EVALUATION AND PRIORITIZATION OF MUTUAL FUNDS USING INTUITIONISTIC FUZZY ANALYTIC HIERARCHY PROCESS

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ABSTRACT

Investment has become increasingly important for individuals in today's economic landscape, particularly regarding the growth of the capital market. A primary concern for investors is selecting the best investment options. When faced with complex decisions, such as choosing a mutual fund, multi-criteria decision-making (MCDM) methods can be used to prioritize options and make optimal choices. This study focuses on the Intuitionistic Fuzzy Analysis Hierarchy Process (IFAHP) technique. Given the significance of investment in the current economy, this study aims to apply and describe the IFAHP technique for ranking mutual funds listed on the Tehran Stock Exchange. A total of 20 mutual funds were selected based on their size and superior performance compared to other mutual funds, utilizing statistics published by the Financial Information Processing Center of Iran. The mutual funds were evaluated and prioritized using the IFAHP technique, resulting in the following cumulative weights and final weights: Moshtarek Agah (0.6360, ranked 1), Sepehr Aval Bazar (0.6248, ranked 2), and Ofoghe Melat (0.6234, ranked 3) holding the highest priorities. Conversely, the mutual funds Firozeh Movafaghiat (0.4550, ranked 20), Toseh Atlas Mofid (0.4584, ranked 19), and Moshtarek Kargozari Bank Meli Iran (0.4803, ranked 18) have the lowest priorities for investment. Therefore, according to these results and their desired criteria, investors can identify the most suitable options for their investments to maximize their profits.

Keywords: mutual fund; fuzzy set; Intuitionistic Fuzzy Analytic Hierarchy Process; MCDM; investment

1. Introduction

In today's era, investment is a basic requirement to participate in a developed economic world. Considering the dynamic and impressive speed of the current economic growth, a healthy and developed economy is necessary for a country to have an efficient capital market. Therefore, officials and politicians must provide the necessary infrastructure for the existence of competitive and efficient financial markets. In the last decade, due to the progress and prosperity of financial markets, the position of financial intermediaries such as banks, which have a monopoly role, has diminished and mutual funds now occupy a special position in the capital market. One of the most suitable financial tools today is mutual funds, whose purpose is to collect cash from investors and buy different types of securities, which reduces investment risk and increases returns (Bogle, 2015; Lin & Neely, 2020). Investment can be approached in two ways, direct and indirect. In the direct method, the investor analyzes the financial markets and chooses the right stocks to buy and sell. The indirect method involves investing through financial intermediaries such as mutual funds or obtaining an exclusive portfolio management contract (Mimovic et al., 2017; Pan & Mishra, 2018; Tachiwou, 2010).

Performance evaluation of mutual funds has been a very interesting research topic not only for financial researchers, but also for managers, banking and investment institutions, and investors. Investors are primarily interested in knowing the results of their investment and its return and comparing it with other financial institutions. Therefore, in order to direct the capital of interested people, their attention and trust should be drawn to mutual funds (Alptekin, 2009).

Investment performance is evaluated through two indicators, return and risk. These indices are based on the Markowitz basket theory (Alptekin, 2009; Hernández-Pacheo & Flores, 2021). Therefore, the basic issue in the evaluation and selection of mutual funds is to determine whether the managers of these funds has been able to perform the necessary and appropriate functions based on the risk and return criteria. Due to the sensitivity of financial markets, managers are judged based on the results of the decisions they make. For this reason, to respond to today's dynamic economy, it is necessary to increase the capabilities and accuracy of the models used (Makridakis et al., 1982).

Due to the growth of the economy and technology in today's world, modern societies face decision-making problems due to inconsistent criteria and goals (Chakraborty et al., 2023; Wiecek et al., 2008). The judgments of decision-makers are often uncertain and cannot be expressed by precise numerical values. Therefore, to address the complexities of such issues, it is necessary to use new interdisciplinary approaches (Mert, 2023). One of the powerful tools for dealing with the ambiguity created by financial markets and investor behavior is the fuzzy set theory. One of the most important features and capabilities of the fuzzy approach is the balance of designing patterns that, like humans, can intelligently process qualitative information. This approach, while creating flexibility in the model, introduces data such as human knowledge, experience, and judgment into the model and gives completely practical answers (Mimovic et al., 2017). Mutual funds are popular investment vehicles in which the investor invests his money in a diverse set of securities, allowing them to participate in large portfolios with small capital and share in its profits. Therefore, the performance of the portfolio of these companies is important from different aspects for the investor (Gursoy, 2001). Mutual fund performance evaluation is an important issue for mutual fund management and is an important part of investment activities. Attracting and retaining investors depends on the performance of a mutual fund or a portfolio manager (Kan et al., 2023; Tsola, 2020; Hsieh et al., 2020). Portfolio managers usually evaluate portfolio performance based on the rate of return. Evaluating the performance of funds is important for investors and portfolio companies, allowing them to measure not only the extent to which defined goals are being met, but also to examine key factors that lead to the improvement or deterioration of business results (Mimovic et al., 2017).

It is important to evaluate the performance of stock mutual funds and their rating so that investors and stock traders can make the right decision about buying, selling, or holding mutual fund units. If the results of the research on the performance of mutual funds are positive, the willingness of investors to invest indirectly will increase. Many criteria have been developed to evaluate the performance of these funds. Some issues, including the decision to choose a mutual fund, which is our topic, have complications that cause uncertainty and difficulties for the decision-maker. For people who do not have enough knowledge or time or who want to invest with little capital, choosing the best mutual fund is an important decision.

In Iran, there are a variety of tradable funds in and out of the stock exchange. To choose the best mutual fund, one must evaluate and review mutual funds using important criteria for investment. One of the most important criteria for choosing a mutual fund is the amount of risk that the investor is willing to accept. Other features to consider in this selection are assets under management, management experience, performance, alpha coefficient, and the beta coefficient for mutual funds. For such problems, considering that it is difficult to apply intuitionistic preference coefficients, the use of fuzzy sets cannot be the answer. Therefore, it is better to use the interdisciplinary techniques of intuitionistic fuzzy sets for this task, so that it can be done with more confidence to reach the goal in a short time. Therefore, in this study, we focus on this issue, by introducing the mentioned approach and analyzing an example of choosing a mutual fund using the IFAHP.

Despite the availability of various evaluation techniques, many traditional methods have focused primarily on quantitative criteria, inadequately addressing qualitative factors that increasingly influence investment decisions. Techniques such as Simple Additive Weighting (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and Analytic Hierarchy Process (AHP) often fail to capture the complexities of investor preferences and the inherent uncertainties in qualitative assessments. This oversight has resulted in methods that do not meet the actual needs of decision-makers, leading to unstable and erroneous outcomes.

To address these limitations, this study introduces the IFAHP as a robust and innovative alternative. This method enhances the clarity of evaluating qualitative criteria and empowers decision-makers to base their choices on a comprehensive set of criteria—both quantitative and qualitative—by converting verbal variables into numerical values. By effectively managing ambiguity and uncertainty in qualitative assessments, the IFAHP fills a significant gap in the current literature.

The novelty of this work lies in its dual focus on both quantitative and qualitative components, providing a holistic framework for mutual fund selection. This research aims to enhance the accuracy and speed of decision-making in mutual fund selection by introducing a method that fills existing gaps in the literature. Furthermore, it serves as a vital tool for both professional decision-makers and retail investors facing complex choices, enabling them to navigate the intricacies of the investment landscape with greater confidence.

2. Research literature

Economic growth and development are not possible without the help of financial markets, especially the modern and efficient capital market. Having information available about investment institutions as well as their performance, for investment, buying and selling shares for the target community, i.e. for investors, financial market analysts, etc. is important (Mimovic et al., 2017).

Investments can be made in both direct and indirect ways. Considering the lower indirect investment risk and the advantages that indirect investing has for its investors, most people, especially beginners, tend to use this method for investment to avoid spending time training on the stock exchange and staring at the monitor and analyzing and examining the stocks of different companies to make investment (Levišauskait, 2010). One of the newest investment options is mutual funds. Past performance must be examined in order to choose the best and safest fund. Mutual funds are financial intermediaries that transfer capital from holders to consumers. These funds sell shares to applicants and invest the money received in portfolios of securities.

Performance appraisal is the basis for investigating the current situation in trading behavior and the financial market. In the case of mutual funds, the realization of defined objectives can be determined by measuring performance (Mimovic et al., 2017). In the early 1960s, the measurement of mutual fund performance became an important part of financial markets in developed countries. The first empirical analysis of the performance of mutual funds was conducted by Freund, Brown, Herman, Herman, and Vickers in their paper entitled “A study of mutual funds” published in 1962 (Murthi et al., 1997).

Jack Treynor (1965), William Sharpe (1966), and Michael Jensen (1967) independently introduced standard performance measures for mutual funds. Today, these criteria are known as the Sharpe, Treynor, and Jensen alpha index (Mimovic et al., 2017). Senfi et al. (2024) evaluated and ranked portfolios using the IFAHP. Irawati and Diyah (2022) analyzed the performance of mutual funds in Indonesia from January 2017 to December 2019 by looking at their asset allocation policy, stock selection, and risk level. The results of this research showed that the performance of mutual funds is affected by asset allocation policy, stock selection, and risk level. The result obtained indicates that the performance of mutual funds is determined by the activities of investment managers and market return conditions. Matallín-Sáez et al. (2019), in an article titled “A study on the relationship between the professionalism of experts and the efficiency of mutual funds,” concluded that mutual funds provide small or personal investors with the opportunity to access professionally managed portfolios of bonds and other securities, allowing each

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shareholder to participate in the fund's profits and losses. With this in mind, the study will focus on measuring and evaluating the performance of mutual funds.

Due to the uncertain and complex conditions governing the stock exchange, as well as the varying tendencies, objectives, and behaviors of investors, it seems necessary to provide a method for selecting a suitable set of portfolios to overcome these problems. Given the characteristics of fuzzy sets, this approach can be considered an efficient method for addressing this issue.

One problem is the existence of different quantitative and qualitative criteria when making decisions in different multi-criteria decision-making processes such as the AHP. This, in addition to other complexities in decision-making such as selecting criteria, comparing and weighing the criteria to each other and weighing different options based on each criterion, causes uncertainty. Considering that a factor called uncertainty is not defined in classical sets and even fuzzy sets, the use of intuitionistic fuzzy sets seems necessary in multi-point decision-making because the degree of membership and non-membership is dealt with as a degree of uncertainty in this case (Laks et al., 2023; Tumsekcali et al., 2021).

The significance and necessity of this research stems from the importance of investment in today’s economy. The preservation and development of a society’s future economy depends on today’s investments. Placing a society’s financial resources in a position to bring the greatest benefits and returns requires efficient management and optimal decision-making. This will not be possible except by properly evaluating the performance of financial intermediaries, including mutual funds, which play an important role in today’s economy, and properly ranking of them, taking into account all the effective criteria.

Therefore, since the issue of performance evaluation and selection of mutual funds is a multi-determinant decision-making problem and current methods do not have the necessary efficiency to solve this problem, the integrated IFAHP method was used in this research to select the appropriate mutual funds.

Vidal-Garcia et al. (2022) examined how different variables affect the profitability-flow relationship in mutual funds in different countries around the world and assessed whether mutual fund investors make decisions to invest in some of the variables they prefer over others or not. They also compared different performance measures for mutual funds and analyzed the relationship between flows and performance using a sample of mutual funds worldwide, from January 1990 to December 2021. Verheyden and Moor (2016) used the Delphi method along with the AHP method to evaluate the performance of mutual funds. The efficiency of American mutual funds was measured using DEA method criteria by Finnegan et al. (2015). Wang and Lee (2011) considered the evaluation of mutual funds as a fuzzy multi-criteria problem and used the combination of fuzzy methods and the AHP to determine the importance of criteria and evaluate mutual funds. Also, Chang et al. (2010) used the TOPSIS method to evaluate the performance of mutual funds, while Alptekin (2009) evaluated Turkish mutual funds and pension funds using the TOPSIS method. Swinkels and Rzezniczak (2009) evaluated the performance of a sample of 38 Polish mutual funds over a period of time. Murthi et al. (1997) evaluated the performance of mutual funds using the then-undiscovered DEA approach and found a positive and significant correlation between the efficiency index and Jensen's alpha index for all asset classes. Pendaraki and Zopounidis (2003) used the PROMETHEE II model to evaluate the performance of mutual funds and developed the model used for this purpose. Markowitz used the historical average rate of return to measure the expected return of capital and the variance of the rate of return to measure the risk of capital (Bai et al., 2016). The performance evaluation of European mutual funds by Otten and Bams (2002) which was based on 506 sample funds in five countries is well known. This study concluded that the average European mutual fund can create added value, that is, it outperforms the relevant market indices, as indicated by positive net alphas. Murthi et al., (1997) evaluated the performance of 731 mutual funds grouped into 7 categories. When analyzing the performance of 115 mutual from 1945-1964, Jensen (1967) concluded that the funds' managers could not achieve higher returns than expected, considering the level of risk accepted. Chen and Huang (2009) studied 122 mutual funds in Taiwan, and classified these funds based on four criteria including return rate, standard deviation, turnover rate, and Treynor index. Then with an optimal model they presented fuzzy modeling to determine the optimal capital allocated to each category. The optimization problem was solved in two ways: 1) maximizing the expected return with the limit of maximizing risk, and 2) minimizing risk by limiting the minimum expected return. Based on the research literature, the IFAHP utilized in this study is superior in speed and accuracy for decision-making with quantitative and qualitative criteria.

