Applying Fuzzy AHP and Similarity-Based Approach for Economic Evaluating Companies Based on Corporate Governance Measures

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ABSTRACT
A large body of literature documents that good corporate governance (CG) mechanisms lead to higher firm valuations by mitigating the conflicts of interest between managers and shareholders. Therefore, evaluating the quality of companies' corporate governance has a great importance for managers, creditors and especially for current or potential investors. In fact, presenting an integrated framework for comparing the corporate governance quality of different companies could be one of the proper measures for investors in order to make decisions about which company is better for the purpose of investment. According to this, the present study proposes a multiple criteria approach to rank companies based on the corporate governance measures. We use fuzzy AHP method to determine the weights of the criteria. The companies are then ranked according to the corporate governance indicators by similarity-based approach.

1. Introduction

The agency relationship between owners and managers has been an important issue for many years. The central hypothesis of agency theory is that managers, as agents of shareholders, can engage in behaviors such as free-riding or shirking that may be inconsistent with maximizing shareholders' wealth (Jensen & Meckling, 1976). In addition, information asymmetry makes it possible for agents to engage in activities that may be a threat for firm performance and share of owners. In this situation, information asymmetry poses a moral hazard to agents. Accordingly, corporate governance is a mechanism that reduces the cost of information asymmetry and the accompanying moral hazard (Martin-Reyna & Duran-Encalada, 2012).

Historically financial scandals in many developed and developing countries and the collapse of major corporate institutions such as Enron and World Com in the USA, Parmalat in Italy and Satyam in India, motivated investors to apply corporate governance practices in promoting transparency and accountability (Filatotchev & Nakajima, 2010). The reason is that effective corporate governance mechanisms increase the probability that managers invest in positive net present value projects (Sunday, 2008). The definition of corporate governance differs depending on one's view of the world. Shleifer and Vishny (1997) define corporate governance as the ways in which suppliers of finance for corporations assure themselves of getting a return on their investment. Taking a broad perspective on the issues, Organization for Economic Co-operation and Development (OECD) (1999) defines corporate governance as the system which specifies the distribution of rights and responsibilities among different participants in the corporation such as, the board, managers, shareholders and other stakeholders, and spells out the rules and procedures for making decisions on corporate affairs (Sunday, 2008). In fact corporate governance measures are proper indicators which can make the companies comparable and consequently help the investors to decide in which company to invest. In this regard, the purpose of this paper is to propose a framework based on the multiple criteria decision making approach for ranking companies based on corporate governance indicators. This framework is especially suitable for individual or institutional investors in order to compare companies and choose the most appropriate one to invest in. The remainder of this paper is organized as follows. The next section deals with the literature review on the subject of corporate governance and its related mechanisms. It is followed by the methodology of the proposed evaluating framework, which applies Fuzzy AHP method for weighting the corporate governance criteria and similarity method for ranking the alternatives. Subsequently, an illustrative example based on the proposed framework is presented in order to show how companies could carry out this comparison among their intended companies. Finally, conclusion is presented in the last section.
2. Corporate Governance Definition and Its Mechanisms

The literature on corporate governance has increased in the last decades in various disciplines of the social sciences, such as economics, law, politics and sociology. This very focus on corporate governance rooted in a theory that defined it as mechanism to mitigate conflicts between shareholders and managers in the political economy of the corporation. Because of the separation of ownership and control, it was managers, rather than the shareholders, who controlled the corporation. The potential conflict of interest between shareholders and managers constituted the main idea of agency theory and highlighted the necessity of presenting ways to resolve the principal-agent conflicts. To guarantee that managers would act in the interest of shareholders, a range of solutions was suggested as the mechanisms of corporate governance (Horn, 2012). Various types of definition have been presented for the term "Corporate Governance", based on different perspectives. In a broad perspective, Gillan and Starks (1998) define corporate governance as the system of laws, rules, and factors that control operations at a company. In spite of the various definitions used, researchers often categorize corporate governance mechanisms in to two groups: mechanisms which are internal to firms and those which are external to firms (Gillan, 2006).

