Neutrosophic-Based Multi-Objectives Model for Financial Risk Management

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Abstract

Financial organizations can no longer ignore the problem of managing risk. As a component of the financial system, efficient Financial Risk Management (FRM) may significantly affect business results. These findings show that the triangular neutrosophic numbers simulate capital asset key metrics. Performance metrics for capital assets may be modeled using this kind of value by accounting for all conceivable outcomes for their attainment. The profit on capital instruments, the risk of financial investments, and the covariance of capital instruments are the Key Performance Metrics (KPIs) modeled using triangular neutrosophic values. Specifically, this research employs two techniques. Prioritizing parameters for financial risk management dimensions using the Analytic Hierarchy Process (AHP). Second, the performance evaluation of financial risk management was evaluated from the perspective of several groups of specialists by the COCOSO method to assess the ranking of possible replies further. By using the presented method, we may better identify where to put our efforts and how to allocate our resources for greater effectiveness in managing financial risks.

Keywords: Neutrosophic Sets; MCDM; Financial Risk Management; MCDM; COCOSO;

1. Introduction

FRM is no longer only a concern for banks and other services firms but also crucial for other businesses, including manufacturers. FRM systems integrated with strategic management are crucial in laying a solid foundation for a company's growth. They need to consider a wide range of potential outcomes and strike a dynamic balance between the firm's operations and operations to help it reach its long-term goals. Such a job may benefit from a variety of methods. A multi-stage simulation tool that may be used to back up FRM. Using the same financial strategy and risk control method is difficult for computerized operations research[1]–[3].

Firms should always work to better their FRM process as they become more vulnerable to the widespread dangers of a quickly changing global market. This article provides a vision for improving FRM to address this compelling and significant problem[4]–[6].

The challenge of selecting the best solutions arises when a business is ready to set up or enhance its FRM. The corporation must make compromises between the many features of FRM since there is no perfect solution. Then, if a corporation is serious about getting a very well system, the performance assessment might be a huge benefit[7]–[10].

Financial risk describes the potential for economic losses or higher profit for a corporation due to many uncontrolled and unpredictable events in various financial operations. A business's financial dealings span its entire operational and manufacturing cycle. Risks may be included in activities like

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crowdfunding, making long and short-term expenditures, and profit distribution. Managing financial risk is an essential but often difficult task for businesses.

It is an indisputable fact that no business management can entirely prevent the possibility of financial loss. Even big corporations like Enron, which was listed as a member of the Fortune Global 500 in 2002, often collapse or declare bankruptcy due to financial concerns in today's business environment [11]. Therefore, we must not disregard the potential financial dangers or suffer the inevitable repercussions.

Potential financial risks that a company could face, businesses can use financial risk indicators derived from financial analysis tools on wide-ranging banking products. It is a system that standardizes financial metrics and early warning mechanisms. The former represents the enterprise's financial assessment system, which reports financial risk. The latter is founded on a more thorough examination of business financial risk by combining different financial indicators, selecting several firm samples, establishing a multi-variable computational formula, and analyzing at a macro level. The purpose of financial risk analysis is to serve as a foundation for financial risk management, to protect and mitigate risk damages, and to understand the fundamental financial risks businesses face. This is done by establishing a financial risk alert and alerting index to detect businesses' financial status and financial results. Figure 1 primarily depicts the design ideas of key financial risks.

