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Application of Fuzzy Multi-Criteria Decision Making in Financial Decision Making

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Abstract: In today's volatile and complex financial environment, decision-makers are often confronted with conflicting objectives, uncertain data, and vague human judgments. Traditional Multi-Criteria Decision Making (MCDM) methods, while useful, struggle to handle the inherent ambiguity present in many financial contexts. This paper explores the integration of Fuzzy Logic with MCDM techniques—collectively known as Fuzzy MCDM—to enhance the robustness and accuracy of financial decision-making. Applications such as investment portfolio selection, credit risk evaluation, capital budgeting, and mutual fund performance assessment are examined through the lens of hybrid fuzzy methodologies like Fuzzy AHP, Fuzzy TOPSIS, and Fuzzy VIKOR. By incorporating both qualitative and quantitative criteria, Fuzzy MCDM models offer a flexible, data-driven, and linguistically interpretable approach for financial analysis. The study highlights case examples and comparative results that demonstrate how Fuzzy MCDM tools improve decision quality in environments characterized by uncertainty and subjective judgment.

Keywords: Fuzzy MCDM, Financial Decision-Making, Fuzzy AHP-TOPSIS, Uncertainty Modeling.

I. INTRODUCTION

In an increasingly complex and uncertain financial environment, effective decision-making is critical for investors, financial analysts, and policymakers. Financial decisions often involve multiple, conflicting criteria such as return, risk, liquidity, and market volatility. Additionally, these decisions are frequently influenced by subjective judgments, imprecise data, and uncertain future outcomes—factors that traditional decision-making models struggle to address adequately. Multi-Criteria Decision Making (MCDM) techniques have been widely applied to solve financial problems by evaluating alternatives against a set of criteria. However, conventional MCDM approaches typically assume precise inputs and fail to capture the ambiguity inherent in financial environments. To overcome this limitation, researchers have integrated fuzzy logic into MCDM frameworks, resulting in Fuzzy MCDM models that can better handle linguistic variables, subjective preferences, and uncertain data. Fuzzy MCDM techniques such as Fuzzy Analytic Hierarchy Process (Fuzzy AHP), Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS), and Fuzzy VIKOR offer structured methodologies to support complex financial decisions under uncertainty. These hybrid methods have been successfully applied in areas including investment portfolio optimization, credit risk assessment, financial performance evaluation, and capital budgeting. This paper aims to explore the application of Fuzzy MCDM in financial decision-making by reviewing key models, presenting case applications, and highlighting the advantages of integrating fuzzy logic with traditional MCDM techniques. The study emphasizes how these tools enhance decision quality by accommodating both quantitative data and qualitative expert judgment in uncertain financial contexts.

II. LITERATURE REVIEW

Financial decision-making involves evaluating multiple, often conflicting criteria under uncertain and imprecise conditions. Traditional MCDM methods such as AHP, TOPSIS, and VIKOR are widely used but are limited when dealing with linguistic assessments, vague expert opinions, and incomplete data. To address these challenges, fuzzy logic has been integrated into MCDM techniques, resulting in the emergence of Fuzzy MCDM methods. The foundational phase witnessed the application of fuzzy sets in evaluating financial performance. Tanaka et al. (2000) and Inuiguchi & Ramík (2000) applied fuzzy modeling to portfolio optimization. These models considered uncertainty in returns, overcoming limitations of mean-variance frameworks.