Many authors have presented a broad range of indicators as the main aspects of corporate governance and have examined the relationship between these mechanisms and different measures of firm performance (see e.g. Florackis, 2008; Bhagat & Bolton, 2008; Ammann, Oesch, & Schmid, 2011; Nelson, 2005; Omran, Bolbol, & Fatheldin, 2008). Among different corporate governance mechanisms presented in the related literature, Gillan (2006) presents a basic framework for corporates elements that may not traditionally view as being part of corporate governance structures but they are aspects of the environment that, at a minimum, affect corporate governance. Gillan (2006) divided internal governance into five basic categories: 1) The Board of Directors, 2) Managerial Incentives, 3) Capital Structure, 4) Bylaw and Charter Provisions and 5) Internal Control Systems. Similarly, he divided external governance into five groups: 1) Law and Regulation, 2) capital markets, the market for corporate control, labor markets, and product markets, 3) providers of capital market information, 4) accounting, financial and legal services from parties external to the firm and 5) Private sources of external oversight, particularly the media and external lawsuits (Gillan, 2006). We choose our corporate governance mechanisms as our study criteria among the indicators of framework presented by Gillan (2006). In the next two sub-sections the criteria which are chosen to evaluate the corporate governance quality of firms in this study, are discussed in more details.

2.1. Internal Corporate Governance Mechanisms

Board of Directors' Structure

Researchers have investigated the usefulness of a board of directors as a monitoring mechanism as they align the shareholders’ and managers' objectives and interests. Increased outsiders on the board are likely to promote managerial decisions that are in the interests of external shareholders (Hutchinson & Gul, 2004). Therefore, we consider the existence of non-executive directors in the board as a corporate governance mechanism and evaluate it in the form of the ratio of non-executive to executive directors on the board.

Management Share Ownership

Share ownership can be an important source of incentives and power for executives. Distribution of stock among executives and shareholders can have a significant impact on corporate actions since executives are less likely to engage in actions that are not in the interests of shareholders (Hutchinson & Gul, 2004). We measure share ownership as a corporate governance mechanism by the fraction of total issued shares owned by executive directors.

Managerial Compensation

The relation between managerial compensation and shareholder wealth is well documented such as when CEO wealth increases, shareholder wealth grow. However, the strength of the pay-performance relation rather than the level of pay is the key to mitigating agency problems. As Cornett, et al. (2007) have implied, we measure pay-performance sensitivity by the ratio of the dollar value of stock options held by executives to the dollar value of total compensation.

2.2. External Corporate Governance Mechanisms

Institutional Investors

A considerable body of research has focused on the role of institutional investors as corporate monitors. The rationale of this statement is that only large shareholders such as institutional investors benefits from monitoring because they have a greater incentive to monitor managers than board of directors' members, who may have little or no wealth invested in the firm. In addition, large institutional investors have the opportunity, resources, and ability to monitor, discipline, and influence managers. Monitoring by institutional investors can result in managers focusing more on corporate performance and less on opportunistic or self-serving behavior (Cornett, et al. 2007). We use two indicators to measure this mechanism. One indicator is number of institutional investors and the other is the fraction of shares owned by them. Corporate governance mechanisms which are used in this study to rank companies are shown in Table 1.
**Table 1. Corporate governance criteria**