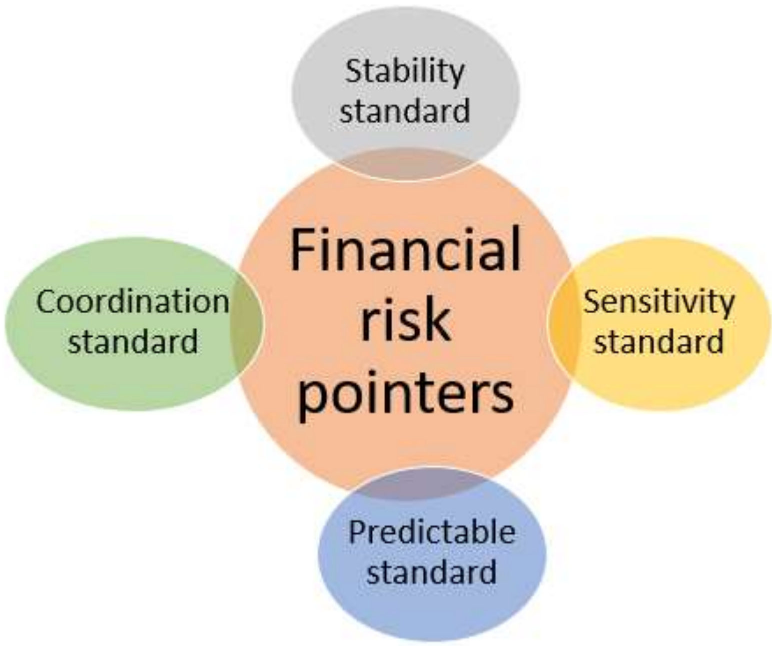

Figure 1: The financial risk standard.

Approaches based on multicriteria decision-making may be used to rank performance.

Experts evaluate businesses using various financial risk indicators, and this process may be seen as a multicriteria decision-making (MCDM) problem. Many other effective methodologies have previously been established to assess the financial risk of business performance. Duan used deep neural networks to evaluate and predict the financial sector. In order to facilitate the financial risk of the ideal investment profile, Gerrard et al. [12] created a straightforward communication tool. Goda

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and Tesfamariam reported on their study of the financial risk associated with a selection of structures in Vancouver and Montreal [13]. Still, these academics focus only on the aggregate financial risk assessment, ignoring the need for individualized assessments (assessments of financial risk over various indicators). There is also a great deal of hazy and unreliable data for gauging business financial risk. The CFO's decision-making under these circumstances requires a high level of expertise in differentiating the optimal course of action. In addition, when faced with several alternatives, the CFO cannot give pinpoint preference information due to the difficulty of estimating the financial risk of the business. At the same time, certain pre-existing theories have been used to simulate fuzziness, such as the intuitionistic fuzzy set (IFS) [14]and the Pythagorean fuzzy set (PFS) [15]. Each of the hypotheses mentioned above is limited and flawed in its unique way.

Decisions involving several, often competing criteria affect a limited number of possible courses of action and hence have significantly benefited from the use of techniques for addressing multicriteria decision-making. Multiple MCDM strategies have been developed to address various classes of practical issues, with much time and energy invested in their creation. The AHP is a powerful MCDM technique that originates from determining the relative importance of each criterion and the overall worth of each possible solution[16]–[19].

Hwang and Yoon [20]also devised a method for comparing the effectiveness of alternatives based on how closely they resemble an ideal solution. They called it the Technique for Order Preference by Similarity to the perfect solution (TOPSIS).

When trying to replicate a real-world scenario, clean data often falls short. Since human preferences and judgments are typically imprecise, the decision maker cannot assign a precise numerical value to his preferences. In this research, we include uncertainty in data input and use a novel judgment strategy that can efficiently deal with uncertainties to have a more realistic approach[21]–[24].

Bellman and Zadeh [25] pioneered fuzzy multi-criterion decision-making (or MCDM for short) to address the uncertainty, ignorance, and ambiguity that permeate the human process for decision-making (FMCDM).

Difficulties in making decisions in the actual world are often addressed with TOPSIS. Despite its widespread use and intuitive nature, this method is often criticized for failing to account for the inherent complexity and fuzziness of mapping judgment views. Numeric values reflect the subjective evaluations in the classic TOPSIS formulation. To address this issue in MCDM, however, Fuzzy TOPSIS was developed and has since been effectively used in various MCDM situations.

It has been widely observed that the financial markets have expanded rapidly over the last several years, expanding the range of available financial instruments for use in FRM. The high importance of FRM is underlined by the considerable resources allocated to the banking markets in major enterprises[26]–[29].

