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# Comprehensive Performance Evaluation Using FAHP-FVIKOR Approach Based on Balanced Scorecard (BSC): A Case of Yazd's Ceramic and Tile Industry

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## Abstract

The comprehensive assessment model considers the financial and non-financial aspects as balanced scorecard. Also, for more comprehensive results of the investigation, four aspects of the balanced scorecard were used and then by using fuzzy Delphi technique and experts' opinions, the standard aspects of each were achieved in two stages. To determine the importance of each aspect of BSC, the process of fuzzy hierarchical analysis was employed. The results showed that among the four aspects of balanced scorecard, the financial index has the greatest significance, the customer index is in second place, and the third place belongs to growth and learning, and internal processes are in fourth place. In the next stage, the companies studied in the previous level were ranked by fuzzy VIKOR technique according to the indices. The results reveal that company A has the best performance among the ten companies from the perspective of four indices.

## Keywords:

Performance evaluation, Balanced scorecard (BSC), Fuzzy Delphi technique, Fuzzy analytic hierarchy process (FAHP), Fuzzy VIKOR.

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## Introduction

Performance is referred to as one kind of measurement of the goals of an enterprise, while evaluation is referred to as the goal that an enterprise can effectively obtain during a specific period. Researchers stated that performance evaluation is an important activity of management control, used to investigate if resources are allocated efficiently; it is applied for the purpose of operational control to achieve a goal adjustment in the short-term and for strategy management and planning in the long run. As indicated by Rue and Byars (2005), performance evaluation tells us how employees define their own work, and it establishes a decision-making and communication process for improvement. Kaplan and Norton (1992) described performance evaluation as a way to review the achievements of organizations of both their financial and non-financial objectives. Performance measurement can be defined as a system by which accompany monitors its daily operations and evaluates whether the company is attaining its objectives. To fully utilize the function of performance measurement, it is suggested to set up a series of indices which properly reflect the performance of a company. These indicators can be quantifiable, or unquantifiable. For instance, an index such as lead time is viewed as a quantifiable (or financial) measure, whereas the degree of customer satisfaction is unquantifiable (or non-financial) measure (Wu et al., 2009). Therefore, a good performance management tool would help managers or operators consider across the broad organizational prospective strategies and develop them into measurable indicators (Chang et al., 2011). It can be said that to evaluate comprehensive performance, managers can use the balanced scorecard. The balanced scorecard (BSC) proposed by Kaplan and Norton (1992) is something that meets the total management purpose and is suitable for performing an overall performance evaluation. The BSC combines financial and non-financial perspectives, which can be classified into four performance constructs: the finance, the customer, the internal process, and learning and growth. These four performance constructs can help an enterprise to see more clearly which construct can contribute the most to the goal of the enterprise, so that it can have an overall deeper insight into the performance of its business operations

(Wu & Chen, 2012). It is essential for the application of performance measurement that a company's tangible and intangible targets are defined in a way that is more appropriate to the requirements and objects of these targets and that its strategy is more extensively operationalized, quantified, and linked in a mutually supplementing way(Sun,2010). In the literature, there are a few fuzzy logic methods aimed at evaluating the relative performance by multi-dimensions. In the evaluation procedure, balanced scorecard approach, which is a comprehensive system evaluation and performance measurement was used as a theoretical basis and then the fuzzy Delphi technique was utilized to gain the consensus of experts in order to obtain standard indices for evaluating the performance of ceramic and tile companies. Then, FAHP is used to determine the weights of the criteria and finally fuzzy VIKOR is used to rank the companies in the ceramic and tile industry. Also, this study used balanced scorecard and fuzzy MCDM to evaluate performance of companies, thus it is comprehensive. In addition, determining the company's position besides being beneficial for companies to be able to identify their strength and weakness, has special importance for their internal and foreign customers, because they can plan better to invest in the future. Also, since a great proportion of non-oil export in Iran is related to tile and ceramic industry, and because of its main role in job creation, this industry is one of the important industries in Iran, and as half of the tile and ceramic is produced in Yazd, it can be said this research has significance value.