<table>
<thead>
<tr>
<th>Corporate Governance Mechanisms</th>
<th>Criteria</th>
<th>Description and Measurement</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Board of directors' structure</td>
<td>▪ ratio of non-executive to executive directors on the board</td>
<td>BSTR</td>
</tr>
<tr>
<td></td>
<td>Management share ownership</td>
<td>▪ fraction of total issued shares owned by executive directors</td>
<td>MSHOWN</td>
</tr>
<tr>
<td></td>
<td>Managerial compensation</td>
<td>▪ ratio of the dollar value of stock options held by executives to the dollar value of total compensation</td>
<td>MCOMP</td>
</tr>
<tr>
<td>External</td>
<td>Institutional investors</td>
<td>▪ number of institutional investors</td>
<td>NII</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ fraction of shares owned by institutional investors</td>
<td>ISOWN</td>
</tr>
</tbody>
</table>

**3. Research Methodology**

**3.1. Research Framework**

The purpose of this paper is developing an integrated framework to rank companies based on some corporate governance criteria. In this framework which is based on the multiple criteria decision making approach, the corporate governance criteria are being weighted through fuzzy AHP method and then companies are ranked based on this weighed criteria through similarity method. The criteria and their related weights could be determined by each of the company's beneficiaries. This integrated framework is useful in order to make decisions about which company is better for the purpose of investment. The overall three-step framework of the study is shown in

**3.2. 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 Figure 2.
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Figure 2. A triangular fuzzy number $\tilde{A}$

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

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

(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

$$
A_1 \otimes k = \left\{ \begin{array}{ll} 
(ka_1, kb_1, kc_1), & k > 0 \\
(kc_1, kb_1, ka_1), & k < 0 
\end{array} \right.
$$

(4)

Division: $A_1 \oslash A_2 \approx (a_1, b_1, c_1), \frac{a_2}{a_2}$, 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 et al. 1988). Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems including personnel selection (e.g. rating for creativity, personality, leadership). 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).

3.3. Fuzzy Analytic Hierarchy Process

First proposed by Thomas L. Saaty (1980), the analytic hierarchy process (AHP) is a widely used multiple criteria decision-making tool. The analytic hierarchy process, since its invention, has been a tool at the hands of decision makers and researchers, becoming one of the most widely used multiple criteria decision-making tools (Vaidya et al. 2006). Although the purpose of AHP is to capture the expert’s knowledge, the traditional AHP still cannot really reflect the human thinking style (Kahraman et al. 2003). The traditional AHP method is problematic in that it uses an exact value to express the decision maker’s opinion in a comparison of alternatives (Wang et al. 2007). And AHP method is often criticized, due to its use of imbalanced scale of judgments and its inability to adequately handle the inherent uncertainty and imprecision in the pairwise comparison process (Deng, 1999). To overcome all these shortcomings, fuzzy analytical hierarchy process was developed for solving the hierarchical problems. Decision-makers usually find that it is more accurate to give interval judgments than fixed value judgments. This is because usually he/she is unable to make his/her preference explicitly about the fuzzy nature of the comparison process (Kahraman et al. 2003). The first study of fuzzy AHP is proposed by Van Laarhoven and Pedrycz (1983), which compared fuzzy ratios described by triangular fuzzy numbers. Buckley (1985) initiated trapezoidal fuzzy numbers to express the decision maker’s evaluation on alternatives with respect to each criterion Chang (1996) introduced a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, and the use of the extent analysis method for the synthetic extent values of the pair-wise comparisons. Fuzzy AHP method is a popular approach for multiple criteria decision-making. In this study the extent fuzzy AHP is utilized, which was originally introduced by Chang (1996). Let $X = \{x_1, x_2, x_3, \ldots, x_n\}$ an object set, and $G = \{g_1, g_2, g_3, \ldots, g_n\}$ be a goal set.
Then, each object is taken and extent analysis for each goal is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$\tilde{M}_{i1}, \tilde{M}_{i2}, \ldots, \tilde{M}_{in}, \ i = 1, 2, \ldots, n$$

Where \(\tilde{M}_{ij}\) (j=1, 2, 3,…, m) are all triangular fuzzy numbers. The steps of the Chang's (1996) extent analysis can be summarized as follows:

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

$$S_i = \sum_{j=1}^{m} \tilde{M}_{ij} \otimes [\sum_{j=1}^{n} \sum_{k=1}^{m} \tilde{M}_{ik}]^{-1}$$  \hspace{1cm} (6)

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

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

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

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{ij}^{-1} = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i)$$  \hspace{1cm} (8)

Then, the inverse of the vector is computed as,

$$[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{ij}]^{-1} = \frac{1}{\sum_{i=1}^{n} l_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} u_i}$$  \hspace{1cm} (9)

Where \(l_i, m_i, u_i > 0\)

Finally, to obtain the \(S_i\), we perform the following multiplication:

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

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup \{ \min \{\tilde{M}_1(x), \tilde{M}_2(y)\} \}$$  \hspace{1cm} (11)

This can be equivalently expressed as,

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \text{hgt}(\tilde{M}_1 \cap \tilde{M}_2) = \tilde{M}_2(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \frac{u_2 - l_1}{(m_2 - l_2) - (m_1 - l_1)} & \text{otherwise} \end{cases}$$  \hspace{1cm} (12)

Figure 3 illustrates \(V(\tilde{M}_2 \geq \tilde{M}_1)\) for the case d 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 \( M_i \) \((i=1, 2... k)\) is defined as

\[
V(\tilde{M}_i \geq \tilde{M}_j, \tilde{M}_k, \ldots, \tilde{M}_k) = \min V(\tilde{M}_i \geq \tilde{M}_j), \ i=1,2,...k
\]

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

3.4. A Similarity-Based Approach

Deng (2007) introduced similarity base approach that in this paper we used this method for ranking process. Deng (2007) described this method as follow.

Real-world decision making problems are very often large, multi-dimensional, conflicting and non-commensurable. There is no exception for multicriteria analysis problems (Deng et al, 2000, Diakoulaki et al, 1995, Olson, 1996, Roy et al, 1981, Shipley et al, 1991). Conflict is a fundamental nature of multicriteria analysis problems which constitutes the core of each decision situation. A multicriteria analysis problem in which the performances of the alternatives in all evaluation criteria are in complete concordance, does not present any interest, as the choice is evident (Carlsson et al, 1995, Chen et al, 1992).

There are various ways to represent the conflict between two alternatives in multicriteria analysis problems (Carlsson et al, 1995, Chen et al, 1992, Diakoulaki et al, 1995, Zeleny, 1998). Among them, the concept of alternative gradient to represent the conflict of decision alternatives in multicriteria analysis problems is the mostly common one (Cohon et al, 1978). Using this method, a conflict index between two alternatives is calculated to show the degree of conflict between the alternatives. Assuming that \( A_i \) and \( A_j \) are the two alternatives concerned in a given multi criteria analysis problem, these two alternatives can be considered as two vectors in the \( m \)-dimensional real space. The angle between \( A_i \) and \( A_j \) in the \( m \)-dimensional real space is a good measure of conflict between them. As shown in Figure 4, \( A_i \) and \( A_j \) is in no-conflict if \( \theta_{ij} = 0 \), the conflict is possible if \( \theta_{ij} \neq 0 \), i.e. when the gradients of both the alternatives \( A_i \) and \( A_j \) are not coincident.

\[
\cos \theta_{ij} = \frac{\sum_{k=1}^{n} \bar{x}_{ik} \bar{x}_{jk}}{\left( \sum_{k=1}^{n} \bar{x}_{ik} \right) \left( \sum_{k=1}^{n} \bar{x}_{jk} \right)^{1/2}}
\]

where \( \theta_{ij} \) is the angle between the gradients of the two alternatives, and \((x_{1i}, x_{2i}, \ldots, x_{ni})\) and \((x_{1j}, x_{2j}, \ldots, x_{nj})\) are the gradients of two alternatives \( A_i \) and \( A_j \), respectively.