When selecting the best mutual fund, the decision maker is usually faced with numerous criteria and variables that cause ambiguity; therefore, one of the most efficient tools to overcome this problem is the new IFAHP hybrid method. Furthermore, when selecting the right mutual fund for investment, the criteria are not only quantitative, and the decision-maker must also consider several qualitative criteria that cannot be measured and weighted in many decision-making methods. One of the important features of the IFAHP method used in the current research is that it can fix this ambiguity by using verbal variables as quantitative equivalents for qualitative variables, and as a result, easily calculate the weight of the criteria which is then used for the proper prioritization of options.

The evaluation of mutual fund performance has been the focus of numerous research efforts utilizing various methodologies. The reviewed studies can be categorized into three main areas: performance evaluation methods, application of fuzzy sets in finance, and comparative studies on mutual funds, and are summarized in Table 1.

Table 1
Classification of previous studies

Theme	Study	Summary
Performance Evaluation Methods	Senfi et al. (2024)	Evaluated and ranked portfolios using the Intuitionistic Fuzzy Analysis Hierarchy Process (IFAHP), contributing to performance appraisal methodologies in finance.
	Irawati & Diyah (2022)	Analyzed performance of Indonesian mutual funds focusing on asset allocation, stock selection, and risk levels; concluded that these factors affect fund performance.
	Vidal-García et al. (2022)	Examined the relationship between profitability and other variables in mutual funds globally, compared performance measures and analyzed investor behavior related to fund flows.
	Mimovic et al. (2017)	Discussed the importance of performance evaluation for investment institutions and its relevance for investors and financial market analysts.
	Gregoriou (2015)	Measured the efficiency of American mutual funds using Data Envelopment Analysis (DEA).
	Chang et al. (2010)	Utilized the TOPSIS method to evaluate mutual fund performance.
	Chen & Huang (2009)	Focused on Taiwanese mutual funds, classified based on various metrics and developed a fuzzy optimization model for capital allocation.
	Otten & Bams (2002)	Evaluated European mutual funds, concluded that average funds can create added value beyond market indices, based on a sample across five countries.
	Murthi et al. (1997)	Evaluated 731 mutual funds using DEA, found correlation between efficiency index and Jensen's alpha across asset classes.
	Jack Treynor (1965), William Sharpe (1966), Michael Jensen (1968)	Introduced fundamental performance measures (Sharpe ratio, Treynor ratio, Jensen’s alpha) that are essential for evaluating mutual fund performance.
	Freund et al. (1962)	Conducted an early empirical analysis of mutual fund performance, establishing its importance in developed financial markets.
Applications of Fuzzy Sets in Finance	Laks et al. (2023)	Introduced intuitionistic fuzzy sets in decision-making to handle uncertainty in multi-criteria evaluations.
	Tumsekcali et al. (2021)	Emphasized the role of intuitionistic fuzzy sets for navigating uncertainty in decision-making processes.

Theme	Study	Summary
	Wang & Lee (2011)	Considered mutual fund evaluation as a fuzzy multi-criteria problem, combining fuzzy methods with AHP for criteria importance determination.
	Alptekin (2009)	Evaluated Turkish mutual funds and pension funds using the TOPSIS method.
	Pendaraki & Zopounidis (2003)	Used PROMETHEE II model to evaluate mutual fund performance and developed the evaluation methodology.
Comparative Studies on Mutual Funds	Matallín-Sáez et al. (2019)	Analyzed the relationship between expert professionalism and mutual fund efficiency, highlighting benefits for small investors regarding access to managed portfolios.
	Levišauskait (2010)	Discussed the advantages of indirect investment methods, especially for beginners, and highlighted mutual funds as a safer option.
	Swinkels & Rzezniczak (2009)	Evaluated the performance of Polish mutual funds over a specified period, focusing on return metrics.
	Jensen (1967)	Analyzed 115 mutual funds from 1945-1964, concluding that managers typically could not achieve higher returns than expected based on risk levels.

Traditional methods such as SAW, TOPSIS, and the AHP have been applied, generally emphasizing quantitative criteria and laying the groundwork for performance assessment. Notable analyses by Murthi et al. (1997) and Jensen (1967) revealed that many mutual fund managers struggle to achieve returns that consistently exceed those anticipated based on risk levels. More contemporary studies, including those by Vidal-Garcia et al. (2022) and Chen and Huang (2009), have broadened the analysis of mutual funds by integrating various performance metrics alongside fuzzy optimization techniques, thereby shedding light on investor behavior and market dynamics.

Additionally, the implementation of fuzzy logic in financial decision-making has gained attention, with researchers like Wang and Lee (2011) and Laks et al. (2023) exploring how fuzzy sets can help address uncertainty and improve multi-criteria decision-making processes. Comparative studies, such as those by Alptekin (2009) and Swinkels and Rzezniczak (2009), have also provided insights into mutual fund performance across different regions, exposing effective management practices and strategies.

Despite these advancements, significant gaps remain in the current literature. Most existing methods continue to prioritize quantitative factors, often overlooking the qualitative aspects that increasingly influence investment decisions. This neglect results in inadequate frameworks for comprehensively capturing investor preferences. Moreover, the integration of advanced analytical techniques, particularly machine learning algorithms that could enhance predictive capabilities and automate ranking processes has been limited. Additionally, there is a noticeable absence of a holistic evaluation framework that combines both quantitative and qualitative assessments to improve decision-making in mutual fund selection.

In response to these gaps, this study introduces the IFAHP, an innovative approach that addresses the shortcomings of traditional methods by comprehensively considering qualitative criteria alongside quantitative ones. The IFAHP transforms verbal expressions into measurable values, thereby offering a robust and effective decision-making tool. By aiming for a holistic framework encompassing both qualitative and quantitative components, the IFAHP enhances the accuracy and efficiency of the decision-making processes for both professional and retail investors.

Furthermore, this research envisions the potential for integrating the IFAHP with advanced machine learning techniques, such as neural networks and Gaussian process regression, to automate the ranking process and improve predictive analytics. This combination is expected to enhance the identification of significant patterns in historical data, ultimately enriching financial decision-making. Through these contributions, this study not only fills existing gaps in the literature but also proposes a novel methodology that advances qualitative assessments and leverages advanced analytical techniques, significantly impacting the field of financial decision-making.

3. Research innovation

This study utilizes the IFAHP approach, which offers improved speed and accuracy in decision-making with both quantitative and qualitative criteria. The selection of an optimal mutual fund often involves numerous criteria and variables, leading to confusion for decision-makers. To address this issue, the new IFAHP combination method is a highly effective tool. Additionally, when choosing a mutual fund, decision-makers encounter qualitative criteria that cannot be measured or weighted using traditional decision-making methods. The method employed in this research fills this gap by using verbal variables to represent quantitative equivalents for qualitative variables. This allows for easy calculation of criteria weights and enables proper prioritization of options.

4. Methodology

The methodology of this research has been carried out in three phases.

4.1. Phase 1

After studying the research literature and extracting the criteria and sub-criteria for evaluating the performance of mutual funds, the Delphi method was used to validate them as described in section 4.1.1.

4.1.1. Delphi method

The Delphi method is a systematic and interactive forecasting process that relies on a panel of experts to achieve consensus on specific issues. Important features include the selection of informed experts, anonymity to minimize bias, iterative rounds of questionnaires that allow participants to reconsider their responses based on group feedback, and a focus on consensus building. This method is particularly useful in criteria development for evaluating complex issues, such as mutual funds or policy formulation, as it effectively gathers diverse expert opinions. The structured approach of the Delphi method leverages collective intelligence, helping to overcome individual judgment limitations in uncertain environments, making it a valuable tool in research, policy-making, and trend forecasting (Humphrey-Murto et al., 2020). The Delphi method (Tumsekcali et al., 2021) has been employed to gather experts' opinions and establish the criteria and sub-criteria for evaluating mutual funds, as illustrated in Figure 1. The criteria and sub-criteria determined using the Delphi method are elaborated upon in section 5.2.

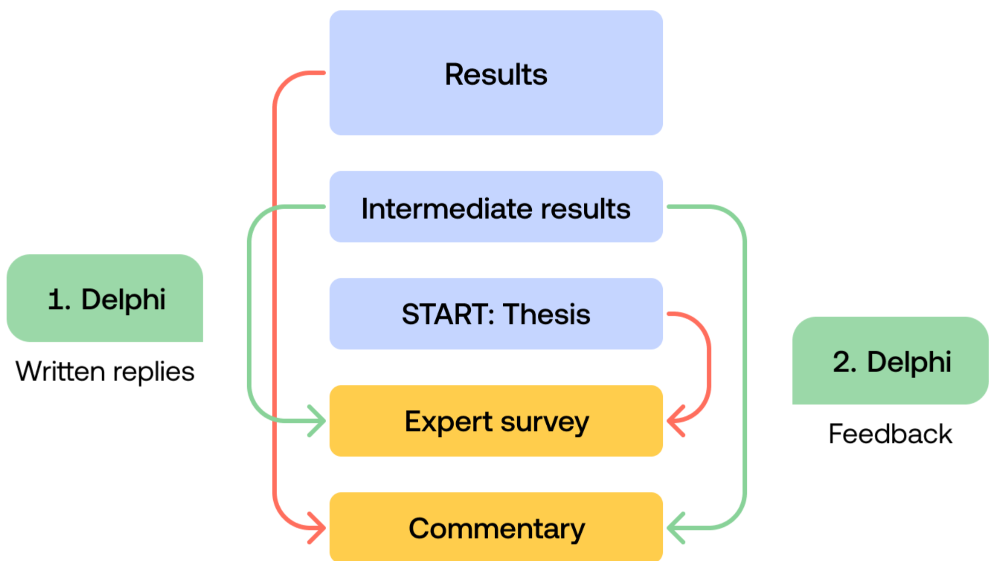

Figure 1 Delphi method

4.2. Phase 2

In the next phase, the best-worst method (BWM) was used to weight the criteria and sub-criteria to facilitate pairwise comparisons in the subsequent stages of the IFAHP method. The process of this method is briefly presented below.

4.2.1. Best-Worst Method (BWM)

The BWM is a multi-criteria decision-making method introduced by Rezaei (2015). It is characterized by its reliance on pairwise comparisons and requires less comparative data than other methods. The method provides more stable comparisons and yields more reliable and consistent results compared to the AHP. Pairwise comparisons are used to evaluate the preferences of one criterion over others and determine the power and priority direction of each criterion. Rezaei (2015) provided an example of comparing trees based on their height, using a ranking system from 1 to 9 to express the preferences. The method involves two groups of comparisons: reference comparisons, where the best and worst elements are identified, and secondary comparisons, where either the best or worst element is identified. To determine the weights in the best-worst method, five steps are

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followed, including determining the research criteria, comparing the best and worst criteria with others, and creating a non-linear programming model.

$$\begin{aligned} &\text{Min}\,\xi \\ &s.t. \\ &\left|\frac{w_b}{w_j} - a_{Bj}\right| \le \xi, \quad for\ \forall\ j \\ &\left|\frac{w_j}{w_w} - a_{jw}\right| \le \xi, \quad for\ \forall\ j \\ &\sum_j W_j = 1 \\ &W_j \ge 0, \quad for\ \forall\ j \end{aligned}$$

By solving this model in optimization software such as Lingo or Gams, the weights of the criteria are calculated. The above relationship is a non-linear model, which Rezaei (2016) converted into a linear model. One of the advantages of this linear model is that it does not use inconsistency rates. This means that the value of ξ is the same as the rate of inconsistency. Also, the weights of this linear model are more accurate. The linear model of the BMW method is created from the following relationship.

$$\begin{aligned} &\text{Min}\,\xi \\ &s.t. \\ &\left|w_b - a_{Bj}.W_j\right| \le \xi, \quad for\ \forall\ j \\ &\left|w_j - a_{jw}.W_w\right| \le \xi, \quad for\ \forall\ j \\ &\sum_j W_j = 1 \\ &W_j \ge 0, \quad for\ \forall\ j \end{aligned}$$

4.3. Phase 3

In the final phase, alternatives are weighted and ranked using the IFAHP method with the preliminaries and steps of implementing this method described in detail.

