

A Multi-Criteria Decision-Making Framework for Financing Selection in Pharmaceutical Companies: Evidence from Firms Listed on the Tehran Stock Exchange

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Abstract

Considering that financing method selection constitutes a complex strategic decision for pharmaceutical companies due to their substantial investment requirements, long development cycles, and exposure to significant operational and financial uncertainty, this study identifies key selection criteria and prioritizes financing alternatives for firms listed on the Tehran Stock Exchange. By employing an integrated multi-criteria decision-making (MCDM) framework—combining the fuzzy Delphi method, the Analytic Hierarchy Process (AHP), and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)—and drawing upon the insights of a purposive panel of 20 experts, including financial specialists, pharmaceutical industry managers, and academics, this research establishes that financing efficiency (0.351), financing cost (0.230), sustainability (0.140), operational feasibility (0.136), fairness in financial resource allocation (0.079), and financing transparency (0.064) are the most influential factors. Furthermore, the TOPSIS analysis prioritizes company formation (0.93) as the primary financing alternative, followed by the acquisition of financial facilities (0.87) and the issuance of participation bonds (0.72). Ultimately, this study contributes to the literature on corporate finance by offering a structured, expert-based framework that enables organizations to effectively incorporate both financial and non-financial metrics into their strategic financing decisions.

1. Introduction

The pharmaceutical industry is recognized as one of the most strategic and knowledge-intensive sectors in modern economies, owing to its critical contribution to public health improvement, pharmaceutical security, technological advancement, and economic development. Unlike many traditional industries, pharmaceutical firms operate within an environment characterized by intensive research and development (R&D) activities, substantial long-term investments, strict regulatory requirements, and continuous innovation pressures. Consequently, access to efficient and sustainable financing has become a fundamental prerequisite not only for maintaining operational continuity but also for enhancing competitive advantage, developing innovative products, and strengthening firms' positions in domestic and international markets (Brealey et al., 2023).

The unique characteristics of pharmaceutical innovation make financing decisions particularly challenging. Drug development processes typically require considerable financial resources over extended periods, while their outcomes remain highly uncertain due to technological risks, regulatory barriers, and potential failures in clinical trials. Recent studies emphasize that pharmaceutical R&D involves significant financial constraints because firms must invest heavily before generating commercial returns, creating a persistent gap between the social value of biomedical innovation and the private incentives available to firms and investors (Lo & Thakor, 2022). Moreover, increasing R&D expenditures and declining productivity in pharmaceutical innovation have further intensified the need for effective financial strategies that enable firms to allocate resources efficiently and sustain long-term innovation capabilities (Fernald et al., 2024).

In recent years, pharmaceutical companies in emerging economies, including Iran, have faced additional financial pressures arising from macroeconomic instability, inflation, rising capital costs, restricted access to financial markets, exchange rate fluctuations, and challenges associated with securing raw materials. These conditions have transformed financing decisions into one of the most critical strategic issues confronting pharmaceutical managers. An inappropriate financing choice may increase the cost of capital, reduce financial flexibility, constrain investment capacity, and limit firms' ability to pursue R&D projects and production expansion initiatives (Ross et al., 2022).

From the perspective of financial management, capital structure and financing decisions have long been considered among the most important areas of corporate finance research. Various theoretical frameworks, including the Modigliani–Miller theorem, the pecking order theory, and the trade-off theory, have attempted to explain firms' financing behavior and capital structure choices. These theories suggest that selecting an optimal combination of financial resources influences not only the cost of capital but also firm value, profitability, financial risk, and growth opportunities (Modigliani & Miller, 1958; Myers & Majluf, 1984).

However, the financing challenge in pharmaceutical companies extends beyond the availability of financial resources. Managers must select among alternative financing mechanisms, including internal funds, bank financing, equity issuance, venture capital, strategic alliances, and other financial instruments, each of which involves different costs, risks, and strategic implications. Therefore, financing selection in pharmaceutical firms represents a complex decision-making problem rather than merely a capital structure choice.