![Figure 4. Degree of conflict between alternatives by gradients](image-url)
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\[ S_{ij} = \left( \frac{\sum_{r=1}^{m} x_{ij}^{r}}{\sqrt{\sum_{r=1}^{m} x_{ij}^{r}} / \sqrt{\sum_{r=1}^{m} x_{ij}^{r}}} \right)^{1/2} \]  

(14)

where \( \theta_{ij} \) is the angle between alternative \( A_i \) and alternative \( A_j \) represented the degree of conflict as discussed above. The larger the \( S_{ij} \) is, the higher the degree of similarity between alternative \( A_i \) and to \( A_j \). The concept of the ideal solution is used in such a way that the most preferred alternative should have the highest degree of similarity to the positive ideal solution and the lowest degree of similarity to the negative-ideal solution. The ranking approach starts by normalizing the decision matrix to ensure all the criteria involved are benefit ones based on (15), described as

\[ x'_{ij} = \frac{x_{ij}}{(\sum_{k=1}^{m} x_{ik}^{k})^{1/2}} \]  

(15)

As a result, a normalized decision matrix can be determined as

\[
X' = \begin{bmatrix}
    x'_{11} & x'_{12} & \cdots & x'_{1m} \\
    x'_{21} & x'_{22} & \cdots & x'_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    x'_{n1} & x'_{n2} & \cdots & x'_{nm}
\end{bmatrix}
\]

(16)

The weighted performance matrix which reflects the performance of each alternative with respect to each criterion is determined by multiplying the normalized decision matrix in (16) by the weight vector, given as

\[ Y = \begin{bmatrix}
    w_1 x'_{11} & w_2 x'_{12} & \cdots & w_m x'_{1m} \\
    w_1 x'_{21} & w_2 x'_{22} & \cdots & w_m x'_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    w_1 x'_{n1} & w_2 x'_{n2} & \cdots & w_m x'_{nm}
\end{bmatrix} = \begin{bmatrix}
    y_{11} & y_{12} & \cdots & y_{1m} \\
    y_{21} & y_{22} & \cdots & y_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    y_{n1} & y_{n2} & \cdots & y_{nm}
\end{bmatrix}
\]

(17)

The positive (or negative) ideal solution consists of the best (or worst) criteria values attainable from all the alternatives if each criterion takes monotonically increasing or decreasing values (Deng et al, 2000, Hwang, 1981). This concept has been widely used in various multicriteria analysis models for solving practical decision problems (Deng, 1999, Deng et al, 1998, Shipley et al, 1991). This is due to (a) its simplicity and comprehensibility in concept, (b) its computational efficiency, and (c) its ability to measure the relative performance of the decision alternatives in a simple mathematical form. Based on this concept, the positive ideal solution and the negative ideal solution can be determined from the performance matrix in (17), given as

\[ A^+ = (y_{11}^+, y_{12}^+, \ldots, y_{1m}^+) \]
\[ A^- = (y_{n1}^-, y_{n2}^-, \ldots, y_{nm}^-) \]  

(18)

Where

\[ y_{j}^+ = \max_{i=1,2,\ldots,n} y_{ij} \]
\[ y_{j}^- = \min_{i=1,2,\ldots,n} y_{ij} \]  

(19)

The degree of conflict between each alternative \( A_i \) and the positive ideal solution (the negative ideal solution) can be determined based on (13), given as

\[ \cos \theta_{i+} = \frac{\sum_{r=1}^{m} y_{ij}^{r} y_{i+}^{r}}{(\sum_{r=1}^{m} y_{ij}^{r} y_{i+}^{r})^{1/2}} \]
\[ \cos \theta_{i-} = \frac{\sum_{r=1}^{m} y_{ij}^{r} y_{i-}^{r}}{(\sum_{r=1}^{m} y_{ij}^{r} y_{i-}^{r})^{1/2}} \]  

(20)