4.3.1. Preliminaries of IFSs and Intuitionistic Fuzzy AHP

The AHP is a decision-making method that breaks down complex problems into a hierarchical structure of goals, criteria, sub-criteria, and alternatives. It provides a relative scale for displaying judgments and is commonly used in management science. However, the AHP may not be sufficient for decision-making in uncertain situations. To address this, fuzzy set theory and fuzzy AHP (FAHP) were introduced, allowing for qualitative evaluation and subjective judgment. Intuitionistic Fuzzy Sets (IFSs) are essential in Multi-Criteria Decision Making (MCDM) as it considers uncertainty an additional factor. The AHP and the FAHP were further developed into intuitionistic fuzzy conditions, which convert qualitative measures into quantitative ones using verbal variables. In intuitionistic fuzzy hierarchical analysis, triangular intuitionistic fuzzy numbers represent the pairwise comparison matrix. The IFS theory, proposed by Atanassov (2002), added a third parameter for uncertainty in fuzzy sets. IFSs are widely used for defining linguistic

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criteria in decision-making. This section provides an introduction to IFSs and their basic definitions to understand the implementation of IFAHP.

Definition 1:
Suppose the value function X from the set of propositions, X is defined as follows:

$$X(A) = < \mu_A(x), \vartheta_A(x) >$$

Therefore, the function $X: A \rightarrow [0,1] \times [0,1]$ is the value function that gives us the "degree of correctness" and "degree of incorrectness" of each statement in the set of X (Dabiri & Safari, 2016).

Definition 2:
Let's fix a set X; it's a nonempty set. $A \subset X$ is a subset of X. The intuitionistic fuzzy set (IFS) is defined as follows:

$$X(A) = \{ (x, \mu_A(x), \vartheta_A(x)) \mid x \in X \}$$

Where: $X \rightarrow [0, 1]$ and: $X \rightarrow [0, 1]$ $s.t$ $\mu_A(x) \in [0, 1]$ denote the membership function and $\vartheta_A(x) \in [0, 1]$ denote the non-membership function and the degree of non-membership of the element $x \in X$ to the set, respectively, and for every $x \in X$, $0 \leq \mu_A(x) + \vartheta_A(x) \leq 1$ holds (Kahraman et al., 2018; Tumsekcali et al., 2021).

Definition 3:
Fuzzy logic is a special case of intuitionistic fuzzy logic where $\mu_A(x) + \vartheta_A(x) = 1$, (Dabiri & Safari, 2016) so:

$$X(A) = < \mu_A(x), 1 - \mu_A(x) >$$

Definition 4:
For each IFS 'A' can be defined as (Dabiri & Safari, 2016):

$$\boldsymbol{\pi_A(x) = 1 - \mu_A(x) - \vartheta_A(x)} \quad (1)$$

Is called the hesitation degree or degree of non-determinacy (uncertainty) of $x \in A$ or x $not \in A$.

Definition 5:
A is a finite set of alternatives as follows (Saaty, 1986; Xu & Liao, 2013):

$$A = \{A_1, A_2, \dots A_m\}$$

C is a set of n criteria as follows:

$$C = \{C_1, C_2, \dots C_n\}$$

w is a vector that defines the weight of criteria and is as follows:

$$w = \{w_1, w_2, \dots w_n\}$$

Where $w_i \geq 0\ for\ i = 1, 2, \dots, n\ and\ \sum_{i=0}^{n} w_i = 1$

Definition 6:
A is an intuitionistic fuzzy set in X with membership function $\mu_A(x)$ and non-membership function $\nu_A(x)$ as follows (Ayyildiz & Taskin Gumus, 2021; de Souza et al., 2021; Tumsekcali et al., 2021).

For $l \leq m \leq u$ l and u are lower and upper values of the support of A, respectively. m, m_1, and m_2 are the modal values (Buckley, 1985).

$$\mu_A(\boldsymbol{x}) = \begin{bmatrix} \frac{\boldsymbol{x}-\boldsymbol{l}}{\boldsymbol{m}-\boldsymbol{l}}, & \boldsymbol{x} \in [\boldsymbol{l}, \boldsymbol{m}] \\ \frac{\boldsymbol{u}-\boldsymbol{x}}{\boldsymbol{u}-\boldsymbol{m}}, & \boldsymbol{x} \in [\boldsymbol{m}, \boldsymbol{u}] \\ \boldsymbol{0}, & \boldsymbol{otherwise} \end{bmatrix} \tag{2}$$

$$\boldsymbol{\nu_A}(\boldsymbol{x}) = \begin{bmatrix} \boldsymbol{0}, & \boldsymbol{x} \in [-\infty, \boldsymbol{l}] \\ \frac{\boldsymbol{x}-\boldsymbol{l}}{\boldsymbol{m_1}-\boldsymbol{l}}, & \boldsymbol{x} \in [\boldsymbol{l}, \boldsymbol{m_1}] \\ \boldsymbol{1}, & \boldsymbol{x} \in [\boldsymbol{m_1}, \boldsymbol{m_2}] \\ \frac{\boldsymbol{u}-\boldsymbol{x}}{\boldsymbol{u}-\boldsymbol{m_2}}, & \boldsymbol{x} \in [\boldsymbol{m_2}, \boldsymbol{u}] \\ \boldsymbol{0}, & \boldsymbol{x} \in [\boldsymbol{\mu}, +\infty] \end{bmatrix} \tag{3}$$

Definition 7:
Intuitionistic fuzzy preference relation in matrix R is like $R = (r_{ij})_{n\times n}$, where
$r_{ij} = (\mu_{ij}, \vartheta_{ij})\ \ for\ \ i,j = (1,2, \dots n)$ (Erensal & Albayrak, 2007)

Here multiplicative consistent if: $i \leq t \leq k\ \ and\ \ i,k = 1,2, \dots, n$.

$$\mu_{\boldsymbol{ik}} = \begin{bmatrix} \boldsymbol{0} & , \boldsymbol{if}(\mu_{\boldsymbol{it}}, \mu_{\boldsymbol{tk}}) \subset \{(\boldsymbol{0}, \boldsymbol{1}), (\boldsymbol{1}, \boldsymbol{0})\} \\ \frac{\mu_{\boldsymbol{it}}\mu_{\boldsymbol{tk}}}{\mu_{\boldsymbol{it}}\mu_{\boldsymbol{tk}} + (\boldsymbol{1}-\mu_{\boldsymbol{it}})(\boldsymbol{1}-\mu_{\boldsymbol{tk}})} & , \boldsymbol{otherwise} \end{bmatrix} \tag{4}$$

$$\boldsymbol{\vartheta_{ik}} = \begin{bmatrix} \boldsymbol{0} & , \boldsymbol{if}(\boldsymbol{\vartheta_{it}}, \boldsymbol{\vartheta_{tk}}) \subset \{(\boldsymbol{0}, \boldsymbol{1}), (\boldsymbol{1}, \boldsymbol{0})\} \\ \frac{\boldsymbol{\vartheta_{it}}\boldsymbol{\vartheta_{tk}}}{\boldsymbol{\vartheta_{it}}\boldsymbol{\vartheta_{tk}} + (\boldsymbol{1}-\boldsymbol{\vartheta_{it}})(\boldsymbol{1}-\boldsymbol{\vartheta_{tk}})} & , \boldsymbol{otherwise} \end{bmatrix} \tag{5}$$

Definition 8:
Pairwise comparison is an important strategy for distinguishing and checking the degree of similarity of each reference pair. To compare the desired pairs, we form a matrix called a pairwise comparison matrix (PCM) (Zhang et al., 2018). One of the fundamental tools in MCDM approaches, especially in the intuitionistic fuzzy hierarchical process, is

the pairwise comparison matrix that simply compares two factors and is used to calculate the relative priorities of criteria or sub-criteria or options.

A pairwise comparison matrix is as follows:

$$A = (a_{ij})_{n\times n} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \dots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}.$$

In fuzzy methods, this matrix is used in which $a_{ii} = 1,\ a_{ij} = \frac{1}{a_{ji}}$ for $i \neq j$ (Sepehrian et al., 2021).

Definition 9:
For any $r_{ij} = (\mu_{ij}, v_{ij})$ and $r_{tl} = (\mu_{tl}, v_{tl})$ in X (Xu, 2007):
μ_{ij}: Degree of membership
Vij: Degree of non − membership

1. $r_{ij} \oplus r_{tl} = (\mu_{ij} + \mu_{tl} - \mu_{ij}\mu_{tl}, \nu_{ij}\nu_{tl})$
2. $r_{ij} \otimes r_{tl} = (\mu_{ij}\mu_{tl}, \nu_{ij} + \nu_{tl} - \nu_{ij}\nu_{tl})$
3. $\lambda r_{ij} = \left(1 - (1 - \mu_{ij})^{\lambda}, {\nu_{ij}}^{\lambda}\right), \lambda > 0$
4. ${r_{ij}}^{\lambda} = \left({\mu_{ij}}^{\lambda}, 1 - (1 - \nu_{ij})^{\lambda}\right), \lambda > 0$

The next section describes the implementation of IFAHP based on the above definitions.

4.3.2 Intuitionistic Fuzzy Analytic Hierarchy Process (IFAHP)

The steps for implementing the IFAHP are as follows:

Step 1. The construction of the pairwise comparison matrix is a crucial first step in the IFAHP, allowing for a systematic evaluation of the relative importance of selected criteria. Using the linguistic terms outlined in Table 2, this matrix facilitates comparisons between pairs of criteria based on expert judgments, transforming qualitative assessments into quantitative data. This process sets the foundation for subsequent analyses, enabling decision-makers to effectively prioritize criteria and make informed evaluations within the overall framework.

Table 2
Scale for the IFAHP evaluations

Linguistic importance value	1-9 scale	0.1-0.9 scale
Extremely not preferred	1/9	0.1
Very strongly not preferred	1/7	0.2
Strongly not preferred	1/5	0.3
Moderately not preferred	1/3	0.4
Equally preferred	1	0.5
Moderately preferred	3	0.6
Strongly preferred	5	0.7
Very strongly preferred	7	0.8
Extremely preferred	9	0.9

Step 2. In this step, it is essential to check the consistency of the pairwise comparison matrix to ensure the reliability of the comparisons made. This is done by calculating the Consistency Index (CI) and subsequently the Consistency Ratio (CR). The CR is derived using specific formulas, and its comparison against the Random Index (RI) values presented in Table 3 helps determine whether the judgments are consistent. A low CR indicates a coherent set of comparisons, while a higher CR signals potential inconsistencies that may require revisiting the original assessments for accuracy and reliability in the decision-making process.

Table 3
RI values for different matrix orders.

RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41
n	1	2	3	4	5	6	7	8

$$\boldsymbol{CI = (\lambda_{max} - 1)/(n - 1)} \tag{6}$$

$$\boldsymbol{CR = \; CI/RI} \tag{7}$$

λ_{max} is the maximum eigenvalue of the decision matrix and n is the matrix order (Ghorbanzadeh et al., 2018).
The acceptable value for 1 is less than or equal to 0.1.

Step 3. The preference vector of each intuitionistic preference relation is calculated using the Equation 8.

$$\boldsymbol{\omega_i = \left(\frac{\sum_{j=1}^{n}\mu_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(1-\vartheta_{ij}\right)}, 1 - \frac{\sum_{j=1}^{n}\left(1-\vartheta_{ij}\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n}\mu_{ij}}\right), \quad for\ \ i \in \{1, 2, \dots, n\}} \tag{8}$$

Step 4. In this step, all the weights obtained from the previous step are added using Equation 9, according to each alternative, and the total weights are obtained.

$$\boldsymbol{\omega_i = \oplus_{j=1}^{n}(\omega_j \otimes \omega_{ij})} \tag{9}$$

Step 5. Then $\rho(\alpha)$ is calculated for the substitutes. Formula $\rho(\alpha)$ is as follows:

$$\boldsymbol{\rho(\alpha) = 0.5\ (1 + \pi_\alpha)(1 - \mu_\alpha)} \tag{10}$$

Step 6. Finally, all the weights are arranged in descending order and the best alternative is introduced.