## Literature Review

### Balanced Scorecard (BSC)

Kaplan and Norton (1992) have proposed the concept of BSC. It is a performance evaluation system made especially for twelve companies in America and the concept of BSC was pointed out in the American Harvard management commentary in 1992. The cardinal purpose of BSC is to replace traditional performance system focusing on assessing one single financial index to obtain more adequate and comelier performance evaluation model. This concept gets out of the traditional

performance evaluation model merely based on financial accounting. For BSC, financial perspective is still the core of performance evaluation but the other four perspectives such as customer, industrial process, learning and growth of employees should be included as well to enable the performance evaluation method to be more balanced and also to have the effectiveness of encouraging organizations. This is for setting up a complete performance evaluation system and forming a whole set of performance indices to assess strategies so that the strategies and prospect of organizations could be achieved. The contents of four perspectives of BSC are described as follows:

1. Financial Perspective

This perspective reflects the past operating performance of a company including the achievement of setting up a financial target and the implementation of executing strategies. In spite of this, it could be seen whether organizations gain growth, return and risk control from operating strategies. The indices of evaluation usually contain operating income, operating costs, return on investment, net profit rate, cash flows, and so forth.

2. Customer Perspective

For emphasizing the market segmentation of customers, organizations should utilize their intrinsic advantages and resources to distinguish the differences from their competitors. The core measurements include market share ratio, acquirement of customers, continuation of customers, customer satisfaction, and profitability of customers.

3. Internal Process Perspective

This perspective addresses the internal operating process of organizations that have to follow a plan of operating strategies made by them and also do their best to achieve the expectations of customers and shareholders. The whole process is starting from understanding customer's requirements, innovation process, operating process, after-sales service and finally achieves customer's requirements to establish evaluation indices through all these.

4. Learning and Growth Perspective

If organizations want to have sustainable operation and development, they have to rely on continual innovation and growth. Kaplan and Norton (1996) considered "companies should persist on some principles such as enhancing the abilities of employees, the performance of information systems, encouragement, the consistence of authority, and so on". This perspective includes three main core evaluation criteria and they are satisfaction of employees, continuation of employees, and productivities of employees. Organizations should establish performance evaluation indices through these three criteria (Wu et al., 2011).

So that, the use of a balanced scorecard (BSC) for performance evaluation is meant to help evaluators make more complete decisions, as they have a variety of financial and non-financial measures to assess (Kang & Fredin, 2012).

**Fuzzy Delphi**

The Delphi method is a method to help management and also a tool to predict the future. In particular, it has been widely applied in the current complex social life in collecting the opinions and judgment of individual members to form high quality decisions. The Delphi method is a way of interaction between experts to obtain the latest and most professional knowledge. It is not only applied to the prediction of future events. The so-called “expert” should satisfy four conditions including “theory and practice”, “capabilities to reflect different views”, “capabilities of communications and research” and “lasting participating enthusiasm” (Hsueh & Yan,2011). The Delphi method accumulates and analyzes the results of anonymous experts that communicate in written, discussion and feedback formats on a particular topic. Anonymous experts share knowledge skills, expertise and opinions until a mutual consensus are achieved. The Delphi method consists of five procedures: (a) select the anonymous experts; (b) conduct the first round of a survey; (c) conduct the second round of a questionnaire survey; (d) conduct the third round of a questionnaire survey; and (e) integrate experts' opinions to reach a consensus. Steps (c) and (d) are normally repeated until a consensus is reached on a particular topic (Tsai et al., 2010). In the process of applying the Delphi method, all participants should be anonymous in order to prevent them from being affected by other

members while assuring they are not affected by various outside pressures in the process of making proposals for solutions. The Delphi method is to get consensus after an adequate questionnaire survey and discussion of experts from academics, industry and government, conducted anonymously and free from outside interference. The objective and professional Delphi method is one of the optimal basic methodologies to improve research reliability (Yang & Hsieh, 2009).