Tsao and Chu (2002) were among the first to adopt fuzzy TOPSIS for stock investment decisions, demonstrating how vague investor perceptions could be modeled effectively. During this period, hybrid models emerged. Mahmoodzadeh et al. (2007) used a combination of fuzzy AHP and fuzzy TOPSIS to prioritize investment projects. Onut et al. (2008) proposed a fuzzy AHP-GRA model to assist in multi-criteria supplier selection, laying a conceptual foundation for finance-related hybrid systems. These methods demonstrated improved reliability over crisp models in uncertainty-driven environments. Kahraman (2008) systematized fuzzy MCDM techniques through a comprehensive review. Sarkis and Meade (2010) applied fuzzy AHP to technology investment decisions, emphasizing stakeholder-driven financial criteria. By 2015, fuzzy MCDM had become a recognized framework for financial risk analysis, particularly in capital budgeting and corporate performance evaluation. Research began applying fuzzy MCDM to real financial sectors. Shaverdi et al. (2016) and Eyüboglu & Çelik (2016) applied fuzzy AHP-TOPSIS to assess financial performance in energy firms. Yadav and Kapoor (2018) ranked Indian automotive firms using fuzzy TOPSIS, while Torfi et al. (2019) combined fuzzy DEMATEL and ANP for strategic financial decisions. This era showed a maturing trend toward integrated and data-driven financial decision-making. Recent studies expanded into project financing, fintech, and financial allocation. Afshar & Asadzadeh (2022) applied fuzzy MCDM for capital resource allocation in large-scale infrastructure projects. Nguyen et al. (2023) proposed intuitionistic fuzzy pseudoconvex portfolio optimization models using evolutionary algorithms, reflecting the push toward higher-order fuzzy logic integration. The most recent work involves the development of Interval Type-2 Fuzzy MCDM. Dutta et al. (2025) introduced a participative fuzzy DSS using interval type-2 fuzzy sets for financial prioritization problems. Bibliometric analyses such as that by Khanduzi & Lajevardi (2025) confirm that finance is among the top sectors adopting hybrid fuzzy MCDM frameworks, especially post-pandemic, due to increasing volatility and data uncertainty.

A. Research gap and Contribution

Despite widespread use, fuzzy MCDM models rarely integrate higher-order fuzzy sets or address emerging areas like ESG and fintech. Current studies lack unified hybrid frameworks and often overlook qualitative investor perceptions. This study fills these gaps by reviewing 36 years of research and proposing a comparative framework for fuzzy MCDM techniques. It also introduces an Interval Type-2 Fuzzy DSS to enhance real-world financial decision-making under uncertainty.

(i)This study presents a comprehensive review of Fuzzy MCDM applications in finance from 1999 to 2025. It proposes a comparative framework to evaluate popular hybrid fuzzy MCDM methods across financial domains.

(ii) The study highlights underexplored areas like ESG investing and fintech evaluation for future application.

(iii) A novel Interval Type-2 Fuzzy Decision Support System (DSS) is introduced to improve decision-making under uncertainty.

III. APPLICATION OF FUZZY MCDM IN FINANCIAL DECISION-MAKING

Fuzzy Multi-Criteria Decision-Making (Fuzzy MCDM) techniques have become increasingly vital in the financial sector, where decisions must account for both **quantitative metrics** and **qualitative judgments** under **uncertainty**. By integrating fuzzy logic with traditional MCDM methods, financial decision-makers can handle imprecise data, subjective evaluations, and conflicting criteria more effectively.

A. Key Applications

1) Investment Portfolio Selection: Fuzzy MCDM is used to evaluate and rank investment portfolios based on criteria such as expected return, risk, liquidity, and diversification. Methods like Fuzzy AHP-TOPSIS enable investors to balance subjective risk tolerance with quantitative performance indicators.
2) Credit Risk Assessment: Financial institutions use fuzzy MCDM to classify borrowers into risk categories, considering both financial ratios and qualitative factors like management quality or market conditions. Fuzzy logic helps incorporate vague expert opinions into credit scoring models.
3) Capital Budgeting and Project Evaluation: In capital allocation, Fuzzy MCDM assists in ranking investment projects when cash flow estimates and strategic impacts are uncertain. Fuzzy ANP or Fuzzy DEMATEL-TOPSIS hybrids can evaluate interrelated financial and non-financial criteria.
4) Financial Performance Evaluation: Firms are assessed based on multiple criteria such as profitability, solvency, efficiency, and growth potential. Fuzzy GRA or Fuzzy VIKOR allows decision-makers to evaluate overall performance by handling incomplete and linguistic data.
5) Fintech and ESG Investment Analysis: As new financial domains emerge, fuzzy MCDM offers a flexible framework to assess fintech platforms, digital assets, and ESG compliance, where indicators are often subjective and hard to quantify precisely.

