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# Impacts of Knowledge Sharing in Saudi Accounting Firms using Fuzzy AHP

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## Abstract

The paper presents a detailed study to measure the impact on knowledge sharing in the Kingdom of Saudi Arabia (KSA) accounting firms using Fuzzy AHP (FAHP). A major problem of accounting managers is to evaluate several firms using standard financial and company-based metrics e.g. revenue, costs, market share, and others. However, these methods have limitations as they look at past data to make a prediction. This paper uses FAHP to examine intangible assets to provide a long-term comparison, share the findings amongst account managers, and help them to identify prospective firms that can provide better revenues in the long term. The paper defined the methodology and experiments to measure and evaluate the impact on business performance and intellectual capital of KSA accounting firms. For a target firm, parameters for the fuzzy scale were defined. A FAHP model was created with four steps and tested on a set of firms to evaluate linguistic variables of the company's intangible assets. Calculations indicate that FAHP helps KSA accounting firms to identify the extent to which portfolios perform against benchmarked firms of KSA firms. The impacts of this knowledge sharing proved that it is possible to maximise the investment portfolio when a large number of stocks must be evaluated using human capital and intellectual capital assets. Feedback was provided to accounting managers to improve the revenue maximisation process by concentrating on important indicators. Results show FAHP and the methodology have the potential for using artificial intelligence to analyse firms and help KSA firms to gain a competitive advantage. This becomes critical in KSA that may lack the networking and interaction of accounting professionals seen in European countries.

**Disciplinary**: Information Management and Business Intelligence.



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# 1 Introduction

Fuzzy analytic hierarchy (FAHP) is a multiple-criteria decision selection method that uses fuzzy logic. This method uses, amongst other things, a fuzzy pairwise matrix for comparison with log non-linear programming to develop priorities with a fuzzy pairwise comparison matrix. Fuzzy decisions are easier to develop than fuzzy crisp values. The zone that this paper evaluates is about using FAHP in accounting firms. Accounting firms operate in a challenging environment where they have to manage intellectual capital to provide a competitive advantage [1]. According to Lee [2], when the number of investments is vast, then managing this huge portfolio becomes a challenge. Account managers possible can commit errors of overinvesting or under-invest in some assets, with reference to the value creation potential of the assets.

Mansour et al. [3] explain that AHP is increasingly used for knowledge creation and sharing to capture the dynamics of the assets. It is important to note that knowledge, data, information, and qualified reports must be first generated using FAHP. Yalçin and Ünlü [4] further expand that knowledge artifacts can then be shared amongst accounting firm members and the efficacy of the knowledge sharing can then be measured.

Whilst methods to generate knowledge and measure the impact of knowledge sharing are in use since time, the previous efforts and methods have focussed on tangibles such as revenue, market share, and other indicators. The intangible aspects [5,6] such as human capital and intellectual capital that are strong indicators are largely ignored. Measurement and assessment of intangible indicators are difficult and researchers have ignored them. However, human and intellectual capitals are very strong contributors to a firm's [7,8]. This paper examines this research gap by focussing on these intangible indicators.

This paper analyses the various methods and systems where FAHP can be used to generate knowledge and then measure the impact of the knowledge sharing methods in the Kingdom of Saudi Arabia (KSA) accounting firms.

The paper sets to find out if FAHP with its system of criteria, subcriteria, alternatives, and ranking weights can generate data on firm performance, to assess if FAHP can be used to compare the intellectual and functional assets of a firm, with reference to benchmarked future. If knowledge can be shared amongst accountant managers so that they can make quick decisions on evaluation of firms, and how the impact can be measured.

This paper is unique since it adopts a novel approach of evaluating the intangible assets of a firm, the human capital, and intellectual capital assets for long-term evaluation of firms, sharing this knowledge, and measuring the impact of this knowledge sharing. Traditional methods use standard financial metrics.

## 1.1 About KSA Accounting Firms

Financial reporting in KSA complies with IFRS. All listed firms in KSA must follow the accounting standards. These standards are issued by the Saudi Organization for Certified Public

Accountants (SOCPA). SOCPA works under the Ministry of Commerce and it prescribes internationally accepted standards of accounting. In fact, SOCPA standards are fully aligned with international accounting standards from 2015 onwards. This move was taken to ensure that KSA firms are listed in international stock markets and that the financial reports are accepted throughout the world. However, KSA firms are still required to follow the requirements of zakat or religious tax and Sharia that are not covered by IFRS [9]. This observation is important since it means that any knowledge sharing developed by KSA accounting firms is acceptable in all international auditing firms.