As a consequence, the degree of similarity between each alternative \( A_i \) and the positive ideal solution and the negative ideal solution can be determined. Based on the degree of the conflict between the alternatives and the PIS and the NIS, the degree of similarity between the alternatives and \( y_{ij}^+ (y_{ij}^-) \) can be calculated. The degree of similarity denoted as \( S_{ij}^+ \), measures the relative similarity of the alternative \( A_i \) to \( y_{ij}^+ \), and the degree of similarity denoted as \( S_{ij}^- \) measures the relative similarity of the alternative \( A_i \) to \( y_{ij}^- \).  

\[ S_{ij}^+ = \frac{\cos \theta_{i+} \cdot |A_i|}{|y_{ij}^+|} \]  

(21)
\[ S_{ij}^- = \frac{\cos \theta_{i-} \cdot |A_i|}{|y_{ij}^-|} \]  

(22)

So we will have a number between 0 and 1 for \( S_{ij}^- \) just as \( S_{ij}^+ \). Then we calculate the overall performance index for each alternative across all criteria. This index can be calculated based on the concept of the degree of similarity of alternative \( A_i \) relative to the ideal solutions.
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\[ P_i = \frac{S_i^+}{S_i^+ + S_i^-}, \quad i = 1, 2, ..., n \quad (23) \]

In contrast to the similarity technique presented by Deng (2007), in the modified similarity technique and \( P_i \) are always between zero and one. To the extent \( A_i \) become more similar to \( S_i^+ \) and less similar to \( S_i^- \), the overall performance index \( (P_i) \) become near to 1. After that we rank alternatives in the descending order of the performance index value.

4. An Illustrative Example

In this section we present a simple example in order to show how assessors could carry out their corporate governance evaluating process by means of the previously proposed model. With this intention, we suppose four manufacturing companies which are active in the stock exchange. In this example our goal is ranking these four companies as alternatives based on the CG criteria in order to determine which company has the better situation in terms of CG quality and could be more proper in order to invest in. In this regard, our sample decision hierarchy is illustrated in Figure 5.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Goal} & \textbf{Criteria} & \textbf{Alternatives} \\
\hline
Ranking Companies based on the their Corporate Governance Quality & Board of directors’ structure (C1) & Company 1 (A1) \\
 & Management share ownership (C2) & Company 2 (A2) \\
 & Managerial compensation (C3) & Company 3 (A3) \\
 & number of institutional investors (C4) & Company 4 (A4) \\
 & percentage of shares owned by institutional investors (C5) & \\
\hline
\end{tabular}
\caption{Sample decision hierarchy}
\end{table}

Fuzzy AHP:

In Fuzzy AHP method, we determine the weights of each factor by utilizing pair-wise comparison matrixes. We compare each factor with respect to other factors. You can see the pair-wise comparison matrix for ranking of these factors in Table 2.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
 & C1 & C2 & C3 & C4 \\
\hline
C1 & (1.00,1.00,1.00) & (3.00,5.00,7.00) & (4.00,4.00,4.00) & (0.20,2.47,7.00) & (0.33,3.44,6.00) \\
C2 & (0.14,0.23,0.33) & (1.00,1.00,1.00) & (1.00,3.25,7.00) & (0.14,1.16,3.00) & (0.20,2.73,5.00) \\
C3 & (0.25,0.25,0.25) & (0.14,0.44,1.00) & (1.00,1.00,1.00) & (0.20,1.18,3.00) & (0.14,0.23,0.33) \\
C4 & (0.14,2.71,5.00) & (0.33,1.78,3.00) & (0.33,0.85,7.00) & (1.00,1.00,1.00) & (0.33,3.44,7.00) \\
C5 & (0.17,1.81,5.00) & (0.20,1.84,5.00) & (1.00,3.00,5.00) & (0.14,1.16,3.00) & (1.00,1.00,1.00) \\
\hline
\end{tabular}
\caption{Fuzzy pair-wise comparison matrix}
\end{table}