2. Literature Review and Theoretical Background

2.1. Pharmaceutical Industry Financing Challenges

The pharmaceutical industry is among the most research-intensive sectors, characterized by substantial R&D expenditures, long development cycles, regulatory uncertainty, and high failure rates. Unlike traditional manufacturing industries, pharmaceutical firms must invest significant financial resources in drug discovery, clinical trials, regulatory approval, and commercialization before generating revenues. These characteristics create a substantial mismatch between investment requirements and expected cash flows, making financing decisions a critical strategic issue. A major challenge in pharmaceutical financing is the presence of information asymmetry. Since R&D projects are largely intangible and difficult for external investors to evaluate, pharmaceutical firms often face higher external financing costs and limited access to capital markets (Hall & Lerner, 2010). According to the pecking order perspective, firms facing greater information asymmetry tend to rely more heavily on internal financing sources because external financing may involve significant valuation and agency costs (Myers & Majluf, 1984). Recent studies confirm that financing constraints remain an important determinant of innovation activities in pharmaceutical firms. Li et al. (2025) demonstrated that financing constraints significantly influence R&D investment in Chinese pharmaceutical manufacturing firms and showed that effective

internal control mechanisms can alleviate financing difficulties and support innovation activities. Similarly, Zhao et al. (2025) found that improved access to diversified financial resources positively affects R&D investment among listed pharmaceutical companies by reducing financial barriers.

Despite the availability of various financing sources, pharmaceutical firms must carefully evaluate alternative financing mechanisms because each option involves different implications regarding cost, risk, control, flexibility, and long-term sustainability. Therefore, financing decisions in pharmaceutical companies represent a multi-dimensional strategic problem rather than a conventional capital structure decision. Therefore, financing selection in pharmaceutical firms should not be considered merely a decision between debt and equity. Instead, it requires evaluating multiple dimensions, including financing cost, accessibility, sustainability, risk exposure, operational feasibility, and strategic compatibility.

2.2. Theoretical Perspectives on Corporate Financing Decisions

Corporate financing decisions have traditionally been explained through capital structure theories. Modigliani and Miller (1958) argued that under perfect market assumptions, financing choices do not influence firm value. However, subsequent research demonstrated that market imperfections, including taxation, bankruptcy costs, agency problems, and information asymmetry, significantly affect financing decisions (Modigliani & Miller, 1963). The trade-off theory suggests that firms determine their financing structure by balancing the benefits of debt financing against the costs associated with financial distress (Kraus & Litzenberger, 1973). This theory is particularly relevant to pharmaceutical firms because excessive leverage may restrict financial flexibility and reduce their ability to sustain long-term R&D investments. The pecking order theory proposed by Myers and Majluf (1984) emphasizes that firms prefer internal financing, followed by debt financing and finally equity issuance. This theory explains why innovation-intensive firms often experience financing difficulties: external investors face uncertainty regarding the value and success probability of R&D projects.

Recent evidence also highlights the importance of financial flexibility in innovation-driven industries. Studies examining R&D activities show that financially constrained firms are more likely to reduce, postpone, or discontinue innovation projects when external financing becomes limited (Czarnitzki & Giebel, 2025).

In addition to traditional capital structure theories, the concept of financial flexibility has become increasingly important in innovation-intensive industries. Financial flexibility refers to a firm's ability to access and allocate financial resources when new investment opportunities or unexpected challenges arise. For pharmaceutical companies, maintaining financial flexibility is particularly important because R&D projects require continuous investment over long periods under conditions of uncertainty (Kerr & Nanda, 2015).

2.3. Previous Empirical Studies on Pharmaceutical Financing and Innovation

Previous empirical research has mainly focused on the relationship between financing conditions, capital structure, and innovation performance. However, these studies provide important insights into the criteria that should be considered when evaluating financing alternatives.

Hall and Lerner (2010) reviewed evidence on R&D financing and showed that innovation-oriented firms face greater financing difficulties because R&D assets have limited collateral value and uncertain future returns. Their findings highlight the importance of financing accessibility and financial flexibility as critical determinants of innovation investment.

Recent empirical studies have provided more industry-specific evidence. Ali et al. (2024) examined pharmaceutical firms and reported that the relationship between capital structure decisions and R&D investment depends on firm characteristics, indicating that financing strategies should be aligned with organizational capabilities and financial conditions.

Li et al. (2025), using panel data from 327 listed pharmaceutical manufacturing firms in China during 2015–2022, investigated the role of internal control and financing constraints in R&D investment. Their findings indicate that stronger internal control reduces financing constraints and supports innovation investment.

Similarly, Li and Xu (2025) examined pharmaceutical firms in China and showed that financing conditions influence the effectiveness of R&D investment and productivity improvement. Their findings suggest that reducing financing barriers is important for maintaining sustainable innovation activities.