This paper addresses "How to use FAHP to evaluate a large number of firms for human capital and intellectual capital assets, to share the knowledge amongst accounting managers so that proper investment in the right portfolios can be undertaken for long term gains.

Why this new approach is needed: Traditional evaluation of stocks was based on financial and performance metrics such as turnover, profits, market share, market cap, and so on. These methods have a limitation in that they look at data of the previous quarters and estimate the performance for the future. Market and economic conditions can make even good firms to show losses. However, it is the human capital and intellectual capital assets that lead a firm to success. This paper proposes a model where these intangible assets are evaluated using FAHP to indicate the future performance.

## 2 Literature Review

AHP is essential for managers to break down the decision process into different components that move from general to specific issues [10]. The problem construction should have a goal or problem statement, criteria, and alternative structure levels that are placed into an ordered hierarchy. Every criterion and subcriterion needs to be split into a detail level. After the hierarchy is defined, managers can evaluate the relative importance of every criterion with paired comparisons that are structured in matrices. Evaluation is carried from the direction of the top-level criterion [11]. As per Halder et al. [12], scoring is done on a relative basis where the importance and relevance of a decision are compared to another. AHP helps to obtain the objective and subjective evaluations along with a mechanism to inspect the consistency of the manager's evaluations. It is used for the analysis of intangibles since the probability for evaluation of qualitative and quantitative criteria and alternatives are placed on the same preference scales. Many accounting assets are attributes that do not have a scale to measure, but they are defined through relative measurements and priorities. AHP is also a subjective system where priority weights and information are derived from managers through a survey.

Measuring intellectual capital: Intellectual capital (IC) is similar to financial capital for the value creation process. There are two types of intangible ICs in the value description tree and these are human capital and structural capital. Human capital refers to the intangible that are a part of the human resources and it has three components such as competence made of skills, competencies, and knowhow; Attitude made of leadership and motivation; and intellectual ability

made of mental flexibility, innovation, creativity, and problem-solving. Structural capital refers to the intangibles that are a part of the firm. It includes relationships or the relational network of the firm with stakeholders, organisation made of structure, routines, structure, processes, and some other terms [13].

Ghassabi [14] presented research on measuring intellectual capital using FAHP for higher education institutes. The study did not use any relative weights to find their relations, nor did the study use any benchmarked results for comparison. Selim et al. [15] conducted another study of manufacturing firms in Turkey to examine the tangible indicators. The gap was in the lack of examining intellectual capital.

Measuring business performance: According to Zaied et al. [16], one of the reasons for using FAHP is to increase the business performance and competitive advantage. One of the problems that accountants and auditors face is to find assets that show trends of positive and negative impact on the investments. This is more so for R&D and innovation capital expenditure that influence competitiveness and firm value, and positive value of the market and business performance using financial indicators to predict future performance. Yazici et al. [17] explain that stakeholders or managers have their perspective for the financial value attributes and they may have a different financial meaning to the financial performance.

Weakness, strength, and research gaps: The previous paragraphs have examined several studies on FAHP. However, it becomes evident that these studies did not examine intangibles, they did not use relative weights and did not refer to benchmarked values. By focussing on intangibles that drive business performance, better prediction of enterprise performance is possible. However, current methods of judging performance are not very satisfactory as they tend to rely on past data and compare them with inadequate benchmarks. In many instances, the IC components from different firms of the same industry are not compared effectively. As a result, benchmarked data is not efficient, and it is difficult to assess the strategies that provide the critical assets knowledge and sharing.

## 3 Proposed Methodology

This paper presents the methodology and algorithm for knowledge sharing in KSA accounting firms. The section details the methodology to identify the relative importance of different criteria, sub-criteria, and alternatives in accounting transactions by using fuzzy comparison matrices without using zero weight issues. The method is then applied to a target KSA accounting firm *T*. The target firm is then compared to 10 firms from the same sectors best practices. FAHP considers the goal of increasing revenue. Figure 1 illustrates the conceptual model for the paper.

Saaty [18] first defined an AHP to evaluate intangibles. Shariati [19] argues that it did not fully capture the qualitative aspects since the discrete scale cannot manage actual transactions. Lee [2] says that when expert preferences are impacted by imprecision, then definite numbers are used to representing the linguistic judgments. To overcome the problem of ambiguity, Rezaei et al. [20]

defined the triangular fuzzy numbers (TFN). FAHP is used for the conversion of TFNs that are placed in fuzzy pairwise comparison matrices that are run to calculate the relative item weights and the alternative ranking. Several ways are available for handling comparison matrices. The method suggested by Chang [21] was improved by Omrani et al. [22] and it is selected since the further implementation is fast and the relative weights are calculated faster. The detailed triangular fuzzy conversation scale is shown in Omrani et al., 2019.