5. Case study

Currently, there are 397 mutual funds in Iran, and to evaluate the performance of the mutual funds, we selected equity funds from different categories. There are 107 active stock funds. There are two types of funds, tradable (ETF), and issuance and cancellation. To invest in issuance and cancellation funds, units are issued and when the investor receives money from the fund, his mutual fund units are canceled. Buying, selling and investing in exchange-traded funds (ETFs) is like buying and selling shares of companies on the stock exchange. Despite the nascent nature of mutual funds in Iran, selecting mutual funds with significant operational experience and the highest assets is particularly important to reduce investment risk and enhance transparency in decision-making. In this research, mutual funds with a minimum of five years of operational experience were identified and selected, as this track record can reflect the capabilities of the managers and the effectiveness of the mutual funds in managing investments. Moreover, given the inability to accurately assess the expertise of mutual fund managers, the use of performance filters over one-year, three-year, and five-year periods, along with the size of the mutual funds, allows researchers and investors to identify credible and reliable alternatives among the 20 mutual funds with the highest assets and best performance. This selection, based on specific and objective criteria, helps provide suitable investment opportunities with lower risk.

5.1. Performance rating

A mutual funds' rating is determined by the Burhan Credit Rating Institute[1]'s guidelines for rating mutual funds. These ratings are based on a quantitative model and allow investors to evaluate a fund's past performance compared to its peers, taking into account the level of risk involved. The performance of mutual funds is assessed by comparing their risk-adjusted returns with those of similar funds during the same period. This rating is updated every three months, considering both concentration risk and excluding concentration risk. Burhan classifies mutual funds into five categories based on their performance, with the highest rating being "Five Star" (MFR-5) and the lowest being "One Star" (MFR-1). Concentration risk arises when a mutual fund has a high level of

[1] https://www.bcr.ir/

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investment in a small number of companies or industries. Burhan categorizes mutual funds according to their level of concentration risk, ranging from very high to very low.

5.2. Determination of criteria, sub-criteria, and alternatives

The evaluation criteria can be divided into two main categories: qualitative criteria and quantitative criteria. Quantitative criteria are measurable metrics expressed numerically. These criteria are typically determined based on observed and measured data. Qualitative criteria, on the other hand, are defined based on characteristics that cannot be quantified numerically. These criteria are generally established based on experiences, opinions, and qualitative assessments by individuals. The use of both quantitative and qualitative criteria in data analysis and evaluation can enhance decision-making and improve organizational performance. In many cases, utilizing both types of criteria in combination can yield more accurate results. The criteria and related sub-criteria for evaluating mutual funds in this study were validated using the Delphi method. Therefore, this research considers both qualitative and quantitative criteria for evaluating the performance of mutual funds. These criteria are categorized into two groups: those related to the structure and performance of the mutual funds, and those concerning the human aspects and management of the mutual funds. The quantitative criteria in this research include “features of mutual fund” and “criteria for evaluating the performance of the mutual fund” while the qualitative criterion includes “personality characteristics of the mutual fund manager.”

Each of these criteria contains several sub-criteria, which will be elaborated upon further. In the evaluation process, quantitative sub-criteria are assessed numerically, while qualitative sub-criteria are analyzed using a Likert scale, which effectively converts qualitative judgments into quantitative metrics. For the sub-criterion “Average managers’ literacy,” managers are evaluated based on their qualifications and resumes which were found on the respective mutual fund websites. Using linguistic values to assess educational background and expertise, these qualitative evaluations were then transformed into quantitative scores through the Likert scale. The resulting average score for each mutual fund’s managers is indicative of the educational level of the management team, as illustrated in Table 4, providing a clear benchmark for assessing managerial competence within the context of mutual fund performance.

Table 4
Average managers’ literacy and their corresponding scale values

Field of study	Scale
Bachelor’s (other fields of study)	1
Master’s (other fields of study)	2
Doctorate (other fields of study)	3
Bachelor’s in Financial Management	4
Master’s in Financial Management	5
Doctorate in Financial Management	6

Table 5 presents a Likert scale that uses linguistic terms to evaluate the performance of mutual fund managers based on the analysis of one-year, three-year, and five-year

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performance data sourced from the Financial Information Processing Center of Iran[2] website. Each performance level is assigned a numerical rating, ranging from “Excellent” (5) to “Very Weak” (1), providing a clear framework for assessing managerial effectiveness. This structured approach helps categorize the trajectory of each fund’s performance over the three-year period as either upward, downward, or stable, enabling a comprehensive understanding of how well managers have navigated market conditions and achieved investment objectives over time. This evaluation is crucial for stakeholders making informed decisions related to mutual fund management and investment strategies.

Table 5
Rating scale for linguistic terms for managers’ performance

Linguistic terms		Scale
E	Excellent	5
VG	Very Good	4
G	Good	3
W	Weak	2
VW	Very Weak	1

After determining the objective of choosing the best mutual fund, we considered three of the most important criteria according to the opinion of experts to evaluate the mutual funds. The criteria, which are the features of a mutual fund, the personality characteristics of the mutual fund manager, and the criteria for evaluating the performance of the mutual fund were placed on the second level of the hierarchy. Also, for each of these criteria, several sub-criteria were selected, which were placed at the third level of this hierarchy. Below is a brief explanation of each sub-criterion:

Criterion1: Features of mutual fund

1. Mutual fund size

Mutual fund size refers to the total amount of capital invested by individuals in a venture capital fund. It represents the overall asset base that a mutual fund manager is responsible for overseeing and investing (Bhojraj et al., 2012; Indro et al., 1999).

2. Life cycle of the mutual fund

The concept of the mutual fund life cycle suggests that funds go through four distinct stages: introduction, growth, maturity, and decline (Ling, 2011).

3. Degree of diversification of the mutual fund portfolio

Diversification plays a crucial role in managing investment risks by breaking down a larger risk into smaller, more manageable components. In the case of mutual funds, diversification, also known as asset allocation, is a strategy that aims to mitigate unsystematic risks. By investing in a diversified portfolio, investors can reduce the risks associated with individual stocks and bonds, making mutual funds an attractive option for those seeking rapid wealth growth (Lhabitant, 2017)

[2] Fipiran (https://www.fipiran.ir/)

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Criterion 2: Personality characteristics of the mutual fund manager

Mutual fund managers score highly on extraversion, meaning that they rely on external stimuli, such as people or exciting surroundings to be happy. They also tend to be high on the measure of conscientiousness, which means that they are methodical, reliable, and generally plan out things in advance.

1. Average managers' literacy

Financial literacy encompasses the understanding and application of various financial concepts, such as managing personal finances, making investments, and planning for taxes. Its main objective is to protect individuals from financial fraud and scams. By being financially literate, individuals become self-sufficient and can achieve financial stability through effective money management, budgeting, and saving (Mohd Padil et al., 2022).

2. Managers' performance

To qualify for a managerial position, candidates must possess a minimum of three years of experience in leadership roles such as Supervisor, Director, or Team Leader. Additionally, successful managers should exhibit strong motivation, exceptional team leadership skills, and the ability to accomplish goals and objectives.

Criterion 3: Criteria for evaluating the performance of the mutual fund

1. Jensen's alpha index

Jensen's alpha index is a measure of risk-adjusted performance that calculates the average return of a portfolio or investment above or below what is predicted by the capital asset pricing model (CAPM), taking into account the portfolio's or investment's beta and the average market return. It is also referred to as the "active return" of the fund. The coefficient alpha is used to assess the internal consistency of items, indicating the degree to which they are interrelated. A higher coefficient suggests a stronger interrelation between the items, where the performance of one item can predict the performance of the remaining items. Alpha can be positive, negative, or zero. A negative alpha indicates weaker performance compared to the benchmark index, while a positive alpha signifies better performance. A zero alpha means that the fund's return is proportional to its risk. Generally, a higher alpha value indicates better mutual fund performance.

2. Beta coefficient

Alpha is a measure of how well an asset manager guides a mutual fund to generate profits compared to a benchmark index. On the other hand, beta quantifies a fund's response to market volatility by measuring the extent to which its prices align with changes in the benchmark index. In the field of finance, beta (β or market beta or beta coefficient) measures how an individual asset typically moves when the overall stock market experiences gains or losses. Therefore, beta provides valuable insight into the contribution of an individual asset to the overall risk of the market portfolio when it is added in small quantities.

3. Annual return

The annual return is the percentage of the initial investment that is generated over a year. It is considered a gain if the return is positive and a loss if the return is negative.

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4. Sharpe ratio

The Sharpe ratio, also known as the Sharpe index, Sharpe measure, or reward-to-variability ratio, is a financial metric that evaluates the performance of an investment, such as a security or portfolio, relative to a risk-free asset while adjusting for risk.

5. Sortino ratio

The Sortino ratio is a performance metric that evaluates the risk-adjusted return of an investment by focusing solely on the downside risk. It is a modified version of the Sharpe ratio, using the standard deviation of negative returns as the risk measure in its calculation. A desirable Sortino ratio scores 2 or higher.

6. Treynor ratio

The Treynor ratio is a measure of portfolio performance that takes into account systematic risk. Unlike the Sharpe Ratio, which considers the portfolio's standard deviation, the Treynor Ratio incorporates the Portfolio Beta, a measure of systematic risk. It is named after Jack Treynor, an American economist who played a key role in developing the Capital Asset Pricing Model. The Treynor Index is a performance evaluation tool that adjusts excess returns for systematic risk. It uses systematic risk in interpreting yield fluctuations. This index indicates how much-adjusted return an investor receives for each unit of systematic risk. The Treynor Index utilizes the beta coefficient as a risk criterion, assuming that the portfolio is well-diversified. A higher ratio of additional portfolio returns to volatility, compared to risk-free returns, indicates better portfolio performance.

7. M2 ratio

The M2 ratio is an enhanced and more practical version of the Sharpe ratio. It calculates the risk-adjusted return of a portfolio by multiplying the Sharpe ratio with the standard deviation of a benchmark market index. It then adds the risk-free return to the result. The return of mutual funds was obtained using the information available on the Fipiran website. Table 6 presents critical formulas used for calculating various performance indicators of mutual funds, leveraging return data sourced from the Financial Information Processing Center of Iran. This table includes ratios such as the Beta Coefficient, which assesses market sensitivity; Jensen's alpha, indicating excess returns relative to risk; and the Sharpe, Treynor, and Sortino ratios, all of which evaluate risk-adjusted performance from different angles. Additionally, the M2 measure provides insights into portfolio returns relative to market benchmarks, while downside deviation focuses on the risk of negative returns. Collectively, these formulas offer a comprehensive framework for analyzing mutual fund performance and guiding investment decisions based on quantitative metrics.

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Table 6
Formula for calculating quantitative measures

Ratio	Formula	Description
Beta Coefficient	$\beta_P = \frac{Covariance\ (R_e,\ R_m)}{variance\ (R_m)}$	R_e = Return on an individual stock R_m = Return on the overall market
Jensen's alpha	$\alpha_P = (R_P - R_f) - [\beta_P(R_m - R_f)]$	R_P = Returns generated by the portfolio R_f = Risk-free rate β_P = Portfolio's beta R_m = Expected market return
Sharpe	$S_p = \frac{R_P - R_f}{\sigma_P}$	R_P = Return of portfolio R_f = Risk-free rate σ_P = standard deviation of the portfolio's excess re turn
Treynor	$T_p = \frac{R_P - R_f}{\beta_P}$	R_P = Return of portfolio R_f = Risk-free rate β_P = Beta of portfolio
Sortino	$So_p = \frac{R_P - R_f}{DD}$	R_P = Return of portfolio R_f = Risk-free rate DD = Standard deviation of negative asset return (Downside deviation)
M2	$M_P^2 = R_P + [\frac{R_P - R_f}{\sigma_P}]\sigma_m$	R_P = Return of portfolio R_f = Risk-free rate σ_P = standard deviation of the portfolio's excess re turn σ_m= Standard deviation of the market
Downside deviation	$DD = \left[\frac{1}{n-1}\sum_{i=1}^{n}(\max\{0, R_f -\right.$	$R_{P,i}$ = Return of portfolio i th R_f = Risk-free rate

Ratio	Formula	Description
	$R_{p,i}\})^2\Big]^{\frac{1}{2}}$	

6. Data analysis

6.1. Summary of the technique implementation process

First, the required data were obtained and the initial data table was formed. To streamline and accelerate the paired comparison process using IFAHP, the weights for each criterion and sub-criterion were initially determined through the BWM method. Next, dominance ratios between the criteria and sub-criteria were established based on these weights, leading to the formation of the pairwise comparison matrix. Subsequently, the intuitionistic fuzzy weight for each criterion and sub-criterion was computed utilizing Equation 8.