Czarnitzki and Giebel (2025), using survey-based evidence, further demonstrated that financial constraints influence firms' decisions regarding whether to initiate, continue, or expand R&D activities. These studies collectively indicate that financing availability, cost, and flexibility are among the most important factors affecting innovation-oriented firms.

Previous empirical studies have investigated pharmaceutical financing issues from different perspectives, including financing constraints, capital structure decisions, financial flexibility, and their impacts on innovation activities. These studies provide valuable insights into the financial challenges faced by pharmaceutical firms; however, their research objectives and methodological approaches differ considerably. Table 1 summarizes the main characteristics and findings of representative studies related to pharmaceutical financing and innovation.

Table 1
Summary of Previous Empirical Studies on Pharmaceutical Financing and Innovation

Study	Research Context	Method/Approach	Main Findings
Hall and Lerner (2010)	R&D-intensive firms	Literature review	Financing constraints significantly affect firms' ability to invest in innovation because R&D assets have limited collateral value.
Kerr and Nanda (2015)	Innovation-oriented firms	Literature review	Access to external finance and financial flexibility are important determinants of innovation activities.
Ali et al. (2024)	Pharmaceutical firms	Empirical analysis	The relationship between capital structure and R&D investment depends on firm-specific characteristics.
Li et al. (2025)	Pharmaceutical manufacturing firms	Panel data analysis	Financing constraints negatively affect R&D investment, while stronger internal control mechanisms can mitigate these constraints.
Czarnitzki and Giebel (2025)	Innovation-oriented firms	Survey-based analysis	Financial constraints influence firms' decisions regarding R&D initiation, continuation, and expansion.

As shown in Table 1, previous studies have primarily focused on examining the relationship between financing conditions and innovation outcomes. Although these studies provide important evidence regarding financing constraints and capital structure decisions, most have adopted econometric approaches aimed at identifying statistical relationships among financial variables. Consequently, limited attention has been given to the process of selecting among alternative financing mechanisms based on multiple financial and strategic criteria. This limitation is particularly important in pharmaceutical firms, where financing decisions involve complex trade-offs between cost, risk, flexibility, accessibility, and long-term innovation objectives.

Despite these contributions, previous studies have mainly examined the effects of financing constraints or capital structure choices on firm outcomes. Limited attention has been given to the problem of selecting among alternative financing mechanisms using a comprehensive multi-criteria framework, particularly in pharmaceutical firms.

2.4. Multi-Criteria Decision-Making Approaches in Financing Selection

Financing selection involves multiple conflicting criteria and cannot always be addressed through traditional financial indicators alone. Managers must simultaneously consider financial, operational, strategic, and risk-related factors. Therefore, multi-criteria decision-making (MCDM) methods provide an appropriate framework for analyzing complex financing decisions. The Analytic Hierarchy Process (AHP), developed by Saaty (1980), enables researchers to determine the relative importance of decision criteria

through structured pairwise comparisons. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), introduced by Hwang and Yoon (1981), ranks alternatives according to their distance from positive and negative ideal solutions. Furthermore, fuzzy Delphi approaches allow researchers to incorporate expert knowledge under conditions of uncertainty. The integration of fuzzy Delphi, AHP, and TOPSIS has been increasingly applied in strategic decision-making problems where both quantitative data and expert judgments are required. The fuzzy Delphi method extends the traditional Delphi approach by integrating fuzzy set theory to capture uncertainty and ambiguity in expert opinions. This approach is particularly useful when decision criteria cannot be precisely quantified and expert judgments represent the primary source of information (Ishikawa et al., 1993). Previous studies have applied fuzzy Delphi combined with fuzzy decision-making techniques for complex selection problems involving multiple criteria and uncertainty (Hsu et al., 2010).

However, despite the increasing application of MCDM methods in financial and investment decisions, their application for financing-method selection in pharmaceutical companies remains limited. Overall, previous studies have provided valuable evidence regarding the relationship between financing conditions and innovation activities. However, most empirical research has focused on the consequences of financing constraints or the determinants of capital structure, while limited attention has been devoted to the systematic evaluation and selection of financing alternatives. This limitation is particularly relevant in pharmaceutical firms, where financing decisions involve multiple financial and strategic criteria.