**Fuzzy Hierarchical Analysis (FAHP)**

The Analytic Hierarchy Process (AHP) is an approach that is suitable for dealing with complex systems related to making a choice from several alternatives, and which provides a comparison of the considered options. Firstly proposed by Saaty, AHP is based on the subdivision of the problem in a hierarchical form (Mikaeila et al., 2011). Although the classical AHP includes the opinions of experts and makes a multiple criteria evaluation, it is not capable of reflecting human's vague thoughts. The classical AHP takes into consideration the definite judgments of decision makers .Experts may prefer intermediate judgments rather than certain judgments. Thus the fuzzy set theory makes the comparison process more flexible and capable to explain experts' preferences (Seçme et al., 2009).

**Fuzzy VIKOR**

The VIKOR method has been developed as an MCDM method to solve a discrete multi-criteria problem with non-commensurable and conflicting criteria. It focuses on ranking and selecting froma set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. The compromise solution is a feasible solution which is the closest to the ideal VIKOR and is based on old ideas of compromise programming. An extension of VIKOR to determine fuzzy compromise solution for multi-criteria is presented in Opricovic (2007). The fuzzy VIKOR method is developed as a fuzzy MCDM method to solve a discrete fuzzy multi-criteria problem with non-commensurable and conflicting criteria. The background for this method, including aggregation, normalization, DM's preference assessment, and operations on fuzzy

numbers is discussed as a study of rationality that in someway justifies the fuzzy VIKOR method and shows the position of its background in the literature on MCDM (Opricovic, 2011).

Several studies about performance evaluation were conducted in many countries that some of them along with variables related to this concept are cited in Table1.

**Table 1. Literature review about performance evaluation model**

| Researchers | Year | Variable related | method | Research society |
|---|---|---|---|---|
| Feng and Wang | 2000 | financial ratios | grey relation analysis and TOPSIS | Taiwan's five major airlines |
| Yurdakul and Iç | 2003 | financial ratios | TOPSIS method | Turkish automotive industry |
| Tung and Lee | 2010 | 27 financial ratios | Grey factor analysis | biotechnology corporations in Taiwan |
| Seçme, Bayrakdaroglu, and Kahraman | 2009 | financial and non-financial | FAHP and TOPSIS methods | commercial banks in the Turkish banking |
| Sun | 2010 | Manufacturing capability Supply chain capability innovation capability financial capability human resource capability service quality capability | Fuzzy AHP and fuzzy TOPSIS method | Notebook computer ODM companies |
| Wu , Lin, and Chang | 2011 | Indices based on Balanced scorecard(BSC) | DEMATEL and ANP and VIKOR | Three universities at Taoyuan County in Taiwan |
| Yalcin, Bayrakdaroglu, and Kahraman | 2012 | AFP and VFP main-criteria and their sub-criteria used | FAHP, TOPSIS and VIKOR | Turkish manufacturing industries |
| Zhang and Tan | 2012 | scientific, reasonable performance evaluation index system from financial, customers, business and innovation | AHP | Logistics Enterprise |
| Wu, Chen, Chen, and Zhuo | 2012 | The official evaluation indices of the university: dministration Professional | AHP VIKOR | Private universities in Taiwan |

## Methodology

### Fuzzy Delphi

Generally, expert opinions are presented as minimum value, possible value, and maximum value (triangular fuzzy numbers). Later, the average expert opinions (given number) and different opinion level of individual expert is calculated from the average and this information is later sent to experts for their new ideas. In the next step, based on the data received from the previous step, each expert will offer new comments or modify the past comments. This process continues until the average fuzzy number is stable enough (Tsai et al., 2010).

