

Fuzzy MCDM Approach for NASDAQ Portfolio Selection: Balancing Risk and Return"

¹Dr. P. Roopa

¹Assistant Professor, Department of Department of Business Management, Sri Padmavati Mahila Visvavidyalayam, Tirupati, Andhra Pradesh, India, 517 501

¹Corresponding Author Email ID: roopauday.p@gmail.com

²Mrs Deivamani S

²Assistant Professor, Department of Management, Sri Ramakrishna College of Arts & Science, Coimbatore, Tamil Nadu, India, 641006

²E- mail id: deivamani@srcas.ac.in

³A.Sethupathi

³Assistant Professor, Department of Mathematics, Dr.N.G.P Arts and Science College Coimbatore, Tamil Nadu, India, 641048

³E-mail Id: Sethupathi.a@dmngpasc.ac.in

⁴D.Sundar

⁴Assistant Professor, Department of Mathematics, Dr.N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India, 641048

⁴E- mail id: srsajeev19@gmail.com

⁵Dr G.Yasmin

⁵Assistant professor, Department of Commerce, United College of Arts and science, Coimbatore, Tamil Nadu, India, 641020

⁵E- mail id: yasminmcs@uit.ac.in

⁶Dr G.Geetha

⁶Assistant professor, Department of Commerce, United College of Arts and science, Coimbatore, Tamil Nadu, India, 641020

⁶E- mail id: ggeetha351@gmail.com

⁷Siddharthan R

⁷Research Scholar, Department of Mathematics, AMET Deemed to be University, Chennai, Tamil Nadu, India, 603112

⁷E- mail id: siddharthanr62@gmail.com

⁸Dr. G. Jenitha

⁸Associate Professor, Department of Mathematics, AMET Deemed to be University, Chennai, Tamil Nadu, India, 603112

⁸E- mail id: jenitha.g@ametuniv.ac.in

Abstract

This study examines stock selection in a complex nonlinear dynamic environment by integrating two primary categories of financial indicators: Accounting Financial Measures (AFM) and Economic Value Financial Measures (EFM). It argues that a comparative evaluation of AFM and EFM offers a more comprehensive and reliable framework for investment decision-making. The analysis incorporates six key financial criteria: Return on Invested Capital (ROIC) (C1), Economic Value Added (EVA) (C2), Price/Earnings-to-Growth (PEG) Ratio (C3), Free Cash Flow (FCF) Yield (C4). To manage uncertainty and subjectivity in financial assessments, the study applies the Fuzzy Analytic Hierarchy Process (FAHP), a structured multi-criteria decision-making approach. Financial data were collected from the top ten companies listed on the NASDAQ Exchange, ensuring a representative sample of leading firms. The FAHP model facilitates the prioritization and ranking of financial indicators based on their relative importance in investment decisions. The results indicate that Return on Invested Capital (ROIC) (C1), is the most influential criterion, highlighting the critical role of profitability and effective utilization of shareholders' equity in stock selection. Other profitability and value-based measures, such as ROIC and EVA, also demonstrate strong influence, reinforcing the importance of long-term value creation. In contrast, liquidity-related measures have comparatively lower significance. Overall, the study provides meaningful insights for investors by emphasizing the prioritization of profitability and growth-oriented metrics over short-term solvency considerations, thereby supporting more strategic and effective portfolio construction.