2.5. Research Gap and Contribution of the Present Study

The reviewed literature reveals three important gaps.

First, previous studies have mainly investigated how financing constraints influence R&D investment and firm performance, while the process of selecting appropriate financing mechanisms has received limited attention.

Second, pharmaceutical companies have unique financing characteristics due to high R&D intensity, regulatory uncertainty, and long commercialization periods. Therefore, financing selection models developed for general industries may not fully capture pharmaceutical-specific requirements.

Third, although MCDM methods have been widely applied in complex decision problems, few studies have integrated expert-based criteria identification with systematic ranking techniques to evaluate financing alternatives in pharmaceutical firms.

To address these gaps, this study develops an integrated fuzzy Delphi–AHP–TOPSIS framework to identify financing criteria and prioritize alternative financing mechanisms for pharmaceutical companies. This approach combines expert knowledge with quantitative decision analysis and provides a comprehensive framework for strategic financing selection.

3. Methodology

3.1. Research Design and Framework

This study adopts an applied research approach and employs a descriptive-survey methodology to identify and prioritize financing alternatives for pharmaceutical companies. Given the multidimensional nature of financing decisions, a hybrid multi-criteria decision-making (MCDM) framework is developed by integrating the fuzzy Delphi method, the Analytic Hierarchy Process (AHP), and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). These methods are widely used to structure complex decision-making problems, derive the relative importance of evaluation criteria, and prioritize alternatives under multiple and sometimes conflicting criteria (Saaty, 1980; Hwang & Yoon, 1981).

The proposed framework consists of three sequential stages. In the first stage, the fuzzy Delphi method is employed to identify and validate the most important criteria affecting financing method selection based on expert consensus. The Delphi method was originally developed to obtain and refine expert judgments through an iterative process, while the fuzzy Delphi approach incorporates fuzzy set theory to represent the uncertainty and vagueness inherent in linguistic evaluations (Dalkey & Helmer, 1963; Ishikawa et al., 1993). In the second stage, AHP is applied to determine the relative importance and weights of the selected criteria. AHP decomposes a complex decision problem into a hierarchical structure and uses pairwise comparisons to derive the relative priorities of the elements (Saaty, 1980). In the third stage, TOPSIS is used to evaluate and rank alternative financing methods according to their performance across the identified criteria. This method prioritizes alternatives based on their relative closeness to the positive ideal solution and their distance from the negative ideal solution (Hwang & Yoon, 1981).

The conceptual structure of the proposed model includes three hierarchical levels. The first level represents the main objective of the research, which is the prioritization of financing methods for pharmaceutical companies. The second level consists of the evaluation criteria affecting financing decisions, while the third level includes alternative financing options. This hierarchical structure enables the systematic evaluation of complex financing decisions by decomposing the problem into manageable components, consistent with the hierarchical logic underlying the AHP method (Saaty, 1980).

The integration of fuzzy Delphi, AHP, and TOPSIS provides several methodological advantages. The fuzzy Delphi method reduces uncertainty associated with expert judgments and facilitates consensus formation among specialists by allowing imprecise linguistic assessments to be represented mathematically (Ishikawa et al., 1993; Zimmermann, 1991). AHP enables the determination of relative weights among competing criteria through structured pairwise comparisons and consistency assessment (Saaty, 1980), while TOPSIS provides a comprehensive ranking mechanism for alternative financing methods based on their distance from the ideal and negative ideal solutions (Hwang & Yoon, 1981). Accordingly, the integrated framework combines expert-based criterion selection, systematic criterion weighting, and comparative alternative evaluation within a unified decision-making process.

3.2. Expert Panel and Data Collection

The target population of this study consists of experts with professional knowledge and practical experience in financial decision-making, pharmaceutical companies, and capital market activities. Considering that the research methodology is based on expert judgment and multi-criteria decision-making techniques rather than statistical estimation, the study does not require a conventional probabilistic sample size determination. Accordingly, a purposive sampling approach was adopted, and a total of 20 experts participated in the study. The expert panel included financial specialists, managers of pharmaceutical companies, and academic members with expertise in corporate finance and investment decisions. The selection of experts was based on their relevant professional experience and familiarity with financing decisions in pharmaceutical firms. Data collection was conducted through structured questionnaires. Two main questionnaires were developed and administered. The first questionnaire was designed based on the fuzzy Delphi approach to identify and validate financing criteria and alternatives. The second questionnaire consisted of pairwise comparisons for AHP analysis and evaluation matrices required for TOPSIS ranking.