In the next phase, the alternatives were compared pairwise. Then, the intuitionistic fuzzy weights for the alternative were calculated using Equation 8. Next, with the intuitionistic fuzzy weights of the sub-criteria and the alternative, the aggregated weight for the alternatives was derived using Equation 9. Ultimately, the final weight for each alternative was determined using Equation 10. The alternative with the highest weight was deemed to have the greatest priority, leading to the ranking of the alternatives accordingly. Next, each step of the algorithm was implemented.

6.2. Step-by-step implementation of the algorithm

First, the selected mutual funds are shown in Table 7, which lists various equity funds in Iran, along with key details such as their website addresses, mutual fund types, and managers. This table also provides comprehensive performance ratings over one-year, two-year, and three-year periods, allowing investors to easily compare the historical performance of each mutual fund. By categorizing funds based on their performance grades, which range from 1 to 5, it offers a clear perspective on the effectiveness of mutual fund management and operational success. This structured information facilitates informed investment decisions by focusing on funds with proven track records and reliable management teams.

Table 7

Information of selected mutual funds

Mutual fund name	Website address	Mutual fund type	Manager	Three-year performance grading	Two-year performance grading	One-year performance grading
Aseman armani saham	asasfund. ir	Stock Funds	Sabad gardane aseman	5	5	5
Bazar omid afarin	bazreomidfund. ir	Stock Funds	Tamine sarmaie omid	3	3	3
Firozeh movafaghiat	firouzehfund. ir	Stock Funds	Sabad gardane tosehe firozeh	5	5	5
Hamyan sepehr	hsfund.ir	Stock Funds	Sabad gardane aseman	4	4	4
Hasti bakhsh agah	hbagahfund.com	Stock Funds	Tamin sarmaie sepehr	5	5	4
Moshtarek agah	agah-fund.ir	Stock Funds	Sabad gardane agah	4	4	4
Moshtarek arzesh kavan ayande	arzeshkavanfund. ir	Stock Funds	Sabad gardane asal	3	2	2
Moshtarek Bank khavarmiane	mebfund.ir	Stock Funds	Sabad gardane artin	3	2	3
Moshtarek kargozari Bank meli iran	bmimf.com	Stock Funds	Sabad gardane farabi	3	3	2
Moshtarek omid toseh	omid-fund.com	Stock Funds	Sabad gardane mofid	4	4	4
Moshtarek pishro	pishrofund.com	Stock Funds	Kargozarie bank meli iran	4	4	3
Moshtarek pishtaz	pishtazfund.com	Stock Funds	Sabad gardane mofid	5	5	5
Moshtarek yekom aban	abfund.ir	Stock Funds	Sabad gardane agah	3	3	2
Moshtarek yekom exir farabi	exir1.irfarabi.com	Stock Funds	Sabad gardane aban	3	4	4
Ofoghe melat	ofoghmellat. ir	Stock Funds	Tamine sarmaie bank mellat	4	4	3
Sahami sepand karizma	scetf.ir	Stock Funds	Sabad gardane karizma	4	4	3
Sarv sodmand modaberan	sarv. fund	Stock Funds	Moshavere sarmaie gozarie toranj	5	4	3
Sepehr aval bazar	sepehraval. ir	Stock Funds	Tamine saramie sepehr	1	1	2
Tejarat shakhesi kardan	iran-kfunds3.ir	Stock Funds	Tamine sarmaie kardan	4	3	3
Toseh atlas mofid	atlasetf.com	Stock Funds	Sabad gardane mofid	5	5	4

As seen in Table 8, each of the mutual funds is considered an alternative investment option, with mutual funds labeled from A1 to A20 for brevity.

Table 8
Selected mutual funds as alternative

Alternative	Mutual fund	Alternative	Mutual fund
A1	Sepehr aval bazar	**A11**	Sahami sepand karizma
A2	Moshtarek kargozari Bank meli iran	**A12**	Moshtarek Bank khavarmiane
A3	Moshtarek pishtaz	**A13**	Bazr omid afarin
A4	Tejarat shakhesi kardan	**A14**	Ofoghe melat
A5	Moshtarek omid toseh	**A15**	Hasti bakhsh agah
A6	Toseh atlas mofid	**A16**	Moshtarek yekom aban
A7	Moshtarek arzesh kavan ayande	**A17**	Moshtarek pishro
A8	Moshtarek yekom exir farabi	**A18**	Aseman armani saham
A9	Moshtarek agah	**A19**	Sarv sodmand modaberan
A10	Firozeh movafaghiat	**A20**	Hamyan sepehr

According to the hierarchical approach utilized in this research, the goal is "Choosing the best mutual fund." To achieve the desired goal, three criteria have been defined, which are the features of a mutual fund, the personality characteristics of the mutual fund manager and criteria for evaluating the performance of the mutual fund. The data obtained for the selected mutual funds based on the considered criteria are given below.

Criterion1: Features of mutual fund

As seen in Figure 2, Criterion 1 focuses on the features of mutual funds and includes three important sub-criteria. These are mutual fund size, which assesses the total assets under management and its influence on mutual fund performance; degree of diversification of the mutual fund portfolio, which evaluates how well the mutual fund spreads risk across various asset classes; and life cycle of the mutual fund, which considers the stage of development of the mutual fund and its potential impact on investment strategies and returns. Together, these sub-criteria provide a comprehensive framework for understanding the foundational aspects that contribute to the overall effectiveness of mutual funds.

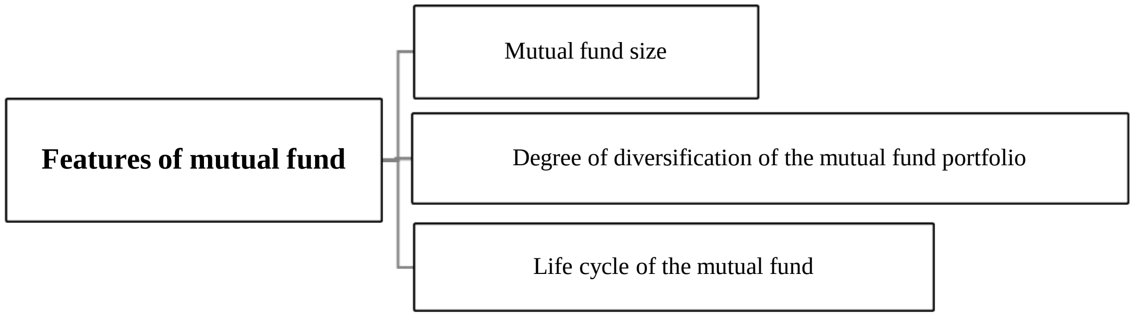

Figure 2 Sub-criteria of criterion features of mutual fund.

The data obtained for Criterion 1 are detailed in Table 9, which outlines the features of mutual funds. This table includes three essential sub-criteria: mutual fund size, indicating the fund's total assets under management and its implications for liquidity and investment capacity; degree of diversification of the mutual fund portfolio, reflecting how well the mutual fund distributes its investments to mitigate risk; and life cycle of the mutual fund, which examines the fund's developmental stage and its impact on performance strategies.

Table 9
Data related to features of mutual fund criterion

Alternative	**Mutual fund size**		**Degree of diversity of the portfolio**						**Life cycle**
	Total net asset value (billions of Rials)	Number of invested units	Bank deposit	Cash	Bonds	Other stocks	Five shares with the highest weight	Other assets	
A1	5035154836304	18657949	5.9	0.01	3.44	56.03	33.26	1.36	110
A2	5126873915548	27319581	0	0	0.93	61.86	31.3	5.91	55
A3	4410496334015	31656400	2.35	0	3.46	62.46	31.38	0.36	110
A4	8034070855120	29078355	11.5	0	0	53.83	34.61	0.06	94
A5	19719985315016	55752024	1.55	0	2.33	72.77	23	0.35	109
A6	6057565615602	192187	0.02	0	1.51	58.54	38.64	1.29	142
A7	11866217617831	111662249	0.12	0	2.55	68.93	23.73	3.58	42
A8	14973112836394	791029760	8.3	0	9.83	64.29	16.99	0.21	112
A9	3546484149394	2161882	11.95	0	0.44	61.1	25.46	1.05	150
A10	8333182637564	15701	0.76	0	3.06	69.92	25.51	0.75	175
A11	12563323861549	1894494	0.11	0	1.21	64.15	34.28	0.25	165
A12	20382915411081	69246255	0.11	0	2.3	60.44	35.06	2.09	119
A13	20816377888758	726110	0	0.02	0	56.21	43.69	0.08	107
A14	46460961381133	9751732	0.13	0	2.82	64.37	32.29	0.39	178
A15	35719073103756	39005281	0.49	0	1.4	72.07	25.3	0.74	142
A16	5043453186240	10689	0.26	3.34	0	63.62	31.74	1.04	178
A17	5719422405807	3436771	2	0	0	78.03	18.03	1.95	159
A18	4572299634219	157406	0.08	0.16	0	62.15	37.21	0.4	98
A19	25203295897530	227545000	1.2	0	5.77	66.13	24.03	2.86	86
A20	7168651805676	353114	0.14	0	8.41	57.36	33.74	0.35	101

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Criterion 2: Personality characteristics of the mutual fund manager

Criterion 2 focuses on the personality traits and professional competencies of mutual fund managers, as depicted in Figure 3. This criterion includes two sub-criteria: average managers' literacy, which evaluates the educational background and knowledge of the managers, and managers' performance, which assesses how these characteristics translate into investment success and effective mutual fund management. Together, these sub-criteria provide insight into the influence of managerial attributes on mutual fund performance.

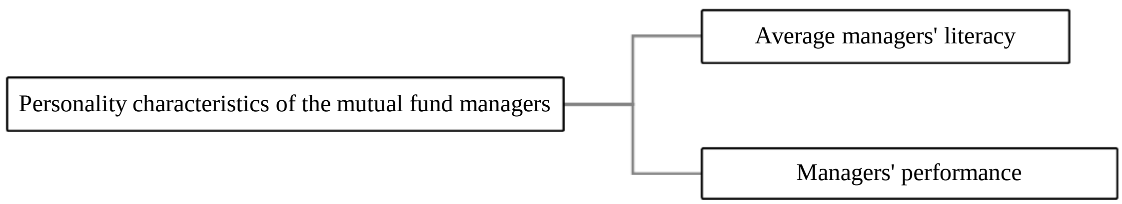

Figure 3 Sub-criteria of criterion personality characteristics of the mutual fund managers

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The data obtained for criterion 2 are shown in Table 10. This table presents two key sub-criteria essential for assessing the effectiveness of mutual fund managers. The average managers' literacy was quantified by analyzing their educational qualifications and professional backgrounds, indicating their preparedness and expertise in managing funds. Meanwhile, the managers' performance was measured through performance scores aggregated over one-year, two-year, and three-year periods, reflecting their ability to achieve financial objectives and potentially enhance investor returns. By combining these two aspects, the table offers valuable insights into how the personal attributes of managers can impact overall mutual fund performance, thereby aiding investors in making informed decisions based on both qualifications and track records.

Table 10
Data related to personality characteristics of the mutual fund managers criterion

Alternative	Average managers' literacy	Managers' performance	
A1	5.3	E	5
A2	3.7	VG	4
A3	3.7	G	3
A4	4.8	VG	4
A5	4.0	E	5
A6	4.0	VW	1
A7	5.3	E	5
A8	5.0	VG	4
A9	4.7	E	5

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Alternative	Average managers' literacy	Managers' performance	
A10	2.7	VG	4
A11	1.7	G	3
A12	2.3	VG	4
A13	1.7	G	3
A14	5.3	E	5
A15	2.7	VG	4
A16	4.8	G	3
A17	2.0	VW	1
A18	2.3	G	3
A19	1.3	E	5
A20	4.0	VG	4

Criterion 3: Criteria for evaluating the performance of the mutual fund
Figure 4 shows criterion 3 and its sub-criteria, which focuses on evaluating the performance of mutual funds, alongside its sub-criteria Jensen's alpha index, beta coefficient, annual return, Sharpe ratio, Sortino ratio, Treynor ratio, and M2 ratio.