## 3.1 Algorithm and Methods

As per [23] and [21], for every level of the hierarchy that is created, a pair of linguistic judgements in the TFN is transformed. They are placed in comparison matrices, which are given below, and the equations are developed from a number of resources [24, 25, 26].

$\tilde{A} = (\underline{a}ij)nxn =$

$[(1,1,1)\ (l12, m12, u12)\quad (l1n, m1n, u1n)\ \vdots \ddots \vdots$

$l21, m21, u21\ \cdots\ (l12, m12, u12)\quad (l1n, m1n, u1n)\ (ln1, mn1, un1)\ (ln2, mn2, un2)\quad (1,1,1)\ ]$ (1),

$$\tilde{a}\ ij = (lij, mij, uij) = \tilde{a}\ ij\ -1 = \left(\frac{1}{uji}\ \frac{1}{mji}\ \frac{1}{lji}\right) \quad i, j = 1 \ldots n = i \neq j \qquad (2),$$

where $\tilde{A}$ stands for the linguistic judgment of entities $i$ and $j$. Therefore $\tilde{A}$ is considered as symmetrical and square matrix. For every row of $\tilde{A}$, the relative row sum is calculated as:

$$\widetilde{RS}\ i = \sum_{j=1}^{n} \tilde{a}_{ij} = \left(\sum_{j=1}^{n} \tilde{l}_{ij}, \sum_{j=1}^{n} \tilde{m}_{ij}, \sum_{j=1}^{n} \tilde{u}_{ij}\right); i = 1, .., n \qquad (3).$$

The formula is normalised with a correction [27] to derive the normalised row sum of $\tilde{S}$ as:

$$\tilde{S}\ i = \frac{\widetilde{RS}\ i}{\sum_{j=1}^{n} \widetilde{RS}\ i} = \left(\frac{\sum_{j=1}^{n} Lij}{\sum_{j\neq 1}^{n} lij, \sum_{k\neq 1}^{n} lij, \sum_{j=1}^{n} ukj}, \left(\frac{\sum_{j=1}^{n} Mij}{\sum_{k\neq 1}^{n} mkj, \sum_{j=1}^{n} ukj}, \left(\frac{\sum_{j=1}^{n} Uij}{\sum_{k\neq 1}^{n} mkj, \sum_{j=1}^{n} ukj}\right.\right.\right. \qquad (4).$$

Once the row sums of $\tilde{S}_i$ $(i = 1 \ldots. n)$ are normalised, then these are compared by using a degree of possibility.

$$V(\widetilde{\tilde{S}\iota} \geqslant \tilde{S}j\ = \{1\ 0\ \ (uj-lj)/\ (uj-mi)+(mj-lj)\quad If\ mi \geqslant mj \qquad (5)$$

$$If\ lj \leq ui\ i, j = 1\ \ldots.\ n,\ j \neq i$$

The relative crisp weight of every asset i is evaluated by normalising the degree of possibility values. This is given as:

$$W\ i = V\ (\tilde{S}i \geqslant \tilde{S}j \mid j = 1, \ldots..\ n\ j\neq 1) / \sum_{k=1}^{n} V(\tilde{S}i \geqslant \tilde{S}j \mid j = 1, \ldots..\ n, j\neq k)\ \ for\ i = 1, ..n \qquad (6)$$

In Equation (6),

$$V\ (\tilde{S}_i \geqslant \tilde{S}_j \mid j = 1, \ldots, n,\ j\neq 1 = \min_{j\in(1\ldots.n)\ j\neq 1} V(\tilde{S}_i \geqslant \tilde{S}_j)\quad i = 1,.. n \qquad (7)$$

Jiang et al. [28] and Wang et al. [29] do not accept this method to calculate relative weights since there is a possibility that the methodology can assign zero weight to the alternatives and criteria, indicating that their elimination is possible since they are classified as unwanted items. However, this removal can create problems with the hierarchical structure and form improper prioritisation of alternatives and criteria.