Introduction

Stock selection is a critical component of investment decision-making, particularly in modern financial markets characterized by complexity, uncertainty, and nonlinear dynamics. The behavior of stock prices is influenced by a wide range of interrelated factors, including firm-specific financial performance, macroeconomic conditions, and investor sentiment. Traditional linear models often fail to capture these intricate relationships, thereby necessitating more advanced approaches that incorporate both quantitative financial indicators and qualitative judgment. In this context, the integration of multiple financial measures becomes essential for improving the reliability and robustness of investment decisions. Financial ratios have long been used as fundamental tools for evaluating corporate performance and guiding stock selection. These ratios can broadly be classified into two categories: Accounting Financial Measures (AFM) and Economic Value Financial Measures (EFM). AFM, such as Return on Equity (ROE) and Return on Invested Capital (ROIC), are derived from financial statements and reflect historical performance based on accounting principles. In contrast, EFM, including Economic Value Added (EVA) and valuation-based metrics like Enterprise Value-to-EBITDA (EV/EBITDA), focus on value creation and incorporate the cost of capital, providing a forward-looking perspective (Stewart, 1991; Damodaran, 2012). While both categories offer valuable insights, relying on a single type of measure may lead to incomplete or biased evaluations. Therefore, a comparative and integrated approach combining AFM and EFM is widely regarded as more effective in capturing the true financial health and growth potential of firms. In recent years, investors and researchers have increasingly emphasized profitability and value-based indicators as key determinants of stock performance. Measures such as ROE, ROIC, and EVA are considered strong indicators of a firm's ability to generate returns and create shareholder value (Penman, 2013). Similarly, growth-oriented metrics like the Price/Earnings-to-Growth (PEG) ratio and cash flow-based indicators such as Free Cash Flow (FCF) yield provide insights into a company's growth prospects and financial sustainability. However, the relative importance of these indicators may vary depending on market conditions and investor preferences, making the decision-making process inherently complex and uncertain. To address this complexity, multi-criteria decision-making (MCDM) techniques have been widely adopted in financial analysis. Among these, the Analytic Hierarchy Process (AHP), developed by Saaty (1980), has gained prominence due to its ability to structure complex decision problems into a hierarchical framework and assign relative weights to different criteria. Nevertheless, traditional AHP assumes precise judgments, which may not accurately reflect real-world uncertainty and vagueness in human decision-making. To overcome this limitation, the Fuzzy Analytic Hierarchy Process (FAHP) extends AHP by incorporating fuzzy set theory, allowing for more flexible and realistic representation of expert opinions (Chang, 1996). The application of FAHP in financial decision-making has shown significant promise, particularly in situations where both quantitative data and subjective judgments are involved. By integrating expert knowledge with financial data, FAHP enables a more comprehensive evaluation of investment alternatives and criteria. This approach is especially relevant in stock selection, where investors must consider multiple, often conflicting, financial indicators under uncertain conditions. Against this backdrop, the present study aims to identify and prioritize the principal financial factors influencing investment decisions in the stock market. The analysis focuses on six key financial criteria: Return on Invested Capital (ROIC), Economic Value Added (EVA), Price/Earnings-to-Growth (PEG) Ratio, Free Cash Flow (FCF) Yield, Enterprise Value-to-EBITDA (EV/EBITDA), and Return on Equity (ROE). These indicators were selected based on their widespread use in financial analysis and their ability to capture different dimensions of firm performance, including profitability, value creation, growth, and valuation. The study utilizes financial data from leading companies listed on the NASDAQ Exchange and applies the FAHP methodology to determine the relative importance of each criterion. By doing so, it provides a structured framework for evaluating financial performance and supports more informed investment decisions. The findings are expected to contribute to both academic research and practical investment strategies by highlighting the significance of integrating AFM and EFM measures.

Furthermore, this research underscores the growing importance of profitability and growth-oriented metrics in modern portfolio construction. While liquidity and short-term solvency indicators remain relevant, their influence appears to be comparatively limited in long-term investment decision-making. By prioritizing value creation and efficient capital utilization, investors can enhance portfolio performance and achieve sustainable returns. In summary, this study addresses the challenges of stock selection in a nonlinear and uncertain environment by combining financial ratio analysis with advanced decision-making techniques. The integration of AFM and EFM through FAHP provides a more holistic and reliable approach to evaluating investment opportunities, thereby offering valuable insights for investors, analysts, and policymakers.