The FRM process's goal is to balance another of the balance sheet, which has access to external cash support, with the capital account, which lists potential investment possibilities. The next level of management thinking is to align the budget with the business's overall goals[30]–[33].

FRM includes financial risk management practices, including assessing and monitoring financial risks. Assessment and Enhance Quality and Process, a type of feedback in the ongoing improvement of the strategic plan, plays a significant part in the suggestion, which lays out a systematic approach for evaluating risk management processes.

Neutrosophic logic is embraced because of its flexibility in dealing with ambiguity. Smarandache presented the neutrosophic theory [34]. In fuzzy theory, neutrosophic sets are categorized according to their truthiness, falsity, and indeterminacy rather than resembling triangular numbers. We used the AHP with the neutrosophic approach to accomplish our study aims.

The multicriteria decision-making method comes in handy when competing or even contradicting criteria exist. Features, requirements, units of measure, and weightage are all particular to each criterion. Some characteristics may be described intuitively, while others may be defined solely mathematically. The MCDM method, established in the 1960s, has now evolved to provide dozens of various approaches to solving MCDM challenges. Rapid growth in management problems throughout the 1990s drew the focus of MCDM techniques. For complex and unpredictable scenarios, such as those including environmental uncertainty, supply chain interruptions, stakeholder

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preferences, contradicting criteria, etc., MCDM has shown to be an effective alternative to more conventional methodologies.

AHP, fuzzy logic, fuzzy-AHP, fuzzy-TOPSIS, and fuzzy interference system (FIS) are only a few MCDM methods employed in prior SCRM research [35]. While many MCDM methods were used for the previous study, they are not without their share of flaws and restrictions. Smarandache created a neutrosophic theory as an efficient and efficient way of dealing with inconsistent, imprecise, or ambiguous knowledge. The theory, like fuzzy theory, is based on triangular numbers. Still, it adds the level of membership, such as truthiness, uncertainty, and falsity, to better handle inconsistent, uncertain, and nebulous data. To this end, we have integrated the MCDM techniques of AHP and TOPSIS with the neutrosophic logic that underpins this investigation.

When relevant data is imprecise, ambiguous, or otherwise hard to pin down in complicated decision-making, multicriteria decision-making may be helpful. Fuzzy logic is an everyday basis for several well-known MCDM methods, and these methods can deal with a wide variety of challenging scenarios. Later, scientists began to worry that the fuzzy sets method of MCDM had too many restrictions. Smarandache and other scholars developed more sophisticated theories on neutrosophic logic to address more complicated problems. Truthiness, indeterminacy, and falsehood are used to categorize neutrosophic sets. Although neutrosophic sets have been used for addressing issues for a long time, in recent years, they have begun to be combined with other methods like AHP and TOPSIS.

Saaty [36]created AHP, an MCDM methodology that has since become a standard way for solving problems and making decisions in highly complex circumstances, scenarios, and organizational structures. After breaking down an issue into its constituent parts (criteria and sub-criteria), AHP creates a matrix of pairwise comparisons and assigns weights to each criterion. N-AHP takes the AHP method developed by Saaty and applies it to Smarandache's neutrosophic sets. In N-AHP, preferences are given to the criteria using a neutrosophic scale, and neutrosophic values are used to represent the relative choice of the criteria, semi, and options. Next, the scoring function converts neutrosophic numbers into crisp values.

2. Neutrosophic Sets

There has not been a standard, agreed-upon symbol for a neutrosophic set in the literature until recently. For the neutrosophic set A, we suggest the notation A..., where the three dots stand for the neutrosophic set's elements, and the T, I, F, and tilde indicate that it is also a fuzzy set. Figure 3 shows the framework of this study.

Definition 1:

A universe, E, is assumed. Truth-membership function TA, indeterminacy-membership function IA, and falsity-membership function FA are the three defining features of a neutrosophic set A... in E.

In the range [0,1], the reals $TA\ (x), IA\ (x), and\ FA\ (x)$ all exist as true standard elements. Eq. (1) defines a neutrosophic set A.