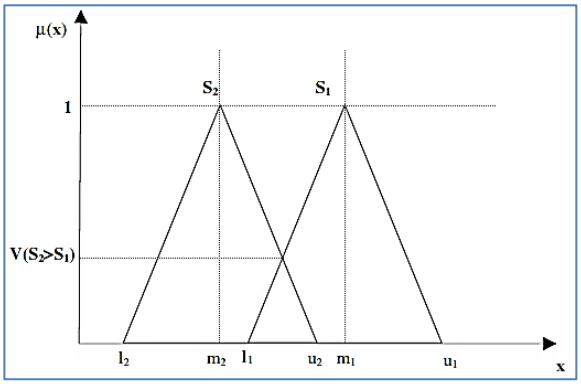


**Figure 1**: Intersection of S1 and S2 [30]

As seen in Figure 1, it is possible that Equation (6) is used for comparison of TFNs. When the pair of comparison matrices (1) is consistent, then the crisp weights can be linked to intervals that are given by Equation (4).

## 4 Evaluation and Experiments

Using the studied methods, the relative importance of the criteria, alternatives, and sub-criteria are used for fuzzy comparison matrices without facing the problem of zero weight problems. The method is carried out in four steps and these are given as follows.

**Step 1**: In this method, the fuzzy comparison matrices are converted into crisp comparison matrices by employing the centered defuzzification method or the center of gravity is used. For TFNs, the translating formula is given as:

$$a_{ij}\,(\tilde{a}_{ij}) = (l_{ij} + m_{ij} + u_{ij})/\,3 \qquad (8),$$

where $(\tilde{a}_{ij}) = (l_{ij,}\, m_{ij}\, u_{ij})$.

**Step 2**: In this step, the consistency of every comparison matrix is found by calculating the *CI* or consistency index and the *CR* or consistency ratio.

$$CI = (\lambda_{max} - n)/\,n\text{-}1 \qquad (9),$$

$$CR = (CI - RI(n))/\,100\% \qquad (10).$$

The subscript *k* is the highest possible Eigenvalue of the comparison matrix, n is the matrix dimension, and RI(n) is the random index that is based on n given in Table 1. Matrix consistency can be taken true only when $CR(10) < 10\%$. This value of *10%* can be increased or decreased based on the tolerance set by the account managers. When the matrix produces an inconsistent result, then a new pair comparison must be obtained to find the pair fuzzy comparison matrix for further analysis. This review of the matrix is continued until the required consistency is obtained.

**Table 1**: Consistency index random matrices (Golden et al., 1989)

| n | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|
| RI(n) | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

**Step 3**: In this step, the local priority weight for each criterion, alternatives, and sub-criterion is found by adding up the row of the consistent fuzzy comparison $\tilde{A}$. This is then normalized with the sum of the rows to derive $(\tilde{S}_i)$ with (4). The crisp weights are then found by conversion of the fuzzy weights.

$$Wi = S_i(\tilde{S}i) = (l_i + m_i + {}_{ui})/3 \text{ Where } (\tilde{S}_i) = (l_{ij,}\ m_{ij}\ u_{ij}) \quad (11)$$

through normalisation of the normalised crisp weight vector give as

$$W = w'_1, w'_2, \ldots. w'_n \quad (12)$$

**Step 4**: In this step, the aggregate local priority weights are arranged into the global priorities. The rank of every alternative is obtained. If multiple managers use the results, then the process of evaluation can lead to different comparison matrices for each manager. Therefore, before the steps are applied, they need to be synthesised into a unit aggregate matrix.

$$If\ \tilde{a}_{ij}^{(k)} = (l_{ij}^{(k)} m_{ij}^{(k)} u_{ij}^{(k)}) \quad (13).$$

This is the number that indicates the judgement given by the kth manager, leading to

$$(if\ \tilde{a}_{ij}^{(k)})^{-1} = \left(\frac{1}{l_{ij}^{(k)}}, \frac{1}{m_{ij}^{(k)}}, \frac{1}{u_{ij}^{(k)}}\right) \quad (14)$$

This is the reciprocal value of the function. By using the fuzzy average judgement addition operator for TFN (Kaufmann and Gupta, 1991):

$$\tilde{a}^{\leftarrow}{}_{ij} = \frac{1}{m}\sum_{k=1}^{m} \tilde{a}_{ij}^{(k)} = \left(\frac{1}{m}\ \sum_{k=1}^{m} l_{ij}^{(k)}, \frac{1}{m}\ \sum_{k=1}^{m} m_{ij}^{(k)}, \frac{1}{m}\ \sum_{k=1}^{m} u_{ij}^{(k)}\right),\ i, j = 1, \ldots\ldots n: j \neq I \quad (15)$$