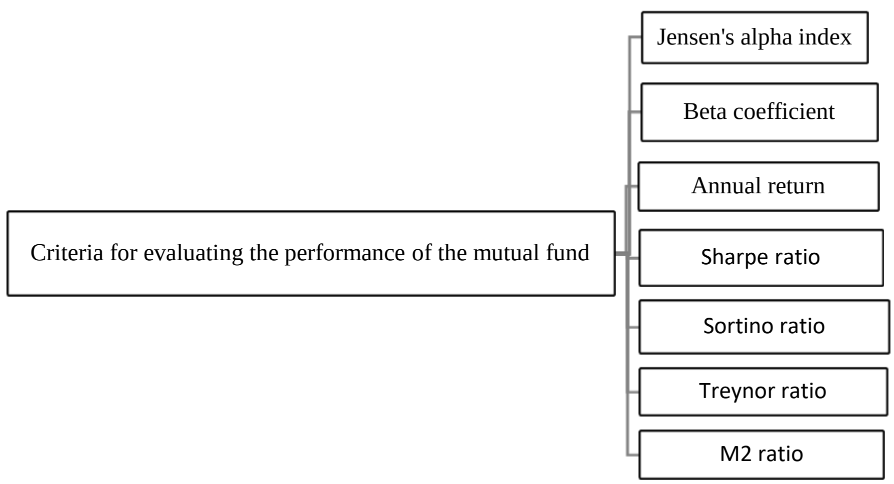

Figure 4 Sub-criteria of criterion criteria for evaluating the performance of the mutual fund.

The data obtained for criterion 3 are shown in Table 11 which outlines several key metrics used to evaluate the performance of mutual funds, including the Jensen's alpha index, beta coefficient, annual return, Sharpe ratio, Sortino ratio, Treynor ratio, and M2 ratio. Each metric serves a specific purpose; for example, Jensen's alpha measures the fund's excess return relative to its risk, while the Sharpe and Sortino ratios assess risk-adjusted performance. These indicators collectively provide a comprehensive framework for analyzing and comparing different mutual funds, facilitating informed investment decisions.

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Table 11
Data related to criteria for evaluating the performance of the mutual fund

Alternative	Beta coefficient	Jensen's alpha index	Annual return
A1	0.77	29.80	58.80
A2	0.89	10.82	41.82
A3	0.99	15.08	48.08
A4	1.02	16.58	49.58
A5	0.90	19.78	51.78
A6	1.24	-1.91	35.09
A7	0.98	19.16	51.16
A8	0.93	19.23	51.23
A9	0.85	31.30	62.30
A10	0.98	9.06	42.06
A11	0.81	6.01	36.01
A12	0.94	9.63	41.63
A13	1.15	18.82	53.82
A14	0.88	17.15	48.15
A15	0.94	16.26	48.26
A16	1.03	21.32	55.32
A17	0.94	10.67	42.67
A18	1.20	9.94	45.94
A19	0.87	15.16	45.16
A20	1.08	16.42	50.42

Alternative	Sharpe ratio	Sortino ratio	Treynor ratio	M2 ratio	Standard deviation	Downside deviation	Market deviation
A1	0.41	0.65	0.53	0.99	1.00	0.62	0.99
A2	0.23	0.38	0.27	0.65	1.02	0.63	0.99
A3	0.26	0.38	0.30	0.48	1.17	0.78	0.01
A4	0.27	0.45	0.31	0.76	1.16	0.70	0.99
A5	0.33	#DIV/0!	0.37	0.84	1.03	0.00	0.99
A6	0.14	0.22	0.14	0.35	1.26	0.77	0.01
A7	0.29	0.47	0.34	0.52	1.13	0.70	0.01
A8	0.31	0.49	0.36	0.52	1.08	0.67	0.01
A9	0.46	0.85	0.52	1.08	0.96	0.52	0.99
A10	0.24	0.41	0.24	0.42	1.00	0.58	0.01
A11	0.20	0.30	0.22	0.36	0.92	0.60	0.01
A12	0.24	0.46	0.25	0.66	0.97	0.51	0.99
A13	0.31	0.56	0.31	0.54	1.15	0.63	0.01
A14	0.33	0.66	0.34	0.80	0.92	0.46	0.99
A15	0.31	0.61	0.32	0.79	0.96	0.50	0.99
A16	0.35	0.62	0.36	0.56	01.06	0.60	0.01
A17	0.24	0.37	0.26	0.43	1.04	0.68	0.01
A18	0.23	0.42	0.23	0.68	1.24	0.66	0.99
A19	0.27	0.42	0.31	0.45	1.01	0.64	0.01
A20	0.30	0.51	0.30	0.51	1.08	0.63	0.01

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To prioritize the criteria and sub-criteria, the BWM was employed, subsequently calculating the weights for the criteria. Following the modeling process, the BWM equations were solved using LINGO 20.0.1, and the results are presented in Table 12. This table displays the calculated weights for each criterion and sub-criterion as determined by the BWM, reflecting their relative importance in the decision-making model. The results provide a quantitative foundation that informs the overall prioritization strategy and aids in objective evaluations.

Table 12
Weight of criteria and sub-criteria using BWM

Criteria		**Weight**	**Sub-criteria**		**Weight**
C1	Features of mutual fund	0.1	**SC1**	Mutual fund size	0.7222
			SC2	Life cycle of the mutual fund	0.0833
			SC3	Degree of diversification of the mutual fund portfolio	0.1944
C2	Personality characteristics of the mutual fund managers	0.1571	**SC4**	Literacy of managers	0.4
			SC5	Performance of managers	0.6
C3	Criteria for evaluating the performance of the mutual fund	0.7428	**SC6**	Jensen’s alpha index	0.1192
			SC7	Beta coefficient	0.3856
			SC8	Annual return	0.1192
			SC9	Sharpe ratio	0.0953
			SC10	Sortino ratio	0.0420
			SC11	Treynor ratio	0.0794
			SC12	M2 ratio	0.1589

The compatibility rate was obtained by dividing the compatibility index by the random index. Comparisons are consistent if the consistency rate is 0.1 or less. According to the calculations made in BWM, the compatibility rate is less than 0.1 and therefore the comparisons are compatible. According to the weights obtained through the BWM techniques presented in Table 12, pairwise comparisons of criteria and sub-criteria are detailed in Tables 13-16. These tables illustrate the relative importance of each criterion and sub-criterion based on the weights assigned, providing a comprehensive overview of their contributions to the overall decision-making framework. Table 13 provides a structured comparison of the main criteria, showing how each criterion is prioritized relative to the others.

Table 13
Pairwise comparison matrix of criteria

R	**C1**	**C2**	**C3**
C1	(0.5,0.5)	(0.3,0.6)	(0.1,0.8)
C2	(0.6,0.3)	(0.5,0.5)	(0.2,0.67)
C3	(0.8,0.1)	(0.67,0.2)	(0.5,0.5)

Table 14, details the pairwise comparisons among the sub-criteria of Criterion 1. It highlights the relative importance of each sub-criterion, thereby clarifying their contributions to the evaluation of C1.

Table 14
Pairwise comparison matrix of the sub-criteria of C

R1	SC1	SC2	SC3
SC1	(0.5,0.5)	(0.82,0.1)	(0.7,0.2)
SC2	(0.1,0.82)	(0.5,0.5)	(0.2,0.65)
SC3	(0.2,0.7)	(0.65,0.2)	(0.5,0.5)

Table 15
Pairwise comparison matrix of the sub-criteria of C2

R2	SC4	SC5
SC4	(0.5, 0.5)	(0.2, 0.65)
SC5	(0.65, 0.2)	(0.5, 0.5)

Table 16
Pairwise comparison matrix of the sub-criteria of C3

R3	SC6	SC7	SC8	SC9	SC10	SC11	SC12
SC6	(0.5,0.5)	(0.2,0.7)	(0.5,0.5)	(0.65,0.15)	(0.7,0.2)	(0.7,0.2)	(0.3,0.6)
SC7	(0.7,0.2)	(0.5,0.5)	(0.7,0.25)	(0.8,0.1)	(0.79,0.12)	(0.8,0.1)	(0.6,0.3)
SC8	(0.5,0.5)	(0.25,0.7)	(0.5,0.5)	(0.7,0.2)	(0.7,0.2)	(0.7,0.2)	(0.3,0.6)
SC9	(0.15,0.65)	(0.1,0.8)	(0.2,0.7)	(0.5,0.5)	(0.6,0.3)	(0.6,0.3)	(0.15,0.68)
SC10	(0.2,0.7)	(0.12,0.79)	(0.2,0.7)	(0.3,0.6)	(0.5,0.5)	(0.32,0.54)	(0.1,0.8)
SC11	(0.2,0.7)	(0.1,0.8)	(0.2,0.7)	(0.3,0.6)	(0.54,0.32)	(0.5,0.5)	(0.25,0.63)
SC12	(0.6,0.3)	(0.3,0.6)	(0.6,0.3)	(0.68,0.15)	(0.8,0.1)	(0.63,0.25)	(0.5,0.5)

In this step, the intuitionistic fuzzy weight for each criterion and sub-criterion is calculated using Equation 8, which effectively captures the uncertainty and partial truths inherent in fuzzy sets. Additionally, the preference vector for each intuitionistic preference relation is computed using the same equation, enabling a nuanced assessment of the alternatives based on these weights. The resulting weights are displayed in Tables 17 and 18, providing a comprehensive overview of the significance attributed to each criterion and sub-criterion in the decision-making process. Table 17 presents the

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Intuitionistic Fuzzy Weight of the criteria and Table 18 focuses on the Intuitionistic Fuzzy Weight of the sub-criteria.

Table 17
Intuitionistic Fuzzy Weight of the criteria

Criteria	**C1**	**C2**	**C3**
Weight	(0.1863, 0.7362, 0.0774)	(0.2691, 0.6330, 0.0977)	(0.4078, 0.4724, 0.1197)

Table 18
Intuitionistic Fuzz Weight of the sub-criteria

Sub-criteria	**SC1**	**SC2**	**SC3**	**SC4**
Weight	(0.4182,0.4724, 0.1094)	(0.1656,0.7529,0.0814)	(0.2795,0.6163,0.1042)	(0.3255,0.5405,0.1339)
Sub-criteria	**SC5**	**SC6**	**SC7**	**SC8**
Weight	(0.5348,0.2972, 0.1678)	(0.1589,0.8141,0.0269)	(0.2189,0.7568,0.0242)	(0.1634,0.8163,0.0202)
Sub-criteria	**SC9**	**SC10**	**SC11**	**SC12**
Weight	(0.1030,0.8625, 0.0345)	(0.0779,0.8938,0.0282)	(0.0935,0.8768,0.0296)	(0.1840,0.7850,0.0309)

Pairwise comparisons of alternative options are calculated for each of the sub-criteria and the preference vector for each intuitionistic preference relation is computed using Equation 8, reflecting the relative desirability of alternatives based on fuzzy logic principles. Table 19 outlines the weights of each alternative, which are derived from Equation 8. This equation integrates specific criteria and evaluations to quantify their significance in the decision-making process, ensuring a clear representation of how each alternative measures up against the others.