$A\sim = \{< x, (TA(x), IA(x), FA(x)) >: x \in E,$

$(TA(x), IA(x), FA(x) \in] - 0,1[+)\}.$
$One\ may\ add\ TA\ (x), IA\ (x), and\ FA\ (x)\ without\ bound, as\ shown\ by$
$0 \leq TA(x) + IA(x) + FA(x) \leq 3.$

Definition 2:

A universe, E, is assumed. Truth-membership function TA, indeterminacy-membership function IA, and falsity-membership function FA are the defining features of a single-valued neutrosophic set A in E. The real standard elements of [0,1] include TA; IA and FA. To express it in text form:

$$A\ldots\sim = \{< x, (TA(x), IA(x), FA(x)) >: x \in E, TA(x), IA(x), FA(x) \in [0,1]\}.$$

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$$The\ combination\ of\ TA\ (x), IA\ (x), and\ FA\ (x) is\ unbounded, therefore$$
$0 \leq TA(x) + IA(x) + FA(x) \leq 3+.$

Definition 3:

In this example, we'll use the generic element x to refer to anything in the space of points (objects) designated by X. Truth-membership function TA, indeterminacy-membership function IA, and falsity-membership function FA all describe a neutrosophic set A... in X. To be clear, subsets of [0,1+] that are TA, IA, and FA are either genuine or artificial. For example,

$TA: X\ \rightarrow]$

$0-, 1+[.(3)\ \backslash sIA: X\ \rightarrow]$

$0-, 1+[.(4)\ \backslash sFA: X\ \rightarrow]$

$0-, 1+[$

Definition 4:

If n is the number of people involved in making a choice, then..$j = [TLj, TUj], [ILj, IUj], [FLj, FUj]$ is a set of interval-valued neutrosophic numbers.

Definition 5:

For neutrosophic numbers, we suggest the following deneutrosophication function:

$$D(x) = (\frac{TLx + TUx}{2} + (1 - \frac{ILx + IUx}{2})$$

$$* (IUx) - (FLx + \frac{FUx}{2}) * (1 - FUx))$$

$x...j = [TLx, TUx], [ILx, IUx], [FLx, FUx].$

Definition 6:

Say X represents the whole of human conversation. For any xX, the truth-membership function $TN(x) = [TLN(x), TUN(x)][0,1]$, the indeterminacy-membership function $IN(x) = [ILN(x), IUN(x)][0,1]$, and the falsity-membership function $FN(x) = [FLN(x), FUN(x)][0,1]$ define the neutrosophic set N.... Also, they satisfy the equation $0 \leq TLN(x) + ILN(x) + FLN(x) \leq 3$. Therefore, the neutrosophic set N... with interval values is provided:

$$N...\sim = \{\langle x, [TLN(x), TUN(x)], [ILN(x), IUN(x)], [FLN(x), FUN(x)]\rangle | x \in X\}.$$

Definition 7:

To illustrate, consider two neutrosophic numbers, a and b, each of which has a value in the interval $[TLa, TUa], [ILa, IUa], [FLa, FUa]$. Relationships and arithmetic operations are provided:

$$a^{\sim c} = \langle [F_a^L, F_a^U], [1 - I_a^U, 1 - I_a^L], [T_a^L, T_a^U] \rangle$$

$$a.\sim \subseteq ILa \geq b...\sim if\ and\ only\ if\ TLa \leq TLb;\ TUa \leq TUb;\ ILb, IUa \geq IUb;\ FLa \geq FLb, FUa \geq FUb$$

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The AHP Method

The AHP approach is used to compute the weights of the criteria.

This method's strengths lie in its simplicity in computation stages and its resemblance to the traditional AHP approach. There is a formulaic gap in the process, though, and that's where deneutrosophication comes in. Below, we outline the methodology behind the IVN-AHP approach.

First, establish the neutrosophic assessment interval scale.