## 4.1 Measuring the Impacts of Knowledge Sharing

To evaluate the impacts of knowledge sharing on the value creation process, the estimation of the impacts is done by evaluating the balance amongst different IC assets. This will help to ascertain if there is over-investment or under-investment of the IC assets and it would therefore be able to find if the use of knowledge sharing is ineffective or efficient. When the balance of the IC assets is effective, this does not indicate that the relative importance and weights can be distributed homogeneously [31]. The objective is to see the impact of knowledge sharing on the value creation process. Every industrial sector has a specific and special knowledge creation process. Therefore, the IC configuration must change as per the industry under analysis. FAHP is therefore used to evaluate the relative importance of different IC assets through the FAHP weights for a clear identification of the IC configuration [32].

This method allows KSA accounting managers to compare firms directly from the same sector for improvement by benchmarking. For this paper, the target firm *T* is compared for the IC configuration of best practices from the same sector. When such information is shared between accounting firms, the decision-making of the account managers can be evaluated. A hierarchy is developed for the analysis as per the structure given in Figure 2.

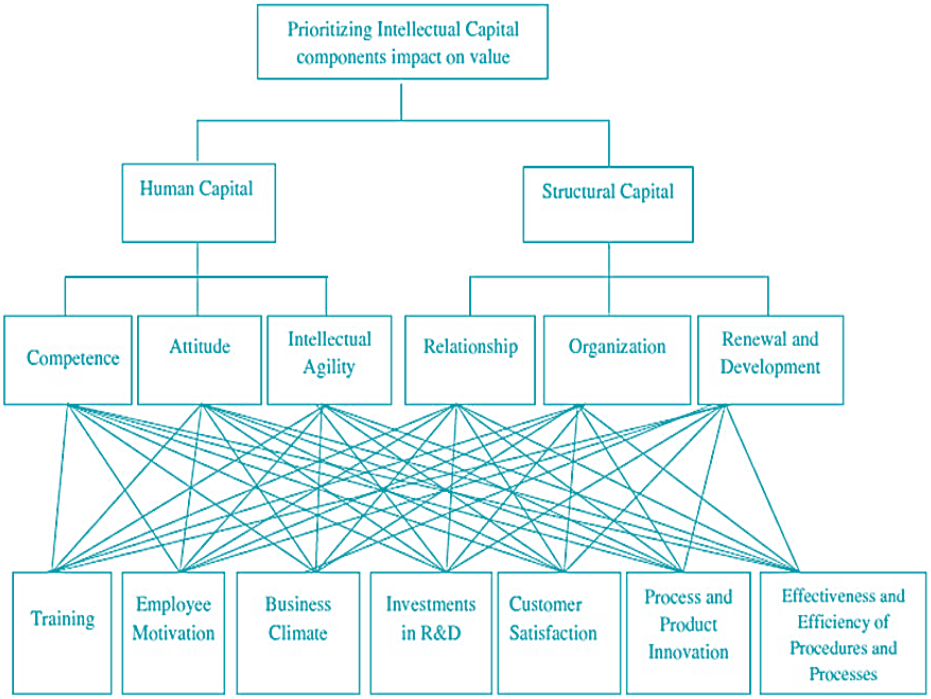


**Figure 2**: The FAHP model.

In the FAHP model illustrated in Figure 2, the following details are to be noted.

**First level**: This is the goal of the FAHP, and this allows the assessment of the impact of the model on the value creation process. The goal for the firm set is the increase in company revenue, and it implies that the IC assets lead to revenue maximisation. The methodology can be extended to include other goals such as market cap, market share, patents held, and other value creation processes.

**Second level**: This is the criteria and there are two types for the analysis: structural and human capital.

**Third level**: This is the subcriteria that are as per the definition of intellectual capital. Human capital is given three subcriteria and these are attitude, agility, and competence. Structural capital is given three subcriteria and these are relationship, organisation, renewal, and development.

**Fourth level**: This is the alternative and related to the indicators for the IC components and selected from the available IC measurement systems. These indicate every component of the IC. The indicators that stand for the IC components as per the available methods indicate the alternatives. These are identified by indicators such as IND1 for training, employee satisfaction and motivation. Also, R&D investments, business climate, customer satisfaction, innovation, efficiency and are also included.