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Table 19
Intuitionistic fuzzy preference relationship of alternatives according to criteria and sub-criteria

	SC1	**SC2**	**SC3**	**SC4**
	Size (0.4667,0.5333)	**Life cycle** (0.222,0.7778)	**Degree of diversification** (0.3111,0.6889)	**Literacy of managers** (0.45,0.55)
A1	(0.1588,0.5063,0.3349)	(0.5602,0.1571,0.2827)	(0.2862,0.4632,0.2506)	(0.161,0.378,0.461)
A2	(0.1641,0.5116,0.3243)	(0.5603,0.1573,0.2824)	(0.2898,0.4667,0.2435)	(0.161,0.378,0.461)
A3	(0.169,0.5166,0.3144)	(0.5603,0.1573,0.2824)	(0.2898,0.4667,0.2435)	(0.161,0.378,0.461)
A4	(0.1741,0.5216,0.3043)	(0.566,0.163,0.271)	(0.2898,0.4667,0.2435)	(0.1668,0.3837,0.4495)
A5	(0.1744,0.522,0.3036)	(0.5704,0.1674,0.2622)	(0.2898,0.4667,0.2435)	(0.1729,0.3899,0.4372)
A6	(0.1766,0.5242,0.2992)	(0.5719,0.1689,0.2592)	(0.3,0.477,0.223)	(0.1729,0.3899,0.4372)
A7	(0.1789,0.5265,0.2946)	(0.58,0.1769,0.2431)	(0.2979,0.4748,0.2273)	(0.1729,0.3899,0.4372)
A8	(0.1802,0.5278,0.292)	(0.58,0.1769,0.2431)	(0.2979,0.4748,0.2273)	(0.1802,0.3972,0.4226)
A9	(0.1802,0.5278,0.292)	(0.5887,0.1857,0.2256)	(0.2979,0.4748,0.2273)	(0.1802,0.3972,0.4226)
A10	(0.1895,0.5371,0.2734)	(0.5862,0.1832,0.2306)	(0.3042,0.4812,0.2146)	(0.1802,0.3972,0.4226)
A11	(0.1895,0.5371,0.2734)	(0.5862,0.1832,0.2306)	(0.3042,0.4812,0.2146)	(0.1875,0.4044,0.4081)
A12	(0.1925,0.54,0.2675)	(0.5837,0.1807,0.2356)	(0.3042,0.4812,0.2146)	(0.1875,0.4044,0.4081)
A13	(0.1987,0.5463,0.255)	(0.594,0.1909,0.2151)	(0.309,0.4859,0.2051)	(0.1945,0.4115,0.394)
A14	(0.1992,0.5468,0.254)	(0.594,0.1909,0.2151)	(0.3124,0.4893,0.1983)	(0.1945,0.4115,0.394)
A15	(0.2037,0.5513,0.245)	(0.5962,0.1932,0.2106)	(0.3135,0.4905,0.196)	(0.2013,0.4183,0.3804)
A16	(0.2053,0.5529,0.2418)	(0.5991,0.196,0.2049)	(0.318,0.495,0.187)	(0.2013,0.4183,0.3804)
A17	(0.2053,0.5529,0.2418)	(0.6005,0.1975,0.202)	(0.3212,0.4982,0.1806)	(0.2013,0.4183,0.3804)
A18	(0.2056,0.5532,0.2412)	(0.6056,0.2026,0.1918)	(0.3245,0.5014,0.1741)	(0.2073,0.4242,0.3685)
A19	(0.211,0.5586,0.2304)	(0.6098,0.2068,0.1834)	(0.3255,0.5024,0.1721)	(0.2073,0.4242,0.3685)
A2	(0.2115,0.5591,0.	(0.611,0.2079,0.1	(0.331,0.508,0.161)	(0.2124,0.4294,0.

0	2294)	811)		3582)
	SC5	**SC6**	**SC7**	**SC8**
	Performance of managers (0.55,0.45)	**Jensen's alpha index** (0.1571, 0.8429)	**Beta coefficient** (0.2041, 0.7959)	**Annual return** (0.1571, 0.8429)
A1	(0.475,0.192,0.333)	(0.3117,0.4887,0.1996)	(0.1761,0.4178,0.4061)	(0.3766,0.3568,0.2666)
A2	(0.475,0.192,0.333)	(0.3098,0.4867,0.2035)	(0.1765,0.5067,0.3168)	(0.3749,0.355,0.2701)
A3	(0.475,0.192,0.333)	(0.3067,0.4837,0.2096)	(0.181,0.5111,0.3079)	(0.3788,0.359,0.2622)
A4	(0.475,0.192,0.333)	(0.3054,0.4823,0.2123)	(0.1867,0.5169,0.2964)	(0.384,0.3642,0.2518)
A5	(0.475,0.192,0.333)	(0.3033,0.4802,0.2165)	(0.1933,0.5235,0.2832)	(0.39,0.3702,0.2398)
A6	(0.475,0.192,0.333)	(0.3017,0.4786,0.2197)	(0.1933,0.5235,0.2832)	(0.39,0.3702,0.2398)
A7	(0.484,0.201,0.315)	(0.3016,0.4785,0.2199)	(0.2007,0.5309,0.2684)	(0.3905,0.3706,0.2389)
A8	(0.484,0.201,0.315)	(0.3038,0.4807,0.2155)	(0.2007,0.5309,0.2684)	(0.3963,0.3764,0.2273)
A9	(0.484,0.201,0.315)	(0.3045,0.4815,0.214)	(0.2007,0.5309,0.2684)	(0.3992,0.3793,0.2215)
A10	(0.484,0.201,0.315)	(0.3059,0.4828,0.2113)	(0.2032,0.5334,0.2634)	(0.4023,0.3825,0.2152)
A11	(0.484,0.201,0.315)	(0.3061,0.4831,0.2108)	(0.2032,0.5334,0.2634)	(0.4023,0.3825,0.2152)
A12	(0.484,0.201,0.315)	(0.31,0.4869,0.2031)	(0.2032,0.5334,0.2634)	(0.4023,0.3825,0.2152)
A13	(0.484,0.201,0.315)	(0.31,0.4869,0.2031)	(0.2063,0.5365,0.2572)	(0.4118,0.3919,0.1963)
A14	(0.4927,0.2097,0.2976)	(0.3183,0.4953,0.1864)	(0.2128,0.543,0.2442)	(0.4129,0.3931,0.194)
A15	(0.4927,0.2097,0.2976)	(0.3183,0.4953,0.1864)	(0.2142,0.5444,0.2414)	(0.4186,0.3987,0.1827)
A16	(0.4927,0.2097,0.2976)	(0.3207,0.4976,0.1817)	(0.2167,0.5469,0.2364)	(0.4199,0.4001,0.18)
A17	(0.4927,0.2097,0.2976)	(0.3207,0.4976,0.1817)	(0.2175,0.5477,0.2348)	(0.42,0.4002,0.1798)
A18	(0.4927,0.2097,0.2976)	(0.3257,0.5027,0.1716)	(0.2233,0.5535,0.2232)	(0.42,0.4002,0.1798)
A19	(0.501,0.218,0.281)	(0.3311,0.508,0.1609)	(0.2264,0.5565,0.2171)	(0.4258,0.4059,0.1683)
A20	(0.501,0.218,0.281)	(0.3361,0.513,0.1509)	(0.2322,0.5624,0.2054)	(0.4258,0.4059,0.1683)
	SC9	**SC10**	**SC11**	**SC12**
	Sharpe ratio	**Sortino ratio**	**Treynor ratio**	**M2 ratio**

	(0.1112, 0.8888)	(0.0888, 0.9112)	(0.1041, 0.8959)	(0.1776, 0.8224)
A1	(0.1772,0.4841,0.3387)	(0.3775,0.2745,0.348)	(0.2772,0.3842,0.3386)	(0.4769,0.1739,0.3492)
A2	(0.1821,0.4891,0.3288)	(0.3824,0.2794,0.3382)	(0.2771,0.384,0.3389)	(0.4813,0.1783,0.3404)
A3	(0.1868,0.4937,0.3195)	(0.3862,0.2832,0.3306)	(0.2896,0.3966,0.3138)	(0.4875,0.1844,0.3281)
A4	(0.1888,0.4958,0.3154)	(0.3862,0.2832,0.3306)	(0.2896,0.3966,0.3138)	(0.4874,0.1844,0.3282)
A5	(0.1888,0.4958,0.3154)	(0.392,0.2889,0.3191)	(0.2896,0.3966,0.3138)	(0.4879,0.1849,0.3272)
A6	(0.1996,0.5066,0.2938)	(0.392,0.2889,0.3191)	(0.295,0.402,0.303)	(0.4953,0.1923,0.3124)
A7	(0.1996,0.5066,0.2938)	(0.3949,0.2918,0.3133)	(0.295,0.402,0.303)	(0.4995,0.1964,0.3041)
A8	(0.1996,0.5066,0.2938)	(0.3994,0.2963,0.3043)	(0.3024,0.4094,0.2882)	(0.4995,0.1964,0.3041)
A9	(0.2013,0.5082,0.2905)	(0.4004,0.2973,0.3023)	(0.3024,0.4094,0.2882)	(0.4995,0.1964,0.3041)
A10	(0.2025,0.5095,0.288)	(0.4071,0.3041,0.2888)	(0.3024,0.4094,0.2882)	(0.5071,0.2041,0.2888)
A11	(0.2098,0.5168,0.2734)	(0.4074,0.3043,0.2883)	(0.3024,0.4094,0.2882)	(0.5093,0.2063,0.2844)
A12	(0.2098,0.5168,0.2734)	(0.4092,0.3062,0.2846)	(0.309,0.416,0.275)	(0.5108,0.2078,0.2814)
A13	(0.2098,0.5168,0.2734)	(0.4154,0.3124,0.2722)	(0.309,0.416,0.275)	(0.5108,0.2078,0.2814)
A14	(0.2173,0.5243,0.2584)	(0.4154,0.3124,0.2722)	(0.315,0.422,0.263)	(0.5108,0.2078,0.2814)
A15	(0.2173,0.5243,0.2584)	(0.4154,0.3124,0.2722)	(0.315,0.422,0.263)	(0.5183,0.2153,0.2664)
A16	(0.2173,0.5243,0.2584)	(0.4219,0.3188,0.2593)	(0.3191,0.4261,0.2548)	(0.5193,0.2163,0.2644)
A17	(0.2181,0.5251,0.2568)	(0.4219,0.3188,0.2593)	(0.3219,0.4289,0.2492)	(0.5217,0.2187,0.2596)
A18	(0.2181,0.5251,0.2568)	(0.4219,0.3188,0.2593)	(0.3255,0.4324,0.2421)	(0.5217,0.2187,0.2596)
A19	(0.2248,0.5318,0.2434)	(0.4278,0.3248,0.2474)	(0.3255,0.4324,0.2421)	(0.5298,0.2268,0.2434)
A20	(0.2304,0.5374,0.2322)	(0.4298,0.3268,0.2434)	(0.3312,0.4382,0.2306)	(0.5298,0.2268,0.2434)

In this step, we aggregated all the weights obtained from the previous calculations by applying the specified operation for each alternative to derive the total weights. Then, the preference value ρ (α) for the alternatives was calculated to evaluate their overall desirability. Table 20 displays both the aggregate weights of each alternative, calculated using Equation 9, and the final weights, derived from Equation 10, which reflect their importance based on relevant criteria and ensure a comprehensive comparison.

Table 20
Final weight of alternatives

Alternative	**Cumulative weight**	**Final weight (ω_i)**	**Ranking**
A1	(0.1212,0.4569,0.4219)	0.6248	2
A2	(0.1824,0.6426,0.175)	0.4803	18
A3	(0.1711,0.6199,0.209)	0.5011	16
A4	(0.1447,0.5435,0.3118)	0.5610	10
A5	(0.1189,0.4813,0.3998)	0.6167	5
A6	(0.1898,0.6785,0.1317)	0.4584	19
A7	(0.1386,0.5053,0.3561)	0.5840	8
A8	(0.1387,0.5139,0.3474)	0.5803	9
A9	(0.1137,0.4511,0.4352)	0.6360	1
A10	(0.2046,0.6512,0.1442)	0.4550	20
A11	(0.1648,0.5872,0.248)	0.5211	12
A12	(0.1761,0.6072,0.2168)	0.5013	15
A13	(0.1291,0.52,0.3509)	0.5883	7
A14	(0.1219,0.4584,0.4197)	0.6234	3
A15	(0.1314,0.5011,0.3674)	0.5939	6
A16	(0.1195,0.4744,0.4061)	0.6190	4
A17	(0.163,0.6259,0.2111)	0.5068	14
A18	(0.1816,0.6292,0.1892)	0.4866	17
A19	(0.1736,0.5964,0.23)	0.5082	13
A20	(0.1407,0.5613,0.298)	0.5577	11

7. Managerial insights

The purpose of this study was to evaluate mutual funds to select the best mutual fund for investment. Based on the information in Table 11, A5 has the highest assets and is the largest stock fund. Next, A8 and A11 have the largest asset volumes compared to the other stock funds. In terms of investment diversification, A14, A16, and A17 have the best asset allocation among different types of investments, which is likely to lead to higher profits for investors in these mutual funds. Conversely, A7 and A8 are weaker in this regard and could achieve greater returns for their investors through better management of the existing assets and more appropriate investment allocation.

Regarding the sub-criteria related to mutual fund management characteristics, the boards of directors of A14, A1, and A7 have performed exceptionally well, followed by A8 and then A16, which also show good performance albeit with a slight difference. The management of A19, A13, and A11 performed weaker in this regard, suggesting a need for improvement. A6, A18, and A13 exhibited the highest beta values, indicating better responsiveness of these mutual funds to market fluctuations. The alpha values of A9 and

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A1 are the highest positive figures compared to the other alternatives, reflecting their excellent performance. These mutual funds also have the highest one-year returns compared to the other mutual funds studied. Since these mutual funds demonstrate the best investment performance, they also possess higher Sharpe and M2 ratios compared to the other mutual funds analyzed.

