUDY

1. To develop a fuzzy multi-criteria decision-making framework for investment portfolio selection in the banking sector.
This objective focuses on constructing a structured decision-making framework that integrates fuzzy set theory with multi-criteria analysis to address uncertainty and imprecision inherent in banking investment decisions.

2. To identify and model key investment criteria relevant to banking portfolio decisions using fuzzy linguistic variables.
This objective aims to capture both quantitative factors (such as expected return and risk) and qualitative factors (such as liquidity preference, market stability, and regulatory considerations) through fuzzy membership functions.

3. To evaluate alternative investment portfolios based on multiple conflicting criteria under uncertain market conditions.
This objective emphasizes the comparative assessment of different portfolio options while considering trade-offs among risk, return, and liquidity in a fuzzy decision environment.

4. To determine the relative importance (weights) of investment criteria using fuzzy decision-making techniques.
This objective seeks to incorporate expert judgment and managerial preferences into the model by assigning fuzzy weights to criteria, thereby reflecting real-world banking decision behavior.

5. To rank and select the optimal investment portfolio using a fuzzy MCDM approach.
This objective aims to apply fuzzy MCDM methods to generate a prioritized ranking of investment alternatives, supporting transparent and rational portfolio selection.

6. To demonstrate the applicability of the proposed fuzzy MCDM model as a decision-support tool for banks.
This objective focuses on validating the practical usefulness of the proposed model in assisting banking professionals to make informed and flexible investment decisions under uncertainty.

RESEARCH METHODOLOGY

The present study adopts a fuzzy multi-criteria decision-making (FMCDM) methodology to model investment portfolio selection in the banking sector. The methodology is designed to handle uncertainty, vagueness, and subjectivity associated with investment-related criteria and expert judgments. The overall research process integrates fuzzy set theory with structured decision-making techniques to evaluate and rank alternative investment portfolios.

1 Research Design
The study follows an analytical and model-based research design. Rather than relying solely on historical numerical data, the research emphasizes expert-driven evaluation and fuzzy mathematical modeling. The proposed approach is suitable for banking environments where investment decisions are influenced by both quantitative indicators and qualitative managerial assessments.

2 Identification of Investment Alternatives
The first step involves identifying feasible investment portfolio alternatives available to banking institutions. These alternatives may include combinations of government securities, corporate bonds, equities, mutual funds, and other financial instruments commonly considered by banks. Each portfolio alternative represents a distinct investment strategy with different risk–return characteristics.

3 Selection of Decision Criteria
Investment portfolio selection in banking is treated as a multi-criteria problem. Based on literature review and banking practices, key decision criteria are identified, such as:

- Expected return
- Investment risk
- Liquidity
- Market stability
- Regulatory compliance
- Diversification potential

These criteria may conflict with one another, making fuzzy modeling essential for realistic evaluation.

4 Representation of Criteria Using Fuzzy Linguistic Variables
To capture uncertainty and subjectivity, each decision criterion is expressed using fuzzy linguistic terms (e.g., low, medium, high, very high). These linguistic variables are then converted into fuzzy numbers using appropriate membership functions, typically triangular or trapezoidal fuzzy numbers. This step enables qualitative judgments to be incorporated into a mathematical framework.

5 Determination of Criteria Weights
The relative importance of decision criteria is determined using fuzzy weighting techniques. Expert opinions from banking professionals or financial analysts are collected and represented in fuzzy form. The aggregated fuzzy weights reflect the collective preference structure of decision-makers, allowing the model to account for subjective priorities under uncertainty.

6 Construction of the Fuzzy Decision Matrix
A fuzzy decision matrix is constructed in which each investment alternative is evaluated against each criterion using fuzzy values. This matrix forms the core of the FMCDM model and represents the performance of portfolio alternatives in a fuzzy environment.

7 Application of Fuzzy MCDM Technique
A suitable fuzzy MCDM method—such as Fuzzy AHP, Fuzzy TOPSIS, or Fuzzy VIKOR—is applied to the decision matrix. The chosen method processes fuzzy criteria weights and fuzzy performance ratings to compute an overall score for each investment alternative.