## 4.2 Application of FAHP Model

The method discussed in the previous sections is applied to a target firm *T* and the results are compared to a sample of 10 benchmarked firms from the same sector. The findings are then shared to assess the impact of the knowledge-sharing process in accounting firms. Data for the

FAHP implementation were obtained through journal articles where managers of KSA accounting firms were interviewed. The responses were then analysed for the respondents who compared the alternatives, criteria, and subcriteria to make paired comparisons. Respondents expressed their relative importance using linguistics terms previously defined. The paired comparisons were then arranged to provide respondents' interpretation of the questions. The judgements were then transformed into fuzzy numbers.

For the data, the consistency matrix was analysed and it is consistent with *CI = 0.11* and *CR = 0.8*. The row sum of $\widetilde{RS}_i$ (3) and the normalised row sum $\tilde{S}_i$ Eqaution (4) were calculated for the indicators that are associated with the row of Table 1. Value of the row sum of alternative Training with reference to competence was calculated by using Equation (3) to give:

$$\widetilde{RS}_i = (1,1,1) \oplus (1.5,2,2.5) \oplus (1,1.5,2) \oplus (0.4,0.5,0.7) \oplus (0.33, 0.4, 0.5) \oplus (0.4, 0.5, 0.7) \oplus (BbbK(1.5,2,2.5) = (.13, 7.9, 9.83)$$

Sum values of all rows are given. Therefore

$$\tilde{S}_i = \left(\frac{6.13}{71.13}, \frac{7.9}{59.67}, \frac{9.83}{50.43}\right) = (0.0862; 0.1324; 0:195)$$

Other row sum values are given in Table 2. Crisp weights are obtained with Equation (11) and through normalization, the relative weights forever alternative for competencies are found as:

$\boldsymbol{W} = (0.13; 0.13; 0.11; 0.17; 0:.0; 0.17; 0.09)$

## 4.3 Measuring the Impacts on Knowledge Sharing on KSA Accounting Firms

Calculated values of synthesized pairs are presented. The seven indicators selected in the fourth level of the FAHP model in Figure 2 are mapped to the respective sub-criteria. The assessment is for all the parameters. The weights assigned by the respondents fall in the same narrow range of agreement. Some variations are seen for firm *T* not being aligned, attitude is the same for T 2%, and BP at 20%. It appears that firm *T* focuses on competence rather than BP, with 35% against 28%. BP invests more from intellectual agility at 52%, whilst *T* invests 43%. Company *T* is seen to have an IC with strength and innovation capacity, with intellectual ability at 3%, competence at 35%, and attitudes at 43%. The overall assessment is that there is a concurrence amongst KSA account managers when FAHP is used.

**Table 2**: Synthesized paired judgments for alternatives for competence.

| | IND1 | | | IND2 | | | IND3 | | | IND4 | | | IND5 | | | IND6 | | | IND7 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | l | m | u | l | m | u | l | m | u | l | m | u | l | m | u | L | m | u | l | m | u |
| IND1 | 1 | 1 | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 0.4 | 0.5 | 0.67 | 0.33 | 0.4 | 0.5 | 0.4 | 0.5 | 0.67 | 1.5 | 2 | 2.5 |
| IND2 | 0.4 | 0.5 | 0.67 | 1 | 1 | 1 | 1.5 | 2 | 2.5 | 0.4 | 0.5 | 0.67 | 1 | 1.5 | 2 | 0.4 | 0.5 | 0.67 | 1 | 1.5 | 2 |
| IND3 | 0.5 | 0.67 | 1 | 0.4 | 0.5 | 0.67 | 1 | 1 | 1 | 0.33 | 0.4 | 0.5 | 0.33 | 0.4 | 0.5 | 0.33 | 0.4 | 0.5 | 1.5 | 2 | 2.5 |
| IND4 | 1.5 | 2 | 2.5 | 1.5 | 2 | 2.5 | 2 | 2.5 | 3 | 1 | 1 | 1 | 0.4 | 0.5 | 0.67 | 0.5 | 1 | 1.5 | 1.5 | 2 | 2.5 |
| IND5 | 2 | 2.5 | 3 | 0.5 | 0.67 | 1 | 2 | 2.5 | 3 | 1.5 | 2 | 2.5 | 1 | 1 | 1 | 1.5 | 2 | 2.5 | 2 | 2.5 | 3 |
| IND6 | 1.5 | 2 | 2.5 | 1.5 | 2 | 2.5 | 2 | 2.5 | 3 | 0.67 | 1 | 2 | 0.4 | 0.5 | 0.67 | 1 | 1 | 1 | 1 | 1.5 | 2 |
| IND7 | 0.4 | 0.5 | 0.67 | 0.5 | 0.67 | 1 | 0.4 | 0.5 | 0.67 | 0.4 | 0.5 | 0.67 | 0.33 | 0.4 | 0.5 | 0.5 | 0.67 | 1 | 1 | 1 | 1 |