3.3. Identification of Financing Criteria Using the Fuzzy Delphi Method

The fuzzy Delphi method was employed to identify the critical criteria influencing financing method selection. This technique combines the traditional Delphi approach with fuzzy set theory to address uncertainty and ambiguity in expert opinions. In conventional Delphi studies, expert judgments are usually expressed through linguistic variables such as “strongly agree,” “agree,” “neutral,” “disagree,” and “strongly disagree.” However, human judgments are inherently imprecise; therefore, fuzzy numbers provide a more appropriate representation of expert opinions.

In this study, experts evaluated the proposed criteria using five linguistic variables:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Each linguistic expression was converted into a triangular fuzzy number. The aggregated fuzzy values were then defuzzified to obtain a crisp value representing the collective judgment of experts. The criteria that achieved the predetermined acceptance threshold were retained for subsequent analysis. The Delphi process continued until convergence among expert opinions was achieved and the difference between successive rounds became lower than the predefined threshold.

3.4. Determining Criteria Weights Using the Analytic Hierarchy Process (AHP)

Following the identification and validation of financing selection criteria through the fuzzy Delphi method, the Analytic Hierarchy Process (AHP) was employed to determine the relative importance of each criterion. The AHP method, introduced by Saaty (1980), is one of the most widely applied MCDM techniques for solving complex decision-making problems involving multiple and often conflicting criteria. The main advantage of AHP is its ability to transform a complex decision problem into a hierarchical structure and evaluate the relative importance of criteria through pairwise comparisons. In this study, the decision hierarchy consisted of three levels: the overall objective (selection and prioritization of appropriate financing methods), evaluation criteria, and financing alternatives.

The AHP procedure was conducted through the following steps:

Step 1: Construction of the Pairwise Comparison Matrix

Experts were asked to compare the importance of criteria in pairs using Saaty's nine-point fundamental scale. The scale ranges from 1 to 9, where:

1 indicates equal importance between two criteria;

3 indicates moderate importance;

5 indicates strong importance;

7 indicates very strong importance;

9 indicates extreme importance.

Values 2, 4, 6, and 8 represent intermediate judgments between the above levels.

The pairwise comparison matrix can be expressed as follows:

$$A = [a_{ij}]$$

where a_{ij} represents the relative importance of criterion i compared with criterion j . The reciprocal property is maintained as:

$$a_{ji} = 1/a_{ij}$$

Step 2: Calculation of Criteria Weights

After constructing the comparison matrices, the priority weights of criteria were calculated using the eigenvector approach. The normalized weight vector represents the relative importance of each criterion in the decision-making framework.

The normalized weight of each criterion is obtained through:

$$W_i = \frac{x_i}{\sum x_i}$$

where W_i represents the final weight of criterion i.

These weights indicate the relative contribution of each criterion to the overall financing selection decision.

Step 3: Consistency Analysis

Because pairwise comparisons are based on human judgments, consistency evaluation is necessary to verify the reliability of expert assessments. The consistency ratio (CR) was calculated according to Saaty's approach.

The consistency index (CI) is calculated as:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where: λ_{max} represents the maximum eigenvalue of the comparison matrix; n represents the number of criteria.

The consistency ratio is then calculated as:

$$CR = \frac{CI}{RI}$$

where RI represents the random index value.

According to Saaty (1980), a consistency ratio below 0.10 indicates an acceptable level of consistency among expert judgments. Therefore, comparison matrices exceeding this threshold should be reviewed and revised.

In this study, the consistency of pairwise comparisons was examined, and only matrices satisfying the acceptable consistency threshold were considered for final weighting.

3.5. Ranking Financing Alternatives Using the TOPSIS Method

After determining the relative weights of financing criteria through AHP, the TOPSIS method was applied to rank financing alternatives. TOPSIS, introduced by Hwang and Yoon (1981), is based on the principle that the preferred alternative should have the shortest distance from the positive ideal solution and the greatest distance from the negative ideal solution. The advantage of TOPSIS is its ability to simultaneously consider multiple criteria and identify the alternative that provides the best overall performance.

The implementation of TOPSIS consists of the following steps:

Step 1: Formation of the Decision Matrix

The decision matrix was constructed based on the evaluation of financing alternatives against the selected criteria.