Second, break down the issue into its parts: the objective, the criteria, the sub-criteria, and the possible solutions in figure 2.

Step 3 Use neutrosophic sets with interval values to build the pairwise comparison matrix (P).

The deneutrosophication equation has been used to quantify the consistency of the matrices for pairwise comparison.

Deneutrosophicated comparison matrix matrices have to be consistent with neutrosophic similarity matrices.

Goal-relevant pairwise criterion comparison matrices.

The options are compared using a pairwise comparison matrix that considers the criteria.

Using the suggested interval-valued neutrosophic assessment scale, determine the normalized weights of the criterion. We outline the procedures involved in the suggested neutrosophic AHP, which uses the alternatives matrix P...An in relation to given criteria.

Use every parameter's most significant possible value and divide the terms by their respective elements.

Neutralistically weigh the rows and find the mean to get a vector representing the relative importance of the options.

To get neutrosophic weight vectors for each possibility, repeat the preceding stages concerning each criterion. The same procedure is used to calculate the relative importance of each criterion.

Learn the full neutrosophic weights of choices as interval values.

The crisp alternate weights may be obtained by using the deneutrosophication method.

Level out the relative crispness of possible choices.

Prioritize the options by weight and choose the one with the most importance.

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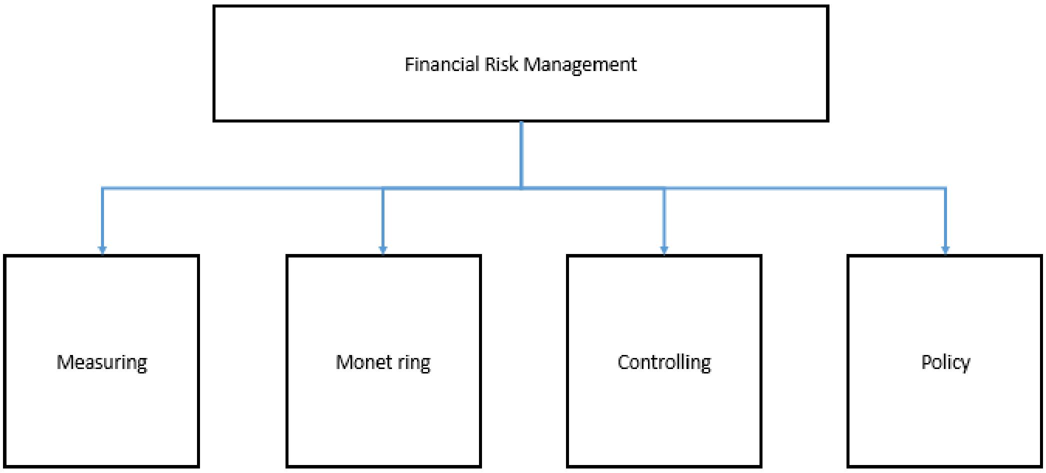

Figure 2: The structure of the AHP method.

The COCOSO Method

New and practical, the Combined Compromise Solution (CoCoSo) technique is provided by Yazdani et al. as a solution for multicriteria decision-making (2018) [37]. The proposed method is grounded on a model that combines exponentially weighted product (EWP) and simple additive weighting (SAW), which may serve as a treasury of middle ground options. Our IVN-CoCoSo strategy is presented as a means of addressing the MCDM problem.

Step 1: Get the decision matrix $P = \left(p_{ij}\right)_{mxn}$ *as the first step.*

Step 2: for each pij, get the scoring function $R = \left(r_{ij}\right)_{mxn}$.

Step 3: Determine the total weight w.