### 4.4 Implications and Recommendations

Findings from the tests bring out the following implications. It is possible to identify the extent to which portfolios perform against benchmarked firms of KSA firms. The implication is that accounting firms can analyse a cohort of firms from the same sector for several criteria, subcriteria, and alternatives to understand their performance for specific indicators. More important this knowledge can be shared in the accounting firm, or in the accounting firm network to analyse portfolios, understand areas where some firms show higher or lower performance. This assessment is independent of the account managers' skills and competence. Therefore, it would be possible for accounting firms to advise their clients on the best-performing stocks and inform leaders for areas in which they can improve.

The recommendations are that for further studies, multiple target firms should be examined to understand their performance. The indicators can be tangible or revenue-based or they can be focussed on intangible indicators such as intellectual capital and human capital. When sufficient studies are run, it will be possible to use the studies through a framework and increase the competitiveness of KSA firms.

## 5 Conclusion

The paper has generated data for criteria, sub-criteria, alternatives, and weights as successful developed for a target firm. The results were then compared to benchmarked figures. The result was useful since there was a high level of concurrence and disagreement for various indicators. When this knowledge was shared and compared amongst managers, an evaluation pattern based on intangibles was developed. This development is very interesting and it has wider implications since it is possible to take up evaluation of a large number of firms based on multiple indicators and decide if they are performing well, if these firms would perform well in the future, and if a framework can be developed for such evaluation. For future studies, it should be possible to test for a very large cohort sample of firms by using artificial intelligence to study stocks, firm performance, and then decide where investment can be done.

## 6 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

## 7 References


[1] Alexander, J. M. 2012. The Analytic Hierarchy Process Applications and Studies. London: Blackwells.

[2] Batista, L., Dora, M., Toth, J., Molnár, A., Malekpoor, H., and Kumari, S., 2019. Knowledge management for food supply chain synergies-A maturity level analysis of SME companies. Production Planning & Control, 30(10-12), pp. 995-1004.

[3] Chang, D. Y. 1996. Application of extend analysis method on Fuzzy AHP. European Journal of Operational Research, 96, pp. 343-350.

[4] Deloitte. 2020. Financial reporting framework in Saudi Arabia. Deloitte. https://www.iasplus.com/en/jurisdictions/asia/saudi-arabia Accessed October 2020.

[5] Dos Santos, P. H., Neves, S. M., Sant'Anna, D. O., de Oliveira, C. H., and Carvalho, H. D., 2019. The analytic hierarchy process supporting decision making for sustainable development: An overview of applications. Journal of cleaner production, 212, pp. 119-138.

[6] Ecer, F., 2018. Third-party logistics (3PLs) provider selection via Fuzzy AHP and EDAS integrated model. Technological and Economic Development of Economy, 24(2), pp. 615-634.

[7] Emrouznejad, A., and Ho, W., 2017. Fuzzy Analytic Hierarchy Process 1st Edition. London: Chapman and Hall/CRC.

[8] Ghassabi, Z., 2018. Measuring of intellectual capital indexes using FAHP technique in institutes of higher education. International Journal of Services and Operations Management, 29(2), pp. 236-251.

[9] Haldar, S., Karmaker, C. L. and Hossain, S. R., 2019. A framework to evaluate and improve supply chain: FAHP based case study on a supermarket. International Journal of Research in Industrial Engineering, 8(3), pp. 225-242.

[10] Halder, S., Roy, M. B., and Roy, P. K., 2020. Fuzzy logic algorithm based analytic hierarchy process for delineation of groundwater potential zones in complex topography. Arabian Journal of Geosciences, 13(13), pp. 1-22.

[11] Jain, J., Walia, N., and Gupta, S., 2019. Evaluation of behavioral biases affecting investment decision making of individual equity investors by fuzzy analytic hierarchy process. Review of Behavioral Finance, 12 (3), pp. 297-314.

[12] Jiang, X., Wang, H., Guo, X., and Gong, X., 2019. Using the FAHP, ISM, and MICMAC approaches to study the sustainability influencing factors of the last mile delivery of rural E-commerce logistics. Sustainability, 11(14), p. 3937.

[13] Khorramrouz, F., Kajabadi, N. P., Galankashi, M. R., and Rafiei, F. M., 2019. Application of Fuzzy Analytic Hierarchy Process (FAHP) in failure investigation of knowledge-based business plans. SN Applied Sciences, 1(11), p. 1386.

