

Applying Fuzzy Analytic Hierarchy Process for Ranking of Financial Strategies

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Abstract: This aim of this study is applying the fuzzy Analytic Hierarchy Process method to prioritize Financial Strategies. The Fuzzy AHP method evaluates Strategies and prioritizes them. This research designs a fuzzy AHP questionnaire sent to ten professional managers and after that we prioritize Financial Strategies according to their Opinions. We apply the fuzzy AHP method in real case to demonstrate the application of proposed method.

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1. Introduction

Most of the investors think that financial situation as the only factor that determines the competitive situation of organization. For formulation of strategy in effective manner, organization's strengths and weaknesses should be identified. The power of liquidity, lending rates, working capital, profitability and cash flows can eliminate some of the strategies. Financial factors cause to change the current strategies (A'arabi et al, 2009). Financial Strategic management is the ability to maximize the net present value of organization, allocate scarce resource, implementation and evaluation of selected strategies in order to achieve objectives. For a profitable company, the most important strategic goals are optimizing the wealth of the owners (A'arabi et al, 2009). Financial manager participate in decision making of company. Financial management help managers in order to evaluate different operational options and it helps to monitor the decisions and a good control over operational decisions, create the expected cash flows for them (A'arabi et al, 2009). Financial management has important role in formulating of financial strategy and evaluating various options. The main goal of financial strategy is increasing of capital with the lowest cost that this matter increases the expected value of shareholders. At first it can appear that these decisions are in the area of financial managers and are not related to others decisions making. However, the operational can influence on financial decisions, financial decisions affect the operational strategy (A'arabi et al, 2009). General managers evaluate the business units based on two reasons. The first reason is that they ensure previous decisions can fulfill the predicted results and otherwise we need decision making for change. The second reason is providing appropriate incentives for managers based on their unit's performance. So it is essential that the tools used for evaluating of performance are consistent with the values expected of shareholders (A'arabi et al, 2009).

The following section presents Financial Strategies. Section 3 presents a concise treatment of the basic concepts of fuzzy set theory. Section 4 explains about Fuzzy AHP. Section 4 outlines an empirical study to show the process of fuzzy AHP method for ranking of financial Strategies. Finally, conclusions are provided in Section 5.

2. Financial Strategies

In this paper, financial strategies are divided into four categories, we explain about them in the following:

1. Investment strategies

The majority of professors and academics consider the investment policy as financial engineering. Results of technical engineering and marketing studies are being processed and will lead to a financial decision. This is done like this: After doing some process, an investment solution is embodied. Estimates of actual costs, cash flow after subtracting tax, value dismantled its useful life is done, Estimates of actual costs, cash flow after tax are done, Then, net present value using a discount rate adjusted and the alleged contingency approach is calculated. If the net present value is negative, the investment will be rejected and if that is positive, the investment is chosen (A'arabi et al, 2009). Investment strategies are divided into four categories:

1. Replace existing assets with similar assets
2. Replace existing assets with assets that reduce cost
3. Develop of productive capacity
4. Strategic Investment

2. Financing or funding strategies

Different companies have two general sources: domestic resources and external resources. Domestic sources are cash flows that are generated by the

operations of the company and cash flows from sales of assets. External sources are provided by capital markets, through loans or distribution of stock. According to two sources, the two different funding strategies that include the following:

1. Distribution of stock
2. Sale of assets
3. Get the Loan
4. Cumulative profits

3. Working capital strategies

Working capital of a company include moneys are invested in current assets. If current liabilities of company minus from current assets, working capital will obtain. Working capital strategies are divided into four categories:

1. Conservative current assets strategy
2. Bold current assets strategy
3. Conservative current debt strategy
4. Bold current liabilities strategy

4. Profit sharing strategies

Decisions are related to profit, determine how much profit should pay to stockholders. Stockholders of company want to have profit as follows:

1. Growth of capital which is provided by them
2. Receive the money in the form of income

Decisions are related to Profit sharing have two elements: The amount must be paid and the amount should be kept in order to support of business. In decision making about profit sharing companies should consider the following factors (A'arabi et al, 2009):

1. Liquidity
2. Repay debts
3. Control
4. Signaling effect

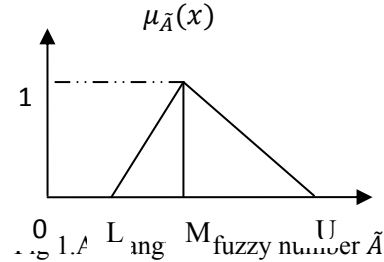
Profit sharing strategies include:

1. Fixed division of profit ratio
2. Profit sharing stable
3. Profit sharing with constant growth rate
4. remained profit sharing

3. Fuzzy sets and Fuzzy Numbers

Fuzzy set theory, which was introduced by Zadeh (1965) to deal with problems in which a source of vagueness is involved, has been utilized for incorporating imprecise data into the decision framework. A fuzzy set \tilde{A} can be defined mathematically by a membership function $\mu_{\tilde{A}}(X)$,

which assigns each element x in the universe of discourse X a real number in the interval $[0,1]$. A triangular fuzzy number \tilde{A} can be defined by a triplet (a, b, c) as illustrated in Fig 1.



The membership function $\mu_{\tilde{A}}(X)$ is defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a}{b-a} & a \leq x \leq b \\ \frac{x-c}{b-c} & b \leq x \leq c \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Basic arithmetic operations on triangular fuzzy numbers $A_1 = (a_1, b_1, c_1)$, where $a_1 \leq b_1 \leq c_1$, and $A_2 = (a_2, b_2, c_2)$, where $a_2 \leq b_2 \leq c_2$, can be shown as follows:

Addition: $A_1 \oplus A_2 = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$ (2)

Subtraction: $A_1 \ominus A_2 = (a_1 - c_2, b_1 - b_2, c_1 - a_2)$ (3)

Multiplication: if k is a scalar

$$k \otimes A_1 = \begin{cases} (ka_1, kb_1, kc_1), & k > 0 \\ (kc_1, kb_1, ka_1), & k < 0 \end{cases}$$

$A_1 \otimes A_2 \approx (a_1 a_2, b_1 b_2, c_1 c_2)$, if $a_1 \geq 0, a_2 \geq 0$ (4)

Division: $A_1 \oslash A_2 \approx (\frac{a_1}{c_2}, \frac{b_1}{b_2}, \frac{c_1}{a_2})$, if $a_1 \geq 0, a_2 \geq 0$ (5)

Although multiplication and division operations on triangular fuzzy numbers do not necessarily yield a triangular fuzzy number, triangular fuzzy number approximations can be used for many practical applications (Kaufmann & Gupta, 1988). Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision. The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation (Karsak, 2002). A linguistic variable is defined as a variable whose values are not numbers, but words or sentences in natural or artificial language. The concept of a linguistic variable appears as a useful means for providing approximate

characterization of phenomena that are too complex or ill defined to be described in conventional quantitative terms (Zadeh, 1975).

4. Fuzzy AHP

Despite of its wide range of applications, the conventional AHP approach may not fully reflect a style of human thinking. One reason is that decision makers usually feel more confident to give interval judgments rather than expressing their judgments in the form of single numeric values. As a result, fuzzy AHP and its extensions are developed to solve alternative selection and justification problems. Although FAHP requires tedious computations, it is capable of capturing a human's appraisal of ambiguity when complex multi-attribute decision making problems are considered. In the literature, many FAHP methods have been proposed ever since the seminal paper by Van Laarhoven and Pedrycz (1983). In his earlier work, Saaty (1980) proposed a method to give meaning to both fuzziness in perception and fuzziness in meaning. This method measures the relativity of fuzziness by structuring the functions of a system hierarchically in a multiple attribute framework. Later on, Buckley (1985) extends Saaty's AHP method in which decision makers can express their preference using fuzzy ratios instead of crisp values. Chang (1996) developed a fuzzy extent analysis for AHP, which has similar steps as that of Saaty's crisp AHP. However, his approach is relatively easier in computation than the other fuzzy AHP approaches. In this paper, we make use of Chang's fuzzy extent analysis for AHP. Kahraman et al. (2003) applied Chang's (1996) fuzzy extent analysis in the selection of the best catering firm, facility layout and the best transportation company, respectively. Let $O = \{o_1, o_2, \dots, o_n\}$ be an object set, and $U = \{g_1, g_2, \dots, g_m\}$ be a goal set. According to the Chang's extent analysis, each object is considered one by one, and for each object, the analysis is carried out for each of the possible goals, g_i . Therefore, m extent analysis values for each object are obtained and shown as follows:

$$\tilde{M}_{g_i}^1, \tilde{M}_{g_i}^2, \dots, \tilde{M}_{g_i}^m, i=1, 2, \dots, n$$