Step 4: add up the weighted comparability sequence of each possible

$$S_i = \sum_{j=1}^{n} w_j * r_j$$

Step 5: Total the power weight of sequences of comparability for each option, P:

$$p_i = \sum_{j=1}^{n} r_j^{w_j}$$

Step 6: The following procedures for aggregating votes are used to determine the relative weights of the alternatives:

$$k_{ia} = \frac{p_i + S_i}{\sum_{i=1}^{m} p_i + S_i}$$

$$k_{ib} = \frac{S_i}{\min_i S_i} + \frac{p_i}{\min_i p_i}$$

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$$k_{ic} = \frac{\lambda S_i + (1-\lambda) p_i}{\lambda \max_i S_i + (1-\lambda) \max_i p_i}$$

Step 7: Compute the value of k

$$k_i = \sqrt[3]{k_{ia} k_{ib} k_{ic}} + \frac{k_{ia} + k_{ib} + k_{ic}}{3}$$

Step 8: Prioritize options by their relative appraised value, or ki.

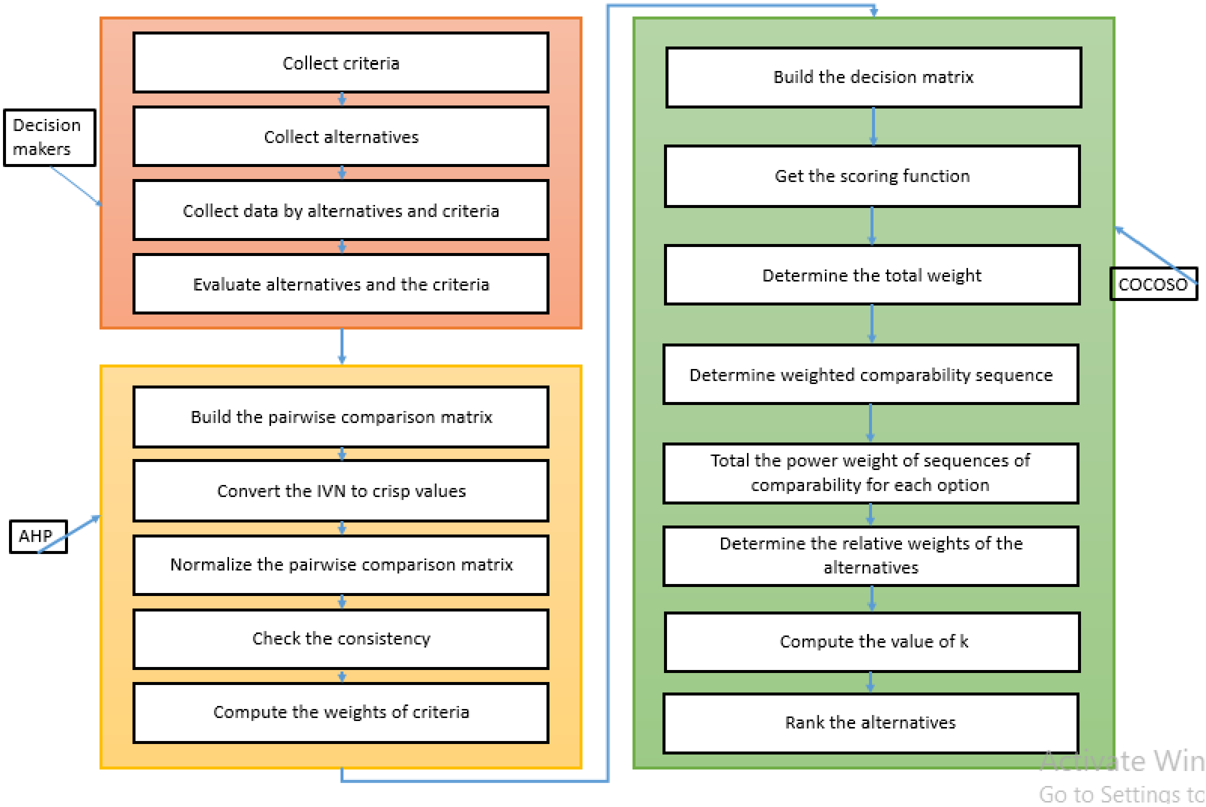

Figure 3: The framework of this study.