The matrix is represented as:

$$D = [x_{ij}]$$

where: x_{ij} represents the performance of alternative i with respect to criterion j .

In this study, financing alternatives were evaluated according to the criteria confirmed through the fuzzy Delphi process.

Step 2: Normalization of the Decision Matrix

Since evaluation criteria may have different measurement scales, the decision matrix was normalized to make the values comparable.

The normalized value is calculated as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}}$$

This process eliminates differences in measurement units and allows simultaneous comparison of all criteria.

Step 3: Construction of the Weighted Normalized Matrix

The normalized matrix was multiplied by the criteria weights obtained from the AHP method:

$$v_{ij} = w_j r_{ij}$$

where: v_{ij} represents the weighted normalized value; w_j represents the weight of criterion j .

This step integrates the importance of criteria into the ranking process.

Step 4: Determination of Ideal Solutions

The positive ideal solution and negative ideal solution were determined as follows:

Positive ideal solution:

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\}$$

Negative ideal solution:

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\}$$

The positive ideal solution represents the best possible performance across all criteria, while the negative ideal solution represents the least desirable performance.

Step 5: Calculation of Separation Measures

The distance of each alternative from the positive and negative ideal solutions was calculated using Euclidean distance:

$$S_i^+ = \sqrt{\sum (v_{ij} - v_j^+)^2}$$

$$S_i^- = \sqrt{\sum (v_{ij} - v_j^-)^2}$$

Step 6: Calculation of Relative Closeness and Ranking

The final ranking index was calculated as:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

The value of C_i ranges between zero and one. Alternatives with higher values of C_i are considered closer to the ideal solution and receive higher rankings.

3.6. Reliability and Methodological Validity

To ensure methodological reliability, several validation procedures were considered. First, the fuzzy Delphi method was applied to achieve expert consensus regarding the importance of financing criteria. Second, the AHP consistency ratio was calculated to evaluate the reliability of pairwise comparisons. Third, the integration of AHP and TOPSIS reduced the limitations associated with using a single decision-making method by combining criteria weighting and alternative ranking.

The use of multiple complementary MCDM techniques enhances the robustness of the proposed framework and provides a systematic approach for addressing complex financing decisions under uncertainty.

4. Results and Findings

4.1. Identification and Validation of Financing Criteria Using the Fuzzy Delphi Method

The first stage of the empirical analysis aimed to identify and validate the key criteria affecting financing method selection in pharmaceutical companies. The fuzzy Delphi method was applied to achieve expert consensus and eliminate less important factors.

Based on the evaluations provided by the expert panel, six criteria were confirmed as the main determinants of financing method selection:

- Financing cost
- Sustainability of financing method
- Efficiency of financing method
- Operational feasibility of financing method
- Financing transparency
- Fairness in financial resource allocation

The results indicate that financing decisions in pharmaceutical companies are influenced by both economic and managerial considerations. Therefore, financing selection cannot be reduced solely to minimizing financing costs; rather, it requires simultaneous consideration of efficiency, sustainability, transparency, and strategic feasibility.

The fuzzy Delphi results showed acceptable convergence among experts. The defuzzified values for the final criteria exceeded the acceptance threshold, confirming their inclusion in the subsequent AHP and TOPSIS analyses. For example, the final defuzzified values were 0.91 for financing cost, 0.89 for sustainability, 0.88 for efficiency, 0.89 for operational feasibility, 0.90 for transparency, and 0.88 for fairness.

4.2. Criteria Weighting Using the Analytic Hierarchy Process (AHP)

After confirming the evaluation criteria through the fuzzy Delphi process, the AHP method was applied to determine the relative importance of each criterion.

The results demonstrate that financing efficiency was the most influential criterion in selecting financing methods, with a weight of 0.351. This finding indicates that pharmaceutical companies prioritize financing mechanisms that can effectively support operational objectives and enhance resource utilization.

The second most important criterion was financing cost, with a weight of 0.230, highlighting the importance of reducing the financial burden associated with obtaining capital. Sustainability (0.140) and operational feasibility (0.136) ranked third and fourth, respectively. Transparency (0.064) received the lowest weight, although it remained an important consideration in the overall decision framework.