Where $\tilde{M}_{g_i}^j (j=1,2,3, \dots, m)$ are all triangular fuzzy numbers. The membership function of the triangular fuzzy number is denoted by $M(x)$. The steps of the Chang's extent analysis can be summarized as follows:

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^m \tilde{M}_{g_i}^j \otimes [\sum_{i=1}^n \sum_{j=1}^m \tilde{M}_{g_i}^j]^{-1} \quad (6)$$

Where \otimes denotes the extended multiplication of two fuzzy numbers. In order to obtain $\sum_{j=1}^m \tilde{M}_{g_i}^j$ We perform the addition of m extent analysis values for a particular matrix such that,

$$\sum_{j=1}^m \tilde{M}_{g_i}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j) \quad (7)$$

And to obtain $[\sum_{i=1}^n \sum_{j=1}^m \tilde{M}_{g_i}^j]^{-1}$ we perform the fuzzy addition operation of $\tilde{M}_{g_i}^j (j=1,2, \dots, m)$ values such that,

$$\sum_{i=1}^n \sum_{j=1}^m \tilde{M}_{g_i}^j = (\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i) \quad (8)$$

Then, the inverse of the vector is computed as,

$$[\sum_{i=1}^n \sum_{j=1}^m \tilde{M}_{g_i}^j]^{-1} = (\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i})$$

Where $u_i, m_i, l_i > 0$ (9)

Finally, to obtain the S_j , we perform the following multiplication:

$$S_i = \sum_{j=1}^m \tilde{M}_{g_i}^j \otimes [\sum_{i=1}^n \sum_{j=1}^m \tilde{M}_{g_i}^j]^{-1} = (\sum_{j=1}^m l_j \otimes \sum_{i=1}^n l_i, \sum_{j=1}^m m_j \otimes \sum_{i=1}^n m_i, \sum_{j=1}^m u_j \otimes \sum_{i=1}^n u_i) \quad (10)$$

Step 2: The degree of possibility of $\tilde{M}_2 = (l_2, m_2, u_2) \geq \tilde{M}_1 = (l_1, m_1, u_1)$ is defined as

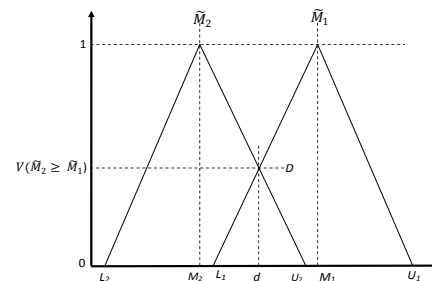


Fig 2. The degree of possibility of $\tilde{M}_1 \geq \tilde{M}_2$

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup[\min(\tilde{M}_1(x), \tilde{M}_2(y))] \quad (11)$$

This can be equivalently expressed as,

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \text{hgt}(\tilde{M}_1 \cap \tilde{M}_2) = \tilde{M}_2(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise} \end{cases} \quad (12)$$

Fig. 2 illustrates $V(\tilde{M}_2 \geq \tilde{M}_1)$ for the case $m_1 < l_1 < u_2 < m_1$, where d is the abscissa value corresponding to the highest crossover point D between \tilde{M}_1 and \tilde{M}_2 . To compare \tilde{M}_1 and \tilde{M}_2 , we need both of the values $V(\tilde{M}_1 \geq \tilde{M}_2)$ and $V(\tilde{M}_2 \geq \tilde{M}_1)$.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i=1, 2, \dots, K$) is defined as

$$V(\tilde{M} \geq \tilde{M}_1, \tilde{M}_2, \dots, \tilde{M}_k) = \min V(\tilde{M} \geq \tilde{M}_i), \quad i = 1, 2, \dots, k$$

Step 4: Finally, $W = (\min V(s_1 \geq s_k), \min V(s_2 \geq s_k), \dots, \min V(s_n \geq s_k))^T$, is the weight vector for $k = 1, \dots, n$.

In order to perform a pairwise comparison among the parameters, a linguistic scale has been developed. Our scale is depicted in Fig.3 and the corresponding explanations are provided in Table 1. Similar to the importance scale defined in Saaty's classical AHP (Saaty, 1980), we have used five main linguistic terms to compare the criteria: "equal importance", "moderate importance", "strong importance", "very strong importance" and "demonstrated importance". We have also considered their reciprocals: "equal unimportance", "moderate unimportance", "strong unimportance", "very strong unimportance" and "demonstrated unimportance". For instance, if criterion A is evaluated "strongly important" than criterion B, then this answer means that criterion B is "strongly unimportant" than criterion A.