3. Results and discussion

Any business nowadays faces several financial dangers in the course of its daily operations and product creation. It is not only difficult to reap financial benefits from taking financial risks, but these risks also pose a serious danger to businesses' continued success and growth. Financial hazards are all around you, but business people give little thought to them at the moment. Businesses focus only on making a profit, notwithstanding the needs of their target audience. This issue sometimes arises when the seller obsessively seeks growth in the market, leading certain customers to default on their purchases. Companies may be taking on unnecessary financial risk due to their vast balance sheets.

Efficient and scientific evaluation findings are impossible without first developing a well-thought-out strategy for assessing financial risk. Financial risk assessment criteria are built and shown as c1, c2,... cj.

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There are three possible paths to take and four criteria to weigh them against in figure 1, the decision matrix. Every criterion is a useful one. The elements of the decision matrix need to be normalized first so that units do not denote them.

Table 1 displays our data, which are uncertain at the moment. In this case, we suppose that 10% of uncertainty is attached to each alternative's rating. Table II shows that the triangular neutrosophic numbers are used to generate the neutrosophic decision matrix. This matrix is subsequently normalized.

The AHP result provides us with the weights for all fourth criteria.
The decision makers' viewpoint is not given equal weight for each criterion in the FRM decision-making process. So, alternative weights for criteria are generated by taking into account the decision matrix and using the Entropy approach. Based on these numbers, we figured they belonged to a different decision-maker. As a result, we offer the concept of a weight vector W to represent the relative significance of different criteria based on the decision maker's point of view. There are two decision-makers in this investigation.
Figure 4 shows the weights of the criteria. Table 2 shows the decision matrix between criteria and alternatives. Complete the weighted comparability sequence calculation. Sum the relative strengths of all sequences of comparisons
Evaluation Score Methods.
Estimate the ki value for the evaluation—top-tier fie businesses. Figure 5 shows the rank of alternatives.

Table 1: The comparison matrix.

	C1	C2	C3	C4
C1	1	0.9	0.494444	0.6
C2	1.111111	1	0.638889	0.6
C3	2.022472	1.565217	1	0.666667
C4	1.666667	1.666667	1.5	1

Table 2: The decision matrix.

	C1	C2	C3	C4
A1	0.9	0.9	0.6	0.9
A2	0.7	0.8	0.3	0.4
A3	0.6	0.3	0.8	0.3

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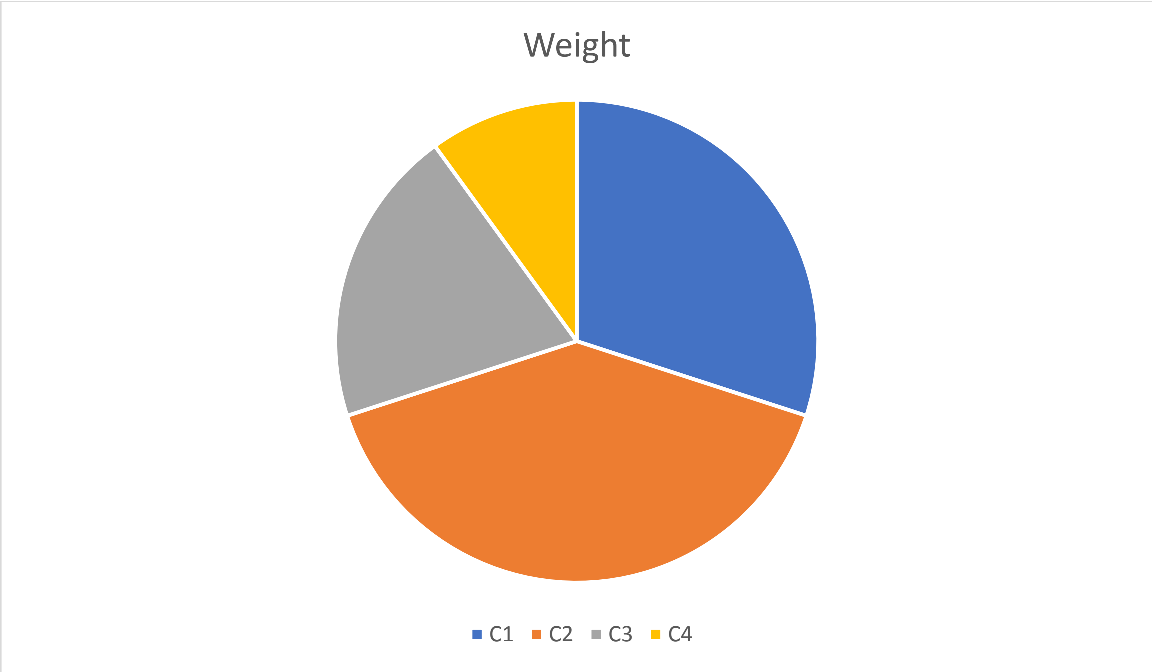