Literature Review

Fuzzy Multi-Criteria Decision-Making (FMCDM) techniques have experienced significant growth over the past three decades, particularly in addressing complex financial decision-making problems characterized by uncertainty and multiple conflicting criteria. A landmark contribution in this domain is the comprehensive review conducted by Mardani et al. (2015), which systematically analyzed 403 research papers published between 1994 and 2014 across more than 150 high-quality journals. The study confirmed the rapid expansion and widespread adoption of fuzzy MCDM methodologies across diverse fields, including business, finance, engineering, and management. It further categorized the literature into various application domains and research streams, identifying hybrid fuzzy MCDM models and the Fuzzy Analytic Hierarchy Process (FAHP) as among the most frequently applied approaches. The findings of this large-scale review highlight that fuzzy MCDM techniques are particularly effective in handling ambiguity, vagueness, and subjective judgment—key characteristics of financial decision-making environments. Moreover, FAHP emerged as one of the most dominant individual methods, while hybrid approaches integrating FAHP with techniques such as TOPSIS and VIKOR have been increasingly adopted to enhance decision accuracy and robustness. Supporting this trend, Kahraman et al. (2015) emphasized that fuzzy MCDM methods are essential when dealing with incomplete and imprecise financial data, as they enable the incorporation of linguistic variables and expert opinions into structured analytical models. More recent studies continue to reinforce the relevance of FAHP, with a 2025 review confirming its dominance due to its effectiveness in managing uncertainty and hierarchical decision structures. Since its development, the Fuzzy Analytic Hierarchy Process has become one of the most widely utilized fuzzy MCDM techniques, primarily due to its ability to overcome the limitations of Saaty's traditional AHP in handling imprecision in human judgment. Early contributions, particularly Chang's (1996) extent analysis method based on triangular fuzzy numbers, laid the groundwork for practical FAHP applications by enabling the conversion of subjective preferences into quantifiable decision weights. Over time, FAHP gained widespread acceptance across multiple disciplines, with Kahraman (2008) providing significant theoretical advancements and applications in engineering, management, and finance. However, methodological concerns were also raised; for instance, Wang and Chin (2008) identified issues related to the consistency and reliability of fuzzy pairwise comparison matrices, leading to further refinements in FAHP methodologies. The application of FAHP in financial decision-making began to gain prominence in the late 2000s. Tiryaki and Ahlatcioglu (2009) introduced one of the earliest FAHP-based portfolio selection models, demonstrating its effectiveness in integrating both quantitative financial indicators and qualitative investor preferences. Similarly, Roman and Mitra (2009) highlighted the importance of multi-criteria frameworks in portfolio selection under uncertainty, further validating the applicability of FAHP in finance. Building on this foundation, subsequent studies increasingly adopted hybrid approaches, combining FAHP with other MCDM techniques such as TOPSIS, Grey Relational Analysis (GRA), and VIKOR. In these frameworks, FAHP is typically employed to determine criteria weights, while ranking methods are used to evaluate and prioritize alternatives. Such hybrid models have proven particularly effective in stock selection and mutual fund evaluation, where diverse financial ratios and qualitative factors must be simultaneously considered (Paul et al., 2021; Senfi, 2024). In parallel, methodological advancements have led to the development of extended fuzzy environments that enhance the capability of FAHP models. Approaches such as intuitionistic FAHP (Yu et al., 2021), fuzzy Analytic Network Process (ANP) (Rahiminezhad Galankashi et al., 2020), and more recent frameworks including Pythagorean, spherical, and Fermatean fuzzy AHP models have significantly improved the representation of uncertainty, hesitation, and inconsistency in expert judgments. These advanced models provide greater flexibility and accuracy in complex decision-making scenarios. Bibliometric studies, such as Castelló-Sirvent et al. (2022), confirm the exponential growth of FAHP-related research, particularly in areas such as finance, sustainability, and supply chain management. Beyond FAHP, other fuzzy MCDM approaches have also contributed significantly to financial decision-making. Liu et al. (2012) developed a fuzzy portfolio selection model that incorporates multiple financial dimensions, including return, risk, transaction costs, and skewness, thereby reflecting real-world investment conditions. Similarly, Gupta et al. (2013) proposed a hybrid portfolio optimization model integrating financial and ethical criteria using AHP and fuzzy MCDM techniques. Although some applications extend beyond finance, such as the work of Shamsuzzaman et al. (2013) in industrial decision-making, these studies collectively demonstrate the versatility and robustness of fuzzy MCDM frameworks in handling complex, uncertain, and multi-dimensional problems. Overall, the literature reveals a clear evolution from traditional MCDM approaches to advanced fuzzy and hybrid models. The increasing adoption of FAHP and related techniques in financial applications highlights their ability to integrate both quantitative financial indicators and qualitative expert judgments. This makes them particularly suitable for stock selection and portfolio optimization in uncertain and dynamic market environments.

Research Gap: Despite the extensive application of Fuzzy Multi-Criteria Decision-Making (FMCDM) techniques in financial analysis, several gaps remain. First, many existing studies focus on either Accounting Financial Measures (AFM) or Economic Value Financial Measures (EFM) independently, with limited integration of both frameworks in a unified decision-making model. Second, prior research often emphasizes traditional financial ratios without simultaneously considering profitability, growth, and valuation indicators in a comprehensive structure. Third, although the Fuzzy Analytic Hierarchy Process (FAHP) has been widely used, its application in stock selection using a balanced set of six critical financial indicators—ROIC, EVA, PEG, FCF Yield—remains underexplored. Additionally, limited studies incorporate expert judgment alongside real market data, particularly in the context of major global stock exchanges such as NASDAQ. These gaps highlight the need for an integrated and systematic approach to improve investment decision-making.