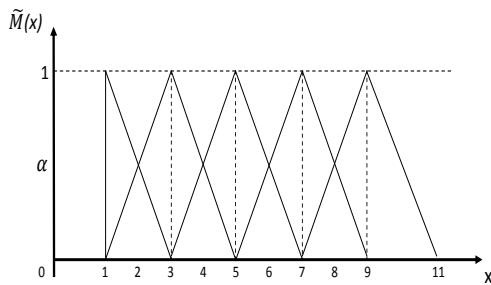


Fig 3. Membership functions of triangular fuzzy numbers corresponding to the linguistic scale

Table 1. the linguistic scale and corresponding triangular fuzzy numbers

Linguistic scale	triangular fuzzy numbers	inverse of triangular fuzzy numbers
Equal Importance	(1, 1, 1)	(1, 1, 1)
Moderate Importance	(1, 3, 5)	(1/5, 1/3, 1)
Strong importance	(3, 5, 7)	(1/7, 1/5, 1/3)
Very strong importance	(5, 7, 9)	(1/9, 1/7, 1/5)
Demonstrated importance	(7, 9, 11)	(1/11, 1/9, 1/7)

5. Case study

This study has been conducted in Padir Company. In this case, we want to prioritize financial strategies using fuzzy AHP. The Financial Strategies are shown in Table 2.

Table 2. The list of financial Strategies

	Financial Strategies
St ₁₁	Replace existing assets with similar assets
St ₁₂	Replace existing assets with assets that reduce cost
St ₁₃	Develop of productive capacity
St ₁₄	Strategic Investment
St ₂₁	Distribution of stock
St ₂₂	Get the Loan
St ₂₃	Cumulative profits
St ₂₄	Sale of assets
St ₃₁	Conservative current assets strategy
St ₃₂	Bold current assets strategy
St ₃₃	Conservative current debt strategy
St ₃₄	Bold current liabilities strategy
St ₄₁	Fixed division of profit ratio
St ₄₂	Profit sharing stable
St ₄₃	Profit sharing with constant growth rate
St ₄₄	Remained profit sharing

First of all, we should compare the main strategies with each other based on opinions ten managers that show in Table 3.

Table 3. Pair-wise comparison of main strategies

	St ₁	St ₂	St ₃	St ₄	weight
St ₁	(1.00,1.00,1.00)	(1.33,1.65,2.13)	(1.73,2.07,2.77)	(1.20,1.60,2.30)	0.371
St ₂	(0.50,0.65,0.83)	(1.00,1.00,1.00)	(1.07,1.53,2.10)	(0.33,0.50,1.00)	0.202
St ₃	(0.37,0.50,0.61)	(0.48,0.65,0.94)	(1.00,1.00,1.00)	(0.14,0.33,0.50)	0.393
St ₄	(0.43,0.63,0.83)	(1.00,2.00,3.03)	(2.00,3.03,7.14)	(1.00,1.00,1.00)	0.387

The hierarchical structure for financial strategy ranking is seen as in Fig. 4.

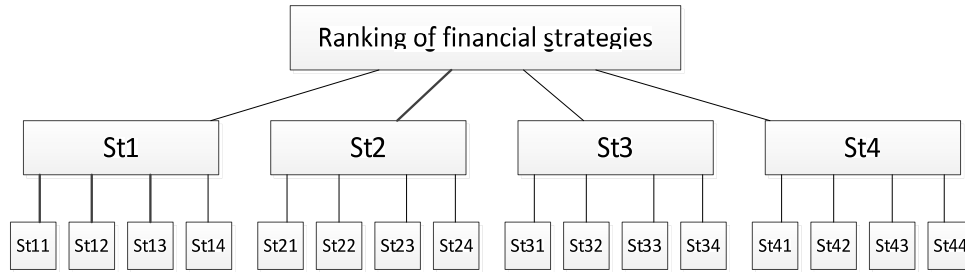


Fig. 4. Hierarchical structure of financial strategies

At the next step, we compare sub strategies with each other that show from Table 4 to Table 7.