Figure 4: The weights of criteria.

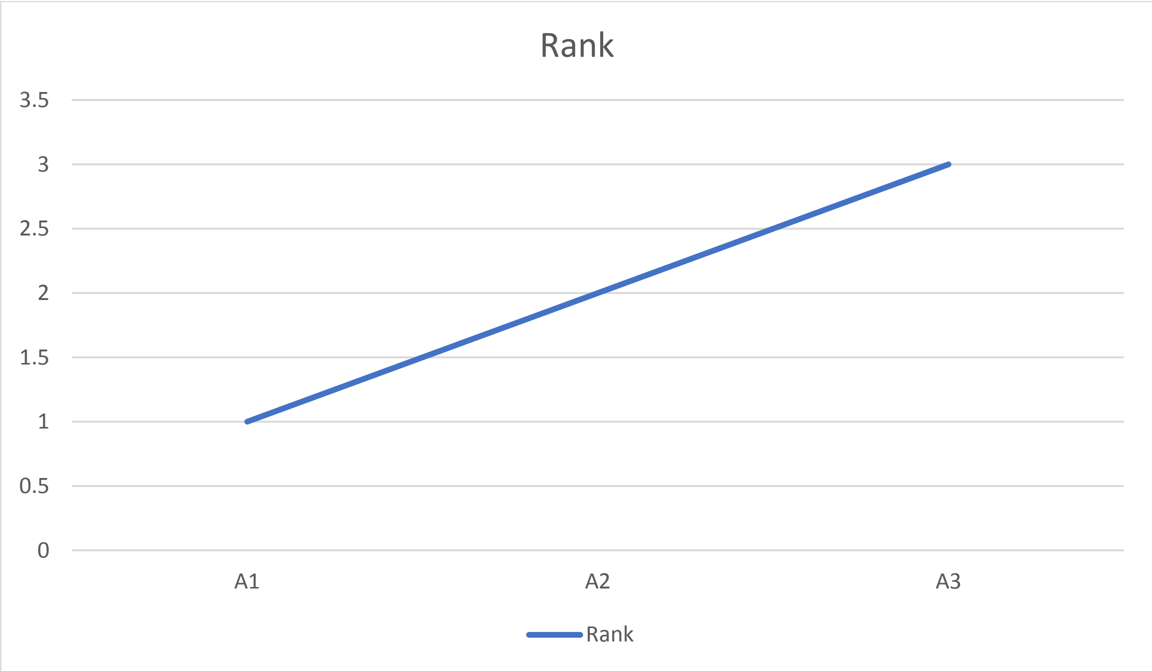

Figure 5: The rank of alternatives.

6. Conclusion

The approach in this research supports the hypothesis that the FRM might function as a driving force for financial strategies in contemporary businesses. It was determined that an effective FRM system is crucial to developing a secure and knowledgeable corporate ecosystem. Therefore, the process mentioned above is not only practical but also very beneficial to the development of FRM. It is interesting to note that reduced identification and the influence of the FRM activities were shown in decisions of equal and unequal priority. Therefore, it is clear that the principle of FRM is successful and that a well-implemented and constantly updated FRM system is crucial for a productive organization. To better align FRM with the requirements of a business, this new method presents a powerful technique.

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