### Definition of Linguistic Variables

As experts in Delphi process have to choose suitable sub-indicators, that are four aspects of the balanced scorecard among the 46 proposed indicators using deterministic value, commenting on the variables was problematic. Therefore, it seems using qualitative variables in terms of good, average, and poor options to some extent solves this problem. The individual comment for qualitative variables is not the same such as high or low. Experts, because of having different characteristics, have different mentality and if they answer the options based on different mentality the analysis of variables is worthless, but with definition of qualitative variables, the experts will answer the questions with same mentality (Kaufmann & Gupta, 1988).Therefore, qualitative variables are defined as triangular fuzzy numbers. The possible values which are defined by triangular fuzzy numbers for good options are (5, 7, 9), average option is (3, 5, 7) and poor option is (1, 3, 5).

### Fuzzy Computation

At each stage of fuzzy test, the mean for triangular fuzzy number $\tilde{A}_1, \tilde{A}_2, \ldots, \tilde{A}_n$ is defined as in Equation 1

$$\tilde{A}_m = \frac{\tilde{A}_1 + \tilde{A}_2 \ldots + \tilde{A}_n}{n} \quad (1)$$

In Equation 1, $A_i\ (a_i, b_i, c_i)$ is the $i^{th}$ triangular fuzzy number and $\tilde{A}_m$ is the fuzzy mean related to each question. After calculating the

mean for the questionnaire at each stage for each expert the population mean difference is calculated using Equation 2.

$$(A_1^m\text{-}A_1^i, B_1^m - B_1^i, C_1^m - C_1^i) \quad (2)$$

In Equation 2, $A_1^m$ ،$B_1^m$ ،$C_1^m$ is the lower, middle, upper limits respectively, the mean triangular fuzzy number related to each questions and $A_1^i$ ،$B_1^i$ ،$C_1^i$ is the lower, middle, upper limits related to $i^{th}$ individual. In the next stage, the mean population of the previous stage and difference of each expert from the mean population, for the expert and each individual with regard to the related difference will answer the question. At this stage, the individuals can adjust their comments or repeat the previous stage comments. Now, the fuzzy mean is again calculated for the new stage and the mean difference of two stages is calculated for each question and if the mean difference of two stages calculated is less than (0.15) using Equation 3, then sufficient consensus has been acquired for the question. This process continues until it achieves sufficient consensus.

$$S(\widetilde{N}_i, \widetilde{N}_j) = \frac{(a_1 + 2a_2 + a_3) - (b_1 + 2b_2 + b_3)}{4(B_2 - B_1)} \quad (3)$$

In Equation 3, $B_2$ is the largest limit and $B_1$is the smallest limit between the means of two stages. Also, $a_1, a_2, a_3$ is the lower, middle, upper limits related to the mean of each question in the previous stage and $b_1, b_2, b_3$ is the lower, middle, upper limits related to the mean of each question in the new stage.

Finally, using fuzzy Delphi technique during the two stage to gain the consensus of expert comments and among the proposed 46 indicators, the selected financial criteria have five sub-indicators, customer criteria include 10 sub-indicators, learning and growth criteria include 6 sub-indicators and internal process criteria include 7 sub-indicators which are shown in Table 2.

**Table 2. Selected balanced scorecard**

| Main-Criteria | Sub- Criteria |
|---|---|
| Financial criteria | Debt to asset ratio<br>Net profit margin<br>ROA<br>Income growth ratio<br>Administrative cost-income ratio |
| Customer criteria | Customer confidence level<br>Attract new customer<br>Preserving current customer<br>Personnel attitude with customers<br>Number of customers<br>Growth rate of customer complains<br>Innovation in products and services<br>Customer loyalty<br>The importance of customer comments and viewpoints<br>Customer satisfaction from the employee treatment |
| Learning and growth criteria | Improved knowledge management professional<br>Conducting educational courses in the company<br>Order in managing the manufacturing process<br>Increase staff skills<br>Easy access to update information to the staff<br>Managers qualifications |
| Internal processes criteria | Employees job satisfaction<br>Management performance<br>Number of internal regulation<br>Number of proposal<br>Personnel experience level<br>Programming system innovation<br>Flexibility of systems and processes |

**Fuzzy Hierarchical Analysis (FAHP)**

AHP is a decision-making method proposed by Saaty (1980). The applications of AHP have produced extensive results in many problems involving planning, resource allocation, priority setting, and selection among alternatives (Vaidya & Kumar, 2006).