Table 4. Pair-wise comparison of Investment strategies

St ₁	St ₁₁	St ₁₂	St ₁₃	St ₁₄	weight
St ₁₁	(1.00,1.00,1.00)	(1.00,1.38,1.80)	(2.00,2.30,2.90)	(1.20,1.60,2.30)	0.375
St ₁₂	(0.56,0.72,1.00)	(1.00,1.00,1.00)	(1.00,1.50,2.00)	(0.33,0.50,1.00)	0.201
St ₁₃	(0.35,0.40,0.50)	(0.50,0.67,1.00)	(1.00,1.00,1.00)	(0.20,0.39,0.67)	0.046
St ₁₄	(0.43,0.63,0.83)	(1.00,2.00,3.03)	(1.67,2.69,5.77)	(1.00,1.00,1.00)	0.376

Table 5. Pair-wise comparison of Financing or funding strategies

St ₂	St ₂₁	St ₂₂	St ₂₃	St ₂₄	weight
St ₂₁	(1.00,1.00,1.00)	(1.40,1.80,2.43)	(2.00,2.30,3.00)	(1.20,1.60,2.30)	0.412
St ₂₂	(0.42,0.58,0.78)	(1.00,1.00,1.00)	(1.00,1.50,2.00)	(0.33,0.50,1.00)	0.174
St ₂₃	(0.33,0.43,0.50)	(0.50,0.67,1.00)	(1.00,1.00,1.00)	(0.27,0.44,0.83)	0.034
St ₂₄	(0.43,0.63,0.83)	(1.00,2.00,3.03)	(1.33,2.34,4.40)	(1.00,1.00,1.00)	0.378

Table 6. Pair-wise comparison of Working capital strategies

St ₃	St ₃₁	St ₃₂	St ₃₃	St ₃₄	weight
St ₃₁	(1.00,1.00,1.00)	(1.66,2.03,2.67)	(2.00,2.30,3.00)	(1.20,1.60,2.30)	0.429
St ₃₂	(0.32,0.51,0.67)	(1.00,1.00,1.00)	(1.00,1.50,2.00)	(0.27,0.44,0.83)	0.144
St ₃₃	(0.33,0.43,0.50)	(0.50,0.67,1.00)	(1.00,1.00,1.00)	(0.27,0.44,0.83)	0.022
St ₃₄	(0.43,0.63,0.83)	(1.33,2.34,4.40)	(1.33,2.34,4.40)	(1.00,1.00,1.00)	0.403

Table 7. Pair-wise comparison of Profit sharing strategies

St ₄	St ₄₁	St ₄₂	St ₄₃	St ₄₄	weight
St ₄₁	(1.00,1.00,1.00)	(1.13,1.56,2.20)	(2.00,2.30,3.00)	(1.20,1.60,2.30)	0.378
St ₄₂	(0.46,0.64,0.89)	(1.00,1.00,1.00)	(1.07,1.53,2.10)	(0.27,0.44,0.83)	0.190
St ₄₃	(0.33,0.43,0.50)	(0.48,0.65,0.94)	(1.00,1.00,1.00)	(0.20,0.39,0.67)	0.043
St ₄₄	(0.43,0.63,0.83)	(1.33,2.34,4.40)	(1.67,2.64,5.77)	(1.00,1.00,1.00)	0.387

After comparing all strategies with each other, the weight of each strategy is obtained and ranked as follow.

The fuzzy AHP results are shown in Table 8. According to each strategy score, st₂ is the best financial strategy for this company.

Table 8. The result of Fuzzy AHP

St	S _{ij}	Score	Ranking
St ₁	St ₁₁	0.139271	4
	St ₁₂	0.074831	7
	St ₁₃	0.017215	10
	St ₁₄	0.139727	3
St ₂	St ₂₁	0.083589	5
	St ₂₂	0.035287	9
	St ₂₃	0.006905	14
	St ₂₄	0.076751	6
St ₃	St ₃₁	0.01688	11
	St ₃₂	0.005686	15
	St ₃₃	0.000881	16
	St ₃₄	0.015873	13
St ₄	St ₄₁	0.146673	2
	St ₄₂	0.073728	8
	St ₄₃	0.01666	12
	St ₄₄	0.150043	1

6. Conclusion

Financial management has important role in formulating of financial strategy and evaluating various options. The main goal of financial strategy is increasing of capital with the lowest cost that this matter increases the expected value of shareholders. At first it can appear that these decisions are in the area of financial managers and are not related to others decisions making. However, the operational can influence on financial decisions, financial decisions affect the operational strategy (A'arabi et al, 2009). This aim of this study is applying the fuzzy AHP method for ranking of financial Strategies. The fuzzy AHP method evaluates Strategies and prioritizes them. According to the method st₄₄ (Remained profit sharing strategy) is the best financial strategy for this company.

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