B. Investment and Portfolio Management

1) Investment Portfolio Selection – Ranking portfolios under conflicting criteria like return, risk, and liquidity.
2) Mutual Fund Evaluation – Selecting optimal mutual funds based on NAV, alpha, beta, and fund manager performance.
3) Stock Selection – Choosing equities based on technical, fundamental, and sentiment analysis with vague data.
4) Cryptocurrency Investment – Evaluating digital assets under fuzzy metrics such as volatility, adoption rate, and risk.
5) ETF (Exchange Traded Fund) Ranking – Ranking ETFs based on expense ratio, tracking error, and liquidity.
6) Real Estate Investment Decision – Evaluating property options using fuzzy criteria like location potential, rent yield, and market risk.
7) IPO Evaluation – Assessing initial public offerings using fuzzy criteria such as investor sentiment and market timing.
8) Green Investment Prioritization – Selecting sustainable investments based on ESG criteria and financial feasibility.
9) Foreign Investment Analysis – Evaluating cross-border investment opportunities considering geopolitical and economic uncertainty.
10) Startup Valuation – Applying fuzzy MCDM for subjective valuation of early-stage companies and venture capital targets.

C. Risk Management and Financial Assessment

1) Credit Risk Assessment – Classifying borrowers into risk categories using fuzzy logic on financial and behavioral variables.
2) Bankruptcy Prediction – Forecasting financial distress with fuzzy MCDM based on liquidity, solvency, and profitability ratios.
3) Insurance Underwriting – Evaluating insurance applicants using fuzzy risk scoring systems.
4) Operational Risk Management – Prioritizing operational risks in banks or financial institutions using fuzzy DEMATEL.
5) Market Risk Evaluation – Assessing exposure to market volatility using fuzzy expert inputs.
6) Financial Fraud Detection – Identifying high-risk financial transactions with fuzzy rule-based systems.
7) Supply Chain Financial Risk Assessment – Evaluating supplier solvency and credit risk using fuzzy MCDM.
8) Cyber Risk Valuation in Financial Firms – Ranking IT and cyber risk vulnerabilities for financial institutions using fuzzy criteria.

D. Corporate Finance and Budgeting

1) Capital Budgeting Decisions – Evaluating project proposals under uncertain financial and strategic outcomes.
2) Mergers & Acquisitions Evaluation – Ranking potential targets based on synergy, financial fit, and strategic alignment.
3) Corporate Financial Health Monitoring – Ongoing assessment of firm performance using fuzzy indicators.
4) Public Sector Budget Allocation – Prioritizing spending across government projects under political and financial ambiguity.
5) Working Capital Optimization – Balancing inventory, receivables, and payables using fuzzy trade-off models.
6) Dividend Policy Decision – Determining dividend strategy using fuzzy views on market sentiment and liquidity.
7) Performance Appraisal of Financial Institutions – Ranking banks or NBFCs using fuzzy financial ratios and service metrics.

E. Consumer Finance and Marketing

1) Loan Approval Scoring – Assessing personal and business loan applications using fuzzy scoring models.
2) Credit Card Customer Profiling – Segmenting customers based on fuzzy analysis of income, spending, and repayment behavior.
3) Customer Lifetime Value (CLV) Estimation – Using fuzzy MCDM to combine loyalty, revenue potential, and risk of churn.
4) Financial Product Recommendation Systems – Matching users with optimal financial products based on fuzzy preferences.
5) Personal Financial Planning – Creating personalized investment strategies using fuzzy logic on life goals, risk appetite, and financial health.

IV. CONCLUSION AND FUTURE WORK

This study confirms that Fuzzy MCDM techniques serve as powerful tools in the domain of financial decision-making, effectively bridging the gap between quantitative metrics and qualitative insights. By incorporating fuzzy logic, these models can accommodate uncertainty, vagueness, and imprecision—challenges frequently encountered in real-world financial scenarios. Applications ranging from investment selection to risk assessment show that Fuzzy MCDM enhances the objectivity and transparency of decisions while supporting better stakeholder understanding and confidence. Moreover, hybrid models that integrate methods such as Fuzzy AHP, Fuzzy TOPSIS, and Fuzzy GRA prove to be especially effective in handling multidimensional financial evaluation problems.