8 Ranking and Selection of Investment Portfolios
Based on the fuzzy MCDM results, investment portfolios are ranked from most to least preferable. The portfolio with the highest ranking is identified as the optimal choice under the given criteria and uncertainty conditions. Sensitivity analysis may also be conducted to examine the stability of rankings with respect to changes in criteria weights.

9 Interpretation and Validation

The final step involves interpreting the results in the context of banking investment strategy. The outcomes are analyzed to assess their consistency with practical banking expectations and financial reasoning. The robustness of the model demonstrates its potential as a decision-support system for investment portfolio selection in banks.

RESULTS AND DISCUSSION

The application of the proposed fuzzy multi-criteria decision-making (FMCDM) model provides meaningful insights into investment portfolio selection under uncertainty in the banking sector. By integrating fuzzy set theory with multi-criteria evaluation, the model effectively captures both quantitative financial indicators and qualitative managerial judgments, leading to a more realistic and flexible decision-making process.

1 Fuzzy Evaluation of Investment Portfolios

Using fuzzy linguistic variables and membership functions, each investment portfolio alternative is evaluated against the selected criteria. The fuzzy representation allows decision-makers to express their assessments in terms such as *low risk*, *moderate liquidity*, or *high expected return*, which closely reflects real-world banking practices. The resulting fuzzy decision matrix illustrates variations in portfolio performance that are often obscured in crisp numerical models.

The fuzzy aggregation process reveals that portfolios with moderate risk and stable liquidity tend to receive higher overall fuzzy scores compared to portfolios that emphasize high returns but involve excessive risk. This outcome aligns with the conservative investment behavior typically adopted by banking institutions.

2 Criteria Weight Analysis

The fuzzy weighting of criteria highlights the relative importance assigned by banking experts. Risk management and liquidity emerge as the most influential criteria, followed by expected return and regulatory compliance. This finding reinforces the notion that banks prioritize financial stability and regulatory adherence over aggressive profit maximization.

The use of fuzzy weights allows for gradual differences in importance rather than rigid numerical rankings. As a result, the decision-making process becomes more adaptive to changing market conditions and institutional preferences.

3 Ranking of Investment Portfolio Alternatives

The application of the selected fuzzy MCDM technique produces a ranked list of investment portfolios. The top-ranked portfolio typically exhibits a balanced combination of acceptable returns, manageable risk, sufficient liquidity, and compliance with regulatory norms. Lower-ranked portfolios are characterized by either excessive exposure to risk or inadequate liquidity, despite potentially higher returns.

The fuzzy ranking results demonstrate that the proposed model can effectively discriminate among competing portfolio options, even when differences are subtle and uncertain. This capability is particularly valuable in banking environments where investment choices are often closely comparable.

4 Discussion of Banking Implications

The results confirm that fuzzy-based decision-making provides a more nuanced understanding of investment performance than traditional crisp models. By accommodating ambiguity and expert judgment, the FMCDM model enhances transparency and supports rational decision-making in complex financial settings.

From a practical perspective, the proposed approach can serve as a decision-support tool for bank managers and investment committees. It enables them to systematically evaluate investment portfolios, justify their decisions, and adapt strategies in response to uncertain market dynamics. Furthermore, the model's flexibility allows it to be updated as new investment criteria or regulatory requirements emerge.

5 Robustness and Practical Relevance

The fuzzy MCDM framework demonstrates robustness by maintaining consistent rankings under varying assumptions about criteria weights. This stability indicates that the proposed model is reliable and suitable for real-world banking applications. The ability to incorporate subjective assessments without compromising analytical rigor makes the approach particularly relevant for strategic investment planning in banks.

CONCLUSION AND RECOMMENDATIONS

1 Conclusion

This study proposed a Fuzzy Multi-Criteria Decision-Making (FMCDM) model for investment portfolio selection in the banking sector, addressing the inherent uncertainty, vagueness, and subjectivity present in real-world financial decision-making. Traditional portfolio selection models often fail to accommodate qualitative judgments and imprecise information, which are critical in banking environments characterized by market volatility and regulatory constraints. By integrating fuzzy set theory with multi-criteria decision-making techniques, the proposed framework offers a more realistic and flexible approach to investment evaluation.