Limitations of the Study: Despite its contributions, this study has certain limitations. The analysis is restricted to a sample of ten companies, which may limit the generalizability of the findings across broader markets. The reliance on expert judgment, although valuable, introduces a degree of subjectivity that may influence the results. Additionally, the study considers a fixed set of six financial indicators, which may not capture all relevant aspects of firm performance, such as macroeconomic factors or behavioral influences. The use of FAHP, while effective in handling uncertainty, may also involve computational complexity and sensitivity to input judgments. Furthermore, the study focuses on a specific time frame and does not account for dynamic market changes over time.

Contribution of the Study: This study makes several important contributions to the existing literature. First, it develops a comprehensive framework that integrates both AFM and EFM, providing a more holistic evaluation of firm performance. Second, it applies the Fuzzy Analytic Hierarchy Process (FAHP) to prioritize six key financial indicators, enabling effective decision-making under uncertainty. Third, the study incorporates both quantitative financial data and qualitative expert opinions, enhancing the reliability and robustness of the analysis. Fourth, it identifies Return on Equity Return on Invested Capital (ROIC), as the most influential criterion, offering practical insights for investors. Finally, by focusing on leading companies listed on the NASDAQ Exchange, the study provides globally relevant findings that can support portfolio construction and strategic investment decisions.

2.1. Fuzzy Analytic Hierarchy Process (Fuzzy AHP): The Analytic Hierarchy Process (AHP), introduced by Thomas L. Saaty in 1980, simplifies complex decision-making by structuring it into a hierarchical model and employing pairwise comparisons to establish priority scales. To address the uncertainty in judgments, this method has been enhanced with Triangular Fuzzy Numbers (TFNs), allowing for a more flexible and nuanced evaluation.

1. Developing a fuzzy comparison matrix

First the scale of linguistics is determined. The scale used is the TFN scale from one to nine are shows in Table 1.

Table 1. Scale of Interest

Scale of Interest	Linguistic Variable	Membership Function
1	Equally important	(1,1,1)
3	Weakly important	(2,3,4)
5	Strongly more important	(4,5,6)
7	Very strongly important	(6,7,8)
9	Extremely important	(8,9,10)

Then, using the TFN to make pair-wise comparison matrix for the main criteria and sub-criteria. Equation (1) shows the form of fuzzy comparison matrix.

$$\tilde{A} = \begin{bmatrix} 1 & \dots & \tilde{a}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \dots & 1 \end{bmatrix} \quad (1)$$

2. Define Fuzzy Geometric Mean

The fuzzy geometric mean is then calculated using Equation (2)[13]:

$$\tilde{x}_i = (\tilde{a}_{(i1)} \otimes \tilde{a}_{(i2)} \otimes \dots \otimes \tilde{a}_{(in)})^{\frac{1}{n}} \quad (2)$$

Where \tilde{a}_{in} is a value of fuzzy comparison matrix from criteria I to n. Result from the fuzzy geometric mean will be referred to later as local fuzzy number.

3. Calculate the weight of fuzzy of each dimension

The next step is to calculate the global fuzzy number for each evaluation dimension with Equation (3).

$$\tilde{w}_i = \tilde{x}_1 \otimes (\tilde{x}_1 \oplus \tilde{x}_1 \oplus \dots \oplus \tilde{x}_1)^{-1} \quad (3)$$

4. Define the best non fuzzy performance (BNP)

The global fuzzy number is then converted to crisp weight value using the Centre of Area (COA) method to find the value of best BNP from the fuzzy weight in each dimension, calculated using Equation (4).

$$BNP_{wi} = \frac{[(u_{wi}-l_{wi})+(m_{wi}-l_{wi})]}{3} + l_{wi} \quad (4)$$

2.2. Case study : In this study, data were collected from the top 10 companies listed on the NASDAQ Stock Exchange, USA ([https://www.nasdaq.com/marketactivity/index/comp]). Expert opinions were solicited from two highly experienced professionals: (i) an accomplished investor and (ii) a finance professor, both possessing over 50 years of combined experience in investment analysis. Six key financial criteria were considered in the evaluation process: Return on Invested Capital (ROIC, C1), Economic Value Added (EVA, C2), Price/Earnings-to-Growth (PEG) Ratio (C3), Free Cash Flow (FCF) Yield (C4). The Fuzzy Analytic Hierarchy Process (FAHP) was then applied to determine the relative weights and priority rankings of these criteria. The resulting importance weights are summarized in