After forming fuzzy pair-wise comparison matrix, we calculate the weight of criteria. The weight calculation details are given below. The value of fuzzy synthetic extent with respect to the \( i \)th object \( (i = 1,2,3,4,5) \) is calculated as
Applying Fuzzy AHP and Similarity-Based Approach for …

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\[ S_1 = (8.53, 15.91, 25.00) \otimes (0.01, 0.02, 0.05) = (0.09, 0.36, 1.28) \]
\[ S_2 = (2.49, 8.37, 16.33) \otimes (0.01, 0.02, 0.05) = (0.02, 0.19, 0.84) \]
\[ S_3 = (1.74, 3.09, 5.58) \otimes (0.01, 0.02, 0.05) = (0.01, 0.07, 0.28) \]
\[ S_4 = (2.14, 9.79, 23.00) \otimes (0.01, 0.02, 0.05) = (0.02, 0.22, 1.18) \]
\[ S_5 = (4.51, 6.81, 19.00) \otimes (0.01, 0.02, 0.05) = (0.05, 0.15, 0.97) \]

Then the V values calculated using these vectors are shown in Table 3.

<table>
<thead>
<tr>
<th>(V)</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>0.684934</td>
<td>1</td>
<td>0.726733</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>0.196234</td>
<td>0.369977</td>
<td>0.260135</td>
<td>0.270862</td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>0.968358</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S5</td>
<td>0.856981</td>
<td>1</td>
<td>1</td>
<td>0.89521</td>
<td></td>
</tr>
</tbody>
</table>

Thus, the weight vector from Table 3 is calculated and normalized as
\[ W^t = (0.2697, 0.1847, 0.0529, 0.2612, 0.2312) \]

**Similarity:**

The weights of criteria are calculated by Fuzzy AHP up to now and then these values can be used in Similarity. According to Similarity methodology, we obtained weighted normalized decision matrix that can be seen in Table 4.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Alternatives</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.198</td>
<td>0.020</td>
<td>0.027</td>
<td>0.141</td>
<td>0.129</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>0.085</td>
<td>0.024</td>
<td>0.025</td>
<td>0.064</td>
<td>0.092</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>0.132</td>
<td>0.022</td>
<td>0.034</td>
<td>0.175</td>
<td>0.155</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>0.093</td>
<td>0.181</td>
<td>0.018</td>
<td>0.118</td>
<td>0.067</td>
<td></td>
</tr>
</tbody>
</table>

The positive ideal solution and the negative-ideal solution are determined by (16) and (17) as
\[ A^+ = [0.198, 0.181, 0.034, 0.175, 0.155] \]
\[ A^- = [0.085, 0.020, 0.018, 0.064, 0.067] \]

Therefore, the degree of conflict between each alternative and the positive ideal solution and the negative ideal solution is calculated by (20) and the degree of similarity between each alternative and the positive ideal solution and the negative ideal solution are determined by (21 & 22). After that the overall performance index for each alternative across all criteria can be determined by (23). The results of this calculation are shown in Table 5.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Alternatives</th>
<th>( \cos \theta_i^+ )</th>
<th>( S^+ )</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.736128</td>
<td>0.455737</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>0.456572</td>
<td>0.049182</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>0.708931</td>
<td>0.43707</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>0.793723</td>
<td>0.555275</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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According to the result of Table 5, Companies are ranked as follow:

Company 4 > Company 1 > Company 3 > Company 2

5. Conclusions

Evaluating the quality of companies' corporate governance has a great importance for managers, creditors and especially for current or potential investors. In fact, presenting an integrated framework for comparing the corporate governance quality of different companies could be one of the proper measures for investors in order to make decisions about which company is better for the purpose of investment. In this paper a two-step Fuzzy AHP and similarity methodology is structured here that similarity uses Fuzzy AHP result weights as input weights. According to this methodology, Company 4 is selected as the best Company.

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References