In contrast, A6 has a negative alpha, indicating that its performance is weak compared to the benchmark index, along with a lower Sharpe ratio, M2 ratio, and returns. Therefore, adjustments to the internal factors of this mutual fund should be made to enhance its performance and increase its returns. The Sortino ratio for A5 has the highest value, meaning that the investment return of this mutual fund is the highest in relation to downside risk. After that, A9 and A14 exhibit the highest returns based on the Sortino ratio, while A6, A11, and A17 have the lowest returns according to their Sortino ratios.

In terms of the Treynor ratio, A1 and A9 have the highest values, indicating a greater return of the excess portfolio over its volatility compared to the risk-free return, which reflects better portfolio performance. A6 has a lower Treynor ratio compared to the other alternatives, necessitating efforts to improve its performance and consequently enhance its returns.

To determine the distance values of the criteria in relation to each other, as well as among the sub-criteria, the BWM was utilized to calculate the relative weights of the main and sub-criteria. Subsequently, pairwise comparisons were conducted using the AHP. By employing the steps of the IFAHP, the fuzzy preference relationships for the alternatives, which represent the 20 selected equity funds, were calculated based on the criteria and sub-criteria. Finally, the weight of each of these alternatives was determined using the relevant equations, allowing the equity fund to be ranked. According to the findings from the IFAHP method, the mutual funds Moshtarek Agah, Sepehr Aval Bazar, and Ofoghe Melat have the highest priority rankings, with weights of 0.6360, 0.6248, and 0.6234, respectively. In contrast, the mutual funds Firozeh Movafaghiat, Toseh Atlas Mofid, and Moshtarek Kargozari Bank Meli Iran rank the lowest in terms of investment priority, with weights of 0.4550, 0.4584, and 0.4803, respectively.

Table 21
Highest and lowest ranked mutual funds based on the IFAHP

Highest ranked	**Lowest ranked**
1. Moshtarek agah	18. Moshtarek kargozari Bank meli iran
2. Sepehr aval bazar	19. Toseh atlas mofid
3. Ofoghe melat	20. Firozeh movafaghiat

The study's findings provide valuable insights for investors looking to select optimal mutual funds, as Figure 5 and Table 21 shows Moshtarek Agah, Sepehr Aval Bazar, and Ofoghe Melat are the top choices due to their high weights (0.6360, 0.6248, and 0.6234 respectively), indicating robust performance in terms of assets, returns, and management quality. In contrast, funds like Firozeh Movafaghiat, Toseh Atlas Mofid, and Moshtarek Kargozari Bank Meli Iran rank low (0.4550, 0.4584, and 0.4803), suggesting poorer investment suitability. Notably, funds demonstrating better asset allocation (e.g., A14, A16, and A17) show potential for higher profits, while management quality and risk-adjusted returns, as reflected in metrics like alpha, Sharpe, and Sortino ratios, further guide investment decisions. Compared to traditional methods which often focus solely on returns, the IFAHP framework offers a more nuanced analysis by integrating quantitative metrics with qualitative assessments, thereby assisting investors in making well-informed, comprehensive investment choices.

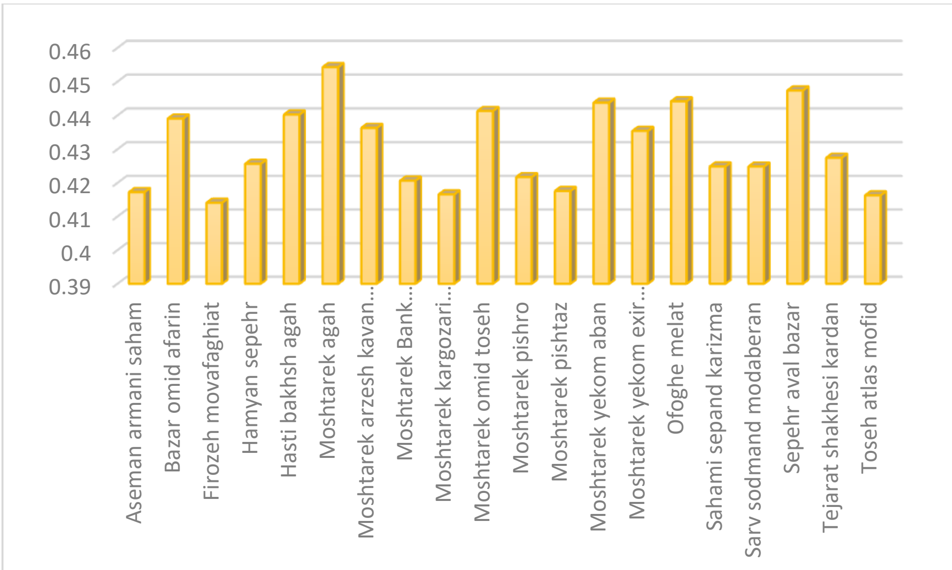

Figure 5 Prioritization of mutual funds based on the considered criteria

8. Conclusion

In the present era, the capital market and economy are witnessing a growing trend of increasing complexity and diversification of investment options in the capital market, which complicates the decision-making process for investors in selecting mutual funds, leading to a multitude of criteria and variables that confuse decision-makers (DMs) when selecting a mutual fund. To tackle the uncertainty arising from financial markets and investor behavior, integrating Multiple Criteria Decision Making (MCDM) techniques can prove to be a powerful tool for DMs. The process of selecting mutual funds involves not only quantitative criteria but also numerous qualitative criteria that cannot be easily measured or weighted using conventional decision-making methods. To address this issue, we employed a new approach called the Intuitionistic Fuzzy Analytical Hierarchy Process (IFAHP). This approach offers high accuracy in decision-making by considering both quantitative and qualitative criteria. A notable advantage of IFAHP is its ability to bridge the gap between verbal variables and quantitative equivalents for qualitative variables, enabling the calculation of criteria weights and prioritization of options with ease.

Furthermore, this approach enables the decision maker to accurately compare investment options and evaluate them based on various criteria that are crucial in financial markets for measuring mutual funds. This ensures the selection of a reliable mutual fund for investment. The background section of the research highlights the high accuracy of the hierarchical fuzzy intuition process in decision-making for both quantitative and qualitative criteria. While traditional methods like the Sharpe index (Si), Treynor index (Ti), Jensen's alpha index (αi), and Sortino index are commonly used to evaluate mutual fund performance, they may not be effective due to the multi-dimensional nature of measuring mutual fund performance. Researchers must possess a solid theoretical understanding of performance and identify appropriate criteria for the research field. This aligns with the principles of multicriteria analysis. Consequently, this article employs multi-criteria decision-making methods to rank mutual funds based on expert-determined criteria.

The evaluation criteria for mutual funds were chosen using multi-criteria methods to ensure optimal decision-making for investors, an increase in profitability and reduction of risk. These criteria encompass liquidity, non-diversifiable risk, and instability. This article utilized the four-level structure of the intuitionistic fuzzy hierarchy technique to select the best mutual fund and rank options based on three different criteria and their sub-criteria, which are both quantitative and qualitative. The alternatives considered are the best mutual funds accepted in the Tehran Stock Exchange.

Upon reviewing the existing literature, such as Moradpour (2021), which employed traditional multi-criteria decision-making (MCDM) methods based on Post-modern Portfolio Theory indicators, it became evident that while these methods provide a foundational framework for ranking mutual funds, they often struggle to accommodate the complexities and uncertainties inherent in investor preferences. Similarly, studies utilizing the TOPSIS method, like those by Muruganandan and Sharma (2024) and Das (2022), present a clear approach to identifying top mutual funds; however, they lack the integration of fuzzy logic, which could significantly enhance decision-making by capturing diverse levels of uncertainty and subjective judgment. The AHP utilized in Vilantika's (2023) research offers a structured methodology for evaluation yet does not possess the flexibility inherent in the IFAHP. The latter facilitates a more nuanced representation of decision criteria through intuitionistic fuzzy sets, allowing for better handling of vague preferences. While Vasantha Lakshmi and Udaya Kumara (2024) explore fuzzy MCDM techniques like FAHP and entropy methods, they do not benchmark against traditional methods, thereby limiting their capacity to substantiate the improvements brought about by the adoption of fuzzy approaches.

In contrast, this research applies the IFAHP method to assess and rank the performance of mutual funds listed on the Tehran Stock Exchange, which results in a more nuanced evaluation. The IFAHP provides significant advantages, including the ability to incorporate varying levels of uncertainty and fuzzy preferences into the ranking process. By utilizing this advanced method, the study identified and prioritized top-performing mutual funds, enabling investors to make more informed decisions based on a comprehensive understanding of their preferences. For example, the IFAHP ranked Moshtarek Agah as the top mutual fund, reflecting its superior performance against the complexities that traditional methods might overlook. This method not only enhances the accuracy of the rankings but also improves the overall investment decision-making process for investors, as they can now better align their choices with their unique risk appetite and investment goals. Overall, the adoption of IFAHP in this research provides a more robust framework for evaluating mutual funds, leading to better investment outcomes in the volatile environment of the Iranian capital market.

9. Limitations and suggestions for future research

The research presented in this study encountered several limitations that may influence the conclusions drawn regarding the evaluation and prioritization of mutual funds in Iran using the IFAHP. First, the study depended on specific datasets, which may not encompass the full range of variables necessary for a comprehensive analysis, potentially leading to biased results. Additionally, the sample size may have been inadequate to establish strong correlations, thereby limiting the generalizability of the findings to larger populations. Methodological constraints, such as reliance on particular statistical techniques, might overlook other relevant factors that could provide deeper insights into mutual fund performance. Temporal factors also presented limitations; if the data was outdated, it may have not accurately reflected recent trends or investor behaviors.

To enhance future research, several suggestions are proposed.

1. Apply method to other financial instruments: Future research could extend the application of the IFAHP methodology to evaluate a broader range of financial instruments, such as bonds, exchange-traded funds (ETFs), real estate investment trusts (REITs), and commodities. By adapting the criteria and sub-criteria used in the mutual fund evaluation, researchers can assess these instruments in terms of risk-adjusted returns, liquidity, and management quality.

2. Cross-market analysis: Researchers could explore the transferability of the IFAHP methodology by applying it to emerging markets, comparing investment opportunities in developed versus developing economies. This comparative analysis could yield insights on how varying economic conditions impact mutual fund performance and management practices.

3. Sector-specific studies: Conducting sector-specific analyses using the IFAHP framework could provide deeper insights into mutual funds focused on particular sectors such as technology, healthcare, or sustainable investments. This would enable investors to make informed decisions within niche markets, evaluating how sector dynamics influence mutual fund performance.

4. Temporal analysis: Future studies could incorporate time-series data to examine the performance of mutual funds over different market cycles. By analyzing how rankings change in response to market fluctuations, researchers could assess the stability and resilience of funds, providing valuable insights for long-term investors.

5. Integration of behavioral factors: Incorporating behavioral finance principles into the IFAHP methodology could enhance the assessment of investor preferences and biases. This approach may facilitate a more holistic understanding of how cognitive factors influence investment decisions and mutual fund performance.

6. Combination with machine learning: Future research could investigate the integration of IFAHP with machine learning algorithms, such as neural networks and Gaussian Process Regression (GPR), to automate the ranking process and enhance predictive analytics. Recent literature has demonstrated the potential of these models to effectively capture complex, nonlinear patterns across various domains. For instance, Jin and Xu (2024a, 2024b) applied neural networks to forecast wholesale prices of green grams and crude oil, heating oil, and natural gas prices. Their research highlights the versatility of neural networks in financial contexts, including carbon emission allowance prices. Similarly, GPR has been shown to be effective in predicting prices for yellow corn and pre-owned housing price indices. Integrating these advanced machine learning techniques with the IFAHP could yield more accurate performance forecasts by identifying patterns and trends in historical data, thereby enhancing decision-making in finance.

7. Impact of regulatory changes: Analyzing how regulatory changes or macroeconomic shifts affect mutual fund performance through the IFAHP methodology would enhance understanding of external factors influencing investment decisions. Research could focus on specific laws or regulations affecting the financial markets in different regions.

8. Stakeholder perspectives: Future studies could involve qualitative research methods, such as interviews or surveys, to gather perspectives from mutual fund managers, financial advisors, and investors. This could help validate the IFAHP findings and enrich understanding of the underlying factors that contribute to mutual fund performance. By investigating these areas, subsequent studies can expand on the results of the present research and help develop a more thorough framework for assessing financial instruments in different contexts.

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