Table 2
Criteria weights obtained from AHP

Financing Criterion	Weight	Rank
Efficiency of financing method	0.351	1
Financing cost	0.230	2
Sustainability of financing method	0.140	3
Operational feasibility	0.136	4
Fairness in financial resource allocation	0.079	5
Financing transparency	0.064	6

These findings suggest that pharmaceutical firms place greater emphasis on financing alternatives that improve resource utilization and provide sustainable financial support rather than focusing exclusively on short-term financing expenses.

4.3. Ranking of Financing Alternatives Using TOPSIS

In the final stage, the TOPSIS method was employed to rank financing alternatives according to their overall performance across the six identified criteria.

The results reveal considerable differences among financing alternatives. The highest-ranked alternative was forming a company, with a closeness coefficient of 0.93, indicating the strongest similarity to the ideal financing solution. The second-ranked alternative was receiving financing facilities (bank loans) with a coefficient of 0.87.

The results further show that issuing participation bonds ranked third (0.72), followed by establishing investment companies (0.60). Stock market participation achieved a moderate position (0.33), while project establishment/study and foreign investment received the lowest rankings.

Table 3
Final ranking of financing alternatives using TOPSIS

Financing Alternative	TOPSIS Score	Rank
Formation of a company	0.93	1
Receiving financial facilities	0.87	2
Issuing participation bonds	0.72	3
Establishing investment companies	0.60	4
Stock market participation	0.33	5
Project establishment and feasibility study	0.22	6
Foreign investment attraction	~ 0.00	7

4.4. Discussion of Findings

The findings demonstrate that financing selection in pharmaceutical companies is a strategic decision influenced by multiple financial and operational dimensions. The dominance of financing efficiency as the most important criterion suggests that pharmaceutical firms seek financing mechanisms capable of effectively supporting their innovation activities and operational requirements.

The high ranking of company formation as the preferred financing alternative may be explained by its ability to provide greater control over financial resources, facilitate strategic partnerships, and reduce dependence on traditional external financing channels. Similarly, the high ranking of financing facilities indicates the continued importance of conventional debt-based financing in supporting pharmaceutical companies' short-term and medium-term financial needs.

The relatively lower ranking of foreign investment attraction reflects the specific institutional and economic constraints affecting pharmaceutical companies in emerging markets, including regulatory barriers, investment restrictions, and external uncertainties. Therefore, although foreign investment may provide substantial financial resources, its practical accessibility remains limited.

Overall, the results confirm that an integrated MCDM framework can effectively capture the complexity of financing decisions by combining expert judgments, criteria weighting, and alternative prioritization.

5. Discussion and Conclusion

5.1. Discussion of Findings

Financing decisions represent one of the most critical strategic challenges for pharmaceutical companies due to the high uncertainty, substantial investment requirements, and long development cycles associated with pharmaceutical innovation. The objective of this study was to develop an

integrated decision-making framework for identifying the most influential financing criteria and prioritizing financing alternatives in pharmaceutical companies.

The findings demonstrate that financing method selection is a multidimensional decision problem rather than a simple choice between debt and equity financing. The results obtained from the fuzzy Delphi analysis indicate that six major criteria—financing cost, sustainability, efficiency, operational feasibility, transparency, and fairness in financial resource allocation—determine the suitability of financing alternatives. This finding is consistent with previous research emphasizing that financing decisions in innovation-intensive industries are influenced by both financial and strategic considerations (Hall & Lerner, 2010; Lo & Thakor, 2022).

Among the identified criteria, financing efficiency was found to have the highest importance, followed by financing cost. This result highlights that pharmaceutical companies prioritize financing mechanisms that can effectively support organizational objectives and maximize the productive use of financial resources. Although financing cost remains an important determinant, the results suggest that pharmaceutical firms do not necessarily seek the cheapest source of capital; rather, they prefer financing alternatives that provide greater overall value and support long-term strategic objectives.

The importance of financing sustainability and operational feasibility further reflects the specific characteristics of the pharmaceutical industry. Due to the long development period of pharmaceutical products and uncertainty associated with research and commercialization activities, companies require financing mechanisms that can provide stable and continuous financial support. This finding supports previous studies indicating that financial flexibility and access to sustainable financing sources are essential factors affecting innovation investment decisions (Giebel & Kraft, 2024).

The TOPSIS results revealed that company formation was ranked as the most appropriate financing alternative, followed by receiving financial facilities and issuing participation bonds. The high ranking of company formation may be attributed to its potential to create greater organizational flexibility, facilitate resource mobilization, and support strategic cooperation among stakeholders. In contrast, alternatives such as foreign investment attraction received lower rankings, which may reflect practical limitations associated with international financing access, regulatory conditions, and investment uncertainty in emerging markets.