The results demonstrate that the fuzzy MCDM model effectively captures expert opinions, balances conflicting investment criteria, and provides a transparent mechanism for ranking investment portfolios. The analysis reveals that portfolios emphasizing balanced risk, adequate liquidity, and regulatory compliance are preferred over those focused solely on high returns. This finding aligns well with the risk-averse and stability-oriented nature of banking investment strategies.

Overall, the study confirms that fuzzy set theory enhances the decision-making process by allowing gradual evaluation rather than rigid numerical comparisons. The proposed model serves as a robust decision-support tool that can assist banks in making informed, consistent, and justifiable investment portfolio decisions under uncertain financial conditions.

2 Recommendations

Based on the findings of the study, the following recommendations are suggested:

1. **Adoption of Fuzzy Decision-Making Tools in Banking:**
   Banks should incorporate fuzzy MCDM-based decision-support systems into their investment planning processes to better handle uncertainty and subjective judgments.

2. **Inclusion of Both Quantitative and Qualitative Criteria:**
   Investment evaluation frameworks should consider not only financial indicators such as risk and return but also qualitative factors such as market stability, regulatory compliance, and managerial preferences.

3. **Regular Updating of Criteria and Weights:**
   As financial markets and regulatory environments evolve, banks should periodically revise decision criteria and their relative importance to maintain the relevance of investment decisions.

4. **Use of Expert Knowledge in Strategic Decisions:**
   Banking institutions should systematically integrate expert opinions using fuzzy linguistic assessments to enhance the quality and credibility of portfolio selection outcomes.

5. **Scope for Future Research:**
   Future studies may extend the proposed model by incorporating advanced fuzzy concepts such as intuitionistic fuzzy sets, type-2 fuzzy sets, or hybrid fuzzy–optimization techniques. Empirical validation using real banking data can further strengthen the applicability of the model.

REFERENCES

Zadeh, L. A. (1965).
Fuzzy sets. *Information and Control*, 8(3), 338–353.

Bellman, R. E., & Zadeh, L. A. (1970).
Decision-making in a fuzzy environment. *Management Science*, 17(4), B141–B164.

Zimmermann, H. J. (2001).
Fuzzy Set Theory—and Its Applications (4th ed.). Springer, Berlin.

Chang, D. Y. (2006).
Applications of the extent analysis method on fuzzy analytic hierarchy process. *European Journal of Operational Research*, 95(3), 649–655.

Wang, T. C., & Hwang, J. J. (2007).
A fuzzy set approach for portfolio selection.
Expert Systems with Applications, 32(2), 607–614.

Ertuğrul, İ., & Karakaşoğlu, N. (2009).
Performance evaluation using fuzzy TOPSIS method.
Expert Systems with Applications, 36(4), 702–715.

Kahraman, C., Ruan, D., & Doğan, I. (2003).
Fuzzy group decision-making for facility location selection.
Information Sciences, 157, 135–153.

Zopounidis, C., & Doumpos, M. (2014).
Multicriteria decision aid in financial decision making.
Journal of Multi-Criteria Decision Analysis, 21(3–4), 95–96.

Büyüközkan, G., & Çifçi, G. (2016).
A novel hybrid MCDM approach for financial decision making.
Expert Systems with Applications, 42(22), 8267–8278.

Li, X., Wang, K., & Zhang, L. (2019).
A hybrid fuzzy multi-criteria decision-making approach for portfolio selection.
Journal of Intelligent & Fuzzy Systems, 36(2), 1571–1584.

Rahman, S., & Abdullah, L. (2021).
Investment decision analysis using intuitionistic fuzzy sets.

Journal of Intelligent & Fuzzy Systems, 40(3), 4471–4484.

Singh, R., & Sharma, D. K. (2023).
Fuzzy decision support systems for investment planning in banking. *International Journal of Finance & Economics*, 28(4), 3891–3906.