Weighting model indices with Fuzzy analytical hierarchy process.

In this step, for calculating weight indices that are under survey as barriers to implementation of VAT from the FAHP are used. For this problem, there are six basic steps:

1. Make hierarchical structure of decision-making factors. It is asked from every decision-maker to state relative importance of each pair of factors of two by two decisions at a level with one to nine scales. Collect points of two by two comparison paired matrices for each individual from decision-maker *k*.
2. Stability analysis: Priority factors can be calculated by comparing the characteristic value vectors. $A.w = \lambda_{\max}.w$

Where, *W* is a special vector or weighting regard to *A* matrix. Then matrix compatibility index is checked for ensuring judgments. Compatibility index ($CI^1$) and the adaptation rate ($CR^2$ ) are defined as fallowing:

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

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

Where, *n*, is the number of items in the comparison matrix and *RI* is a random index. Saaty has suggested that above ceiling of *CR* values are, for matrix3*3 (0.05), and for matrix4*4 (0.08), and for bigger than matrixes (0.1). If compatibility test is rejected, decision maker should amend the initial values in comparison matrix.

3. Create a Fuzzy positive matrix. Paired comparison scores are converted into linguistic variables that are shown by fuzzy triangular number in Table 4.

**Table 3. The random index (RI)**

| N | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *RI* | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.19 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

Source: Saaty (1994)

1. Consistency index
2. Consistency rate

**Table 4. Triangular numbers**

| Linguistic variables | Positive triangular fuzzy numbers | Positive and negative fuzzy numbers |
|---|---|---|
| Extremely strong | (9and 9 and 9) | (1/9 and 1/9 and 1/9) |
| Average | (7 and 8 and 9) | (1/9 and 1/8 and 1/7) |
| Strong | (6 and 7 and 8) | (1/8 and 1/7 and 1/6) |
| Average | (5 and 6 and 7) | (1/7 and 1/6 and 1/5) |
| Strong | (4 and 5 and 6) | (1/6 and 1/5 and 1/4) |
| Average | (3 and 4 and 5) | (1/5 and 1/4 and 1/3) |
| Strong | (2, 3 and 4) | (1/4 and 1/3 and 1/2) |
| Average | (1, 2 and 3) | (1/3and 1/2 and 1) |
| With equal strength | (1, 1, 1) | (1, 1, 1) |

Source: Saaty (1994)

Two-way positive matrix phase can be defined as follows:

$$\tilde{R}^K = \left[\tilde{r}_{ij}\right]^k$$

$\tilde{R}^K$ : A two-way matrix belonging to the decision maker *k* is positive

$\tilde{r}_{ij}$ :*I* and *j* is the relative importance of factors.

$$\forall i = j \ , \quad \tilde{r}_{ij} = \frac{1}{\tilde{r}_{ij}} \quad , \qquad \forall_{i,j} = 1,2,....,n$$

4. The Saas Rshv Lambda - Max (lambda-max). Calculate the weights of fuzzy decision factors.

Of cutting use $\alpha$ .To obtain $\tilde{R}_b^k = (\tilde{r}_{ij})_b^k$ positive matrix of decision maker. Select $\alpha$ = l, *k* and obtain $\tilde{R}_c^K = (\tilde{r}_{ij})_c^k$ ,and $\tilde{R}_a^K = (\tilde{r}_{ij})_a^k$ , high and low level of positive matrices related to the decision maker. Select based on the weight matrix to calculate AHP.