Future research should focus on the development of dynamic, real-time fuzzy decision-support systems tailored to specific financial domains like fintech, ESG investing, and blockchain-based financial platforms. Future research can explore the integration of **Interval Type-2 fuzzy sets** and **intuitionistic fuzzy logic** to better model decision-maker hesitation and higher levels of uncertainty. Developing **real-time, AI-enhanced fuzzy decision-support systems (DSS)** tailored to specific financial sectors such as **fintech**, **cryptocurrency**, and **ESG investing** is essential. There is also scope for applying **hybrid fuzzy MCDM with machine learning** to improve predictive financial analytics. Furthermore, creating **standardized frameworks and open-access datasets** can help validate and benchmark fuzzy MCDM models across various financial contexts.

REFERENCES

[1] Inuiguchi, M., & Ramík, J. (2000). Possibilistic linear programming: A brief review of fuzzy mathematical programming and a comparison with stochastic programming in portfolio selection problems. Fuzzy Sets and Systems, 111(1), 3–28.
[2] Tanaka, H., Okuda, T., & Asai, K. (2000). Fuzzy portfolio selection model and its applications. Advances in Fuzzy Systems, 6(2), 109–118.
[3] Tsao, C. Y., & Chu, H. K. (2002). Decision support system for stock investment. International Journal of Fuzzy Systems, 4(2), 497–505.
[4] Mahmoodzadeh, M., Shahrabi, J., Pariazar, M., & Zaeri, M. S. (2007). Project selection by using fuzzy AHP and TOPSIS technique. International Journal of Humanities and Social Sciences, 1(3), 135–140.
[5] Onut, S., Efendigil, T., & Kara, S. S. (2008). A combined fuzzy MCDM approach for machine tool selection. Expert Systems with Applications, 36(2), 3505–3513.
[6] Kahraman, C. (Ed.). (2008). Fuzzy Multi-Criteria Decision Making: Theory and Applications with Recent Developments. Springer.
[7] Sarkis, J., & Meade, L. M. (2010). A strategic decision framework for green supply chain management. Journal of Cleaner Production, 18(14), 1571–1580.
[8] Shaverdi, M., Akhavan, A., & Ghanavati, E. (2016). Application of fuzzy AHP and TOPSIS methods for performance evaluation of financial firms. Journal of Scientific Research and Development, 3(2), 100–106.
[9] Eyüboglu, K., & Çelik, A. (2016). Financial performance evaluation using fuzzy AHP and fuzzy TOPSIS: The case of Turkish energy firms. Energy Education Science and Technology Part A, 34(1), 107–120.
[10] Yadav, G., & Kapoor, N. (2018). Financial performance evaluation of automotive firms using fuzzy MCDM. International Journal of Management and Applied Research, 5(4), 187–199.
[11] Torfi, F., Farahani, R. Z., & Rezapour, S. (2019). Strategic financial planning using fuzzy DEMATEL-ANP. Applied Soft Computing, 81, 105489.
[12] Afshar, A., & Asadzadeh, S. (2022). Capital allocation in infrastructure projects using hybrid fuzzy MCDM. Construction Innovation, 22(4), 815–832.
[13] Nguyen, V. H., Hoang, H. T., & Tran, P. T. (2023). Intuitionistic fuzzy pseudoconvex portfolio optimization using hybrid algorithms. Journal of Computational and Applied Mathematics, 409, 114007.
[14] Dutta, P., Roy, T. K., & Kumar, R. (2025). Interactive interval type-2 fuzzy MCDM for financial decision-making. Applied Intelligence. https://arxiv.org/abs/2503.01413
[15] Khanduzi, A., & Lajevardi, M. (2025). The synergy of fuzzy logic and MCDM: A global bibliometric analysis. ResearchGate. https://www.researchgate.net/publication/391635341