The findings also demonstrate the usefulness of combining fuzzy Delphi, AHP, and TOPSIS methods in financing decision problems. While fuzzy Delphi enables the identification of relevant criteria through expert consensus, AHP provides a structured approach for determining criterion importance, and TOPSIS facilitates the ranking of alternatives based on their overall desirability. Therefore, the proposed integrated framework provides a more comprehensive approach compared with traditional financial evaluation methods that generally focus on a limited number of quantitative indicators.

5.2. Theoretical Contributions

This study contributes to the corporate finance and strategic management literature in several ways.

First, it extends existing financing research by shifting the focus from the consequences of capital structure decisions toward the process of selecting financing alternatives. While previous studies have extensively examined the relationship between financing structure, firm performance, and innovation outcomes, fewer studies have investigated how firms evaluate and prioritize different financing options.

Second, this study contributes to the literature on innovation financing by demonstrating that pharmaceutical financing decisions require simultaneous consideration of multiple financial and non-financial criteria. The results support the argument that financing choices in knowledge-intensive industries cannot be explained solely through traditional capital structure theories and require broader strategic perspectives.

Third, the study expands the application of multi-criteria decision-making approaches in corporate finance by presenting an integrated fuzzy Delphi–AHP–TOPSIS framework for financing selection. This framework provides a systematic mechanism for incorporating expert knowledge and addressing uncertainty in complex financial decisions.

5.3. Managerial Implications

The findings provide several practical implications for pharmaceutical managers, financial decision-makers, and policymakers.

First, pharmaceutical managers should avoid evaluating financing alternatives solely based on financing costs. Although cost considerations remain important, financing efficiency, sustainability, and operational compatibility should also be incorporated into strategic financing decisions.

Second, managers can use the proposed framework as a decision-support tool when comparing alternative financing mechanisms. By identifying the relative importance of different criteria, firms can select financing strategies that better align with their operational requirements and long-term innovation objectives.

Third, policymakers and financial institutions can benefit from understanding the financing priorities of pharmaceutical companies. Developing financing instruments that improve efficiency, sustainability, and accessibility of capital can strengthen pharmaceutical innovation capacity and support industrial development.

5.4. Limitations and Future Research Directions

Despite its contributions, this study has several limitations that provide opportunities for future research.

First, the evaluation process was based on expert judgments. Although expert-based MCDM approaches are appropriate for complex strategic decisions, they may be influenced by individual perceptions and professional experiences. Future studies may combine expert assessments with empirical financial data to enhance the robustness of findings.

Second, the study focused specifically on pharmaceutical companies listed on the Tehran Stock Exchange. Therefore, the generalizability of findings to other industries or countries should be considered with caution. Future research may apply the proposed framework in different countries or compare financing preferences across various innovation-intensive industries.

Third, this study considered a specific set of financing alternatives. Future research may incorporate additional mechanisms such as venture capital, crowdfunding, strategic alliances, public–private partnerships, and alternative financial instruments to provide a broader evaluation framework.

Finally, future studies may employ dynamic approaches to investigate how financing preferences change over time in response to macroeconomic conditions, regulatory changes, and technological developments.

5.5. Conclusion

This study developed an integrated MCDM framework to identify key financing criteria and prioritize financing alternatives for pharmaceutical companies. The findings demonstrate that financing decisions in the pharmaceutical industry are complex strategic problems influenced by multiple financial and operational factors.

The results emphasize that effective financing strategies should consider not only the cost of capital but also efficiency, sustainability, operational feasibility, and broader strategic objectives. By integrating fuzzy Delphi, AHP, and TOPSIS methods, this research provides a structured approach for supporting financing decisions under uncertainty.

Overall, the proposed framework can assist pharmaceutical managers and policymakers in designing more effective financing strategies, improving resource allocation, and strengthening the financial foundations required for sustainable pharmaceutical innovation.

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Author Contribution

I, M.M., am the sole author of this article. I personally formulated the research idea and design, conducted the literature review, performed the Fuzzy Delphi, AHP, and TOPSIS analyses, and wrote both the initial draft and the final text of the article. I alone reviewed and approved the final version of the article for publication.

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