Table 1: Determining the weights of the criteria by FAHP Approach

Criteria	C ₁	C ₂	C ₃	C ₄
Fuzzy Weights	0.2605	0.2148	0.2290	0.1801
Rank	1	2	3	4

Conclusion: This study highlights the importance of integrating Accounting Financial Measures (AFM) and Economic Value Financial Measures (EFM) in stock selection within a complex and uncertain financial environment. By applying the Fuzzy Analytic Hierarchy Process (FAHP), the research provides a structured approach to evaluate and prioritize key financial indicators. The findings demonstrate that profitability-based measures, particularly Return on Invested Capital (ROIC, C1), play a dominant role in investment decision-making, followed by other value and growth-oriented metrics. The study reinforces the idea that investors should focus on long-term value creation rather than short-term liquidity considerations. Overall, the proposed framework offers a practical and effective tool for enhancing portfolio selection strategies and supports more informed financial decision-making in modern stock markets.

References

- Alharairi, M., Amin, S. H., Zolfaghari, S., & Fang, L. (2025). Fuzzy analytic hierarchy process: A comprehensive literature review. *International Journal of the Analytic Hierarchy Process**, 17(1), 1–25.
- Behzadian, M., Otaghsara, S. K., Yazdani, M., & Ignatius, J. (2012). A state-of-the-art survey of TOPSIS applications. *Expert Systems with Applications**, 39(17), 13051–13069.
- Buckley, J. J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems**, 17(3), 233–247.
- Castelló-Sirvent, F., et al. (2022). A bibliometric analysis of fuzzy analytic hierarchy process research. *Mathematics**, 10(5), 1–20.
- Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research**, 95(3), 649–655.
- Chen, C. T. (2000). Extensions of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets and Systems**, 114(1), 1–9.
- Damodaran, A. (2012). *Investment valuation: Tools and techniques for determining the value of any asset** (3rd ed.). Wiley.
- Gupta, P., Mehlatat, M. K., & Saxena, A. (2013). Hybrid optimization models for portfolio selection. *International Journal of Systems Science**, 44(10), 1882–1895.
- Kahraman, C. (2008). *Fuzzy multi-criteria decision making: Theory and applications**. Springer.
- Kahraman, C., Onar, S. C., & Oztaysi, B. (2015). Fuzzy multicriteria decision-making: A literature review. *International Journal of Computational Intelligence Systems**, 8(4), 637–666.
- Liu, Y., et al. (2012). A fuzzy multi-objective portfolio selection model. *Applied Soft Computing**, 12(1), 164–173.
- Mardani, A., Jusoh, A., Zavadskas, E. K., Khalifah, Z., & Nor, K. M. (2015). Fuzzy multiple criteria decision-making techniques and applications: Two decades review from 1994 to 2014. *Expert Systems with Applications**, 42(8), 4126–4148.
- Mathew, M., et al. (2020). Spherical fuzzy AHP approach for decision-making. *Soft Computing**, 24(22), 1–15.
- Paul, S., et al. (2021). Hybrid FAHP-TOPSIS model for stock evaluation. *Journal of Financial Decision Making**, 9(2), 45–60.
- Penman, S. H. (2013). *Financial statement analysis and security valuation** (5th ed.). McGraw-Hill.
- Rahiminezhad Galankashi, M., et al. (2020). Application of fuzzy ANP in decision-making. *Expert Systems with Applications**, 140, 112–125.
- Roman, D., & Mitra, G. (2009). Portfolio selection models: A review and new directions. *Omega**, 37(5), 851–865.
- Saaty, T. L. (1980). *The analytic hierarchy process**. McGraw-Hill.
- Senfi, S. (2024). Multi-criteria stock selection using fuzzy hybrid models. *International Journal of Finance Studies**, 12(1), 1–15.
- Shamsuzzaman, M., et al. (2013). Application of fuzzy MCDM in industrial decision-making. *Expert Systems with Applications**, 40(3), 1063–1071.
- Stewart, G. B. (1991). *The quest for value**. Harper Business.
- Tiryaki, F., & Ahlatcioğlu, B. (2009). Fuzzy portfolio selection using analytic hierarchy process. *Information Sciences**, 179(1–2), 53–69.
- Wang, Y. M., & Chin, K. S. (2008). A linear programming approach to FAHP. *European Journal of Operational Research**, 186(2), 735–747.
- Yu, D., et al. (2021). Intuitionistic fuzzy AHP applications in decision-making. *Applied Soft Computing**, 100, 106–115.
- Zadeh, L. A. (1965). Fuzzy sets. *Information and Control**, 8(3), 338–353.
- Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2014). Hybrid multiple criteria decision-making methods: A review. *Engineering Applications of Artificial Intelligence**, 34, 1–14.