[14] Lee, S. H. 2010. Using Fuzzy AHP to develop Intellectual Capital evaluation model for assessing their performance contribution in a University. Expert Systems with Applications, 37, 4941-4947.

[15] Mabrouk, N., Omri, A., and Jarraya, B., 2020. Factors influencing the performance of supply chain management in Saudi SMEs. Uncertain Supply Chain Management, 8(3), pp. 569-578.

[16] Mansour, M., Dawood, S., and Falqi, I., 2020. An Integrated Structural Equation Modeling and Analytic Hierarchy Process Approach to Prioritize Investment in the Construction Industry to Achieve Sustainable Development in Saudi Arabia. Polish Journal of Environmental Studies, 29(3), 56-67.

[17] Matteo, B. 2015. Introduction to the Analytic Hierarchy Process. London: Springer.

[18] Omrani, S., Jafari, M., and Mansori, A., 2019. Analysis of Financial Performance of Cement Industry Manufacturing Companies in Tehran Stock Exchange Using the FAHP Technique and the TOPSIS Method. Independent Journal of Management & Production, 10(2), pp. 512-536.

[19] Rezaei, A., Jahanshad, A., and Nataj Malekshah, G. H. T. 2019. Identification and Ranking of Barriers to the Expected Credit Loss (ECL) Model Implementation in Iranian Banks Using the FAHP and WASPAS Technique. Journal of Accounting and Auditing Review, 26(2), pp. 239-254.

[20] Rostami, M., Goudarzi, A., and Zaj, M., 2015. Defining balanced scorecard aspects in banking industry using FAHP approach. International Journal of Economics and Business Administration, 1(1), pp. 25-38.

[21] Saaty, T. L. 1980. The analytic hierarchy process. New York: McGraw-Hill.

[22] Selim, Ö. Y., Erman, E. T., and Ugur, B. A. C. 2018. A Fuzzy AHP Ranking Model for Intellectual Capital Management Level in Ankara Industries. ISCAMI2012, Malenovice, Czech Republic.

[23] Shariati, M., 2019. Ranking Firms based on Manager's Biased Behavior and Investigating its Relation to Information Asymmetry using FAHP-Shannon Entropy-TOPSIS. Asian Journal of Research in Business Economics and Management, 9(12), pp. 1-28.

[24] Sidek, Z., Ramzi, N. M. M., Hashim, H., Mohamad, S. N. F., and Kamil, M. A. A. M., 2019. Comparison of AHP and fuzzy AHP for multi-criteria decision making. Journal of Mathematics & Computing Science, 5(1), pp. 15-26.

[25] Stević, Ž., Stjepanović, Ž., Božičković, Z., Das, D. K., and Stanujkić, D., 2018. Assessment of conditions for implementing information technology in a warehouse system: A novel fuzzy piprecia method. Symmetry, 10(11), p. 586.

[26] Wang, C. H., Lee, W. H., Yeh, C. H., and Pang, C. T., 2019, November. Evaluating of factor affecting the cloud-based collaboration system based on FAHP. In Proceedings of the 3rd International Conference on Telecommunications and Communication Engineering, pp. 95-99.

[27] Wang, Y. M., Luo, Y., and Hua, Z. 2008. On the extent analysis method for Fuzzy AHP and its applications. European Journal of Operational Research, 186, 735-747.

[28] Wu, C. R., Chang, C. W., and Lin, H. L., 2008. FAHP sensitivity analysis for measurement nonprofit organizational performance. Quality & Quantity, 42(3), pp. 283-302.

[29] Yalçin, N., and Ünlü, U., 2018. A multi-criteria performance analysis of Initial Public Offering (IPO) firms using CRITIC and VIKOR methods. Technological and Economic development of Economy, 24(2), pp. 534-560.

[30] Yazici, I., Beyca, O. F., Gurcan, O. F., Zaim, H., Delen, D., and Zaim, S., 2020. A comparative analysis of machine learning techniques and fuzzy analytic hierarchy process to determine the tacit knowledge criteria. Annals of Operations Research, pp. 1-24.

[31] Zaied, A. N. H., Grida, M. O., and Hussein, G. S., 2018. Evaluation of critical success factors for business intelligence systems using fuzzy AHP. Journal of Theoretical and Applied Information Technology, 96(19), pp. 6406-6422.

[32] Zhao, L., and Tu, W. J., 2011. Risk assessment of China's PPP projects based on the integration of FAHP and FCE. Sci. Technol. Manag. Res, 2, pp. 80-83.

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