$$W_c^k = \left(w_i\right)_c^k \quad , \ I = 1,2,3,....,n$$

$$W_b^k = \left(w_i\right)_b^k \qquad , \qquad W_a^k = \left(w_i\right)_a^k$$

For minimizing fuzziness (uncertainty) in weight, two constant

$M_a^k$ , $M_c^k$ are chosen as follows:

$$M_a^k = \min\left\{\frac{W_{ib}^k}{W_{ia}^k}\middle| 1 \le i \le n\right.$$

$$M_c^k = \min\left\{\frac{W_{ib}^k}{W_{ic}^k}\middle| 1 \le i \le n\right.$$

Low and high weights are defined as follows:

$$w_{ia}^{*k} = M_a^k . w_{ia}^k$$

$$w_{ic}^{*k} = M_a^k . w_{ic}^k$$

The lower and upper bound matrices are as follows:

$$w_a^{*k} = (W_i^*)_a^k \qquad i = 1,2,....,n$$

$$w_c^{*k} = (W_i^*)_c^k \qquad i = 1,2,....,n$$

Combination $w_b^k$, $w_a^{*k}$ And $w_c^{*k}$ Fuzzy weight matrix can be obtained for decision maker *k* that Is $w_i^k = (w_{ia}^{*k}, w_{ib}^{*k}, w_{ic}^{*k})$ , $i = 1,2,....,n$.

5. Send comments to borrowers together. Fuzzy weights for combining the geometric mean is used:

$$\overline{\widetilde{W}_i} = \left(\prod_{k=1}^{k}\right)^{\frac{1}{k}} \quad , \quad \forall k = 1,2,...,k$$

$\overline{\widetilde{W}_i}$: Weight of the combined fuzzy decision is based on the decision maker *k*.

$\overline{\widetilde{W}_i}^k$: Weight factor of the fuzzy decision is based on the decision maker *k*.

6. Apply the final classification. Wang and colleagues based on an equation that was proposed in 2006 suggested a close coefficient that is defined as follows: Divide the decision factors.

$$CC_1 = \frac{d-(\tilde{\tilde{W}}_i,0)}{d^*(\tilde{\tilde{W}}_i,1)+d^-(\tilde{\tilde{W}}_i,0)} \quad 0 \le CC_i \le 1 \qquad i=1,2,....,n$$

*CCi* is the weight factor for the *i* And $d^-(\tilde{\tilde{W}}_i,0)$, and $d^*(\tilde{\tilde{W}}_i,0)$ are the size between the two fuzzy numbers.

$$d^-(\tilde{\tilde{W}}_i,0) = \sqrt{\frac{1}{3}[\ (\overline{W}_{ia}-0)^2+(\overline{W}_{ib}-0)^2+(\overline{W}_{ic}-0)^2\ ]}$$

$$d^*(\tilde{\tilde{W}}_i,0) = \sqrt{\frac{1}{3}[\ (\overline{W}_{ic}-0)^2+(\overline{W}_{ib}-0)^2+(\overline{W}_{ic}-0)^2\ ]}$$

The relation of fuzzy analytic hierarchy process (AHP) is used to calculate the weights related to indicator and sub-indicator of balanced scorecard. A good decision making model should be tolerant of ambiguity and uncertainty, because fuzzy and ambiguity are the general characteristics of many decision making problems. Because the decision makers instead of presenting methods and accurate numbers offer unreliable responses, therefore, conversion of qualitative preferences and direct estimates are not reasonable. The analytical hierarchical process (AHP) needs selected values comparing binaries and those which are not suitable and adequate and lack confidence in all or a few of the values cannot be considered as binary. Since the fuzzy linguistic approach can bring into account the optimistic or pessimistic tendencies of decision makers for desirable measurement instead of using classical method and definitive data, it is suggested to use fuzzy linguistic data. Therefore, when there is environmental comparison between binaries, the fuzzy AHP is suitable and efficient than classical AHP (Yu, 2002). By using this method the weights for the four indicators and sub-indicators of the balanced scorecard are calculated to estimate the degree of significance by statistical population perspective and to determine which indicator and sub-indicator are important through company's viewpoint while evaluating performance.

**Table 5. The weights of main-criteria and sub-criteria of the balanced scorecard**

| Main-criteria | | Sub-criteria | weight |
|---|---|---|---|
| Financial | 0.5215 | Debt to asset ratio | 0.422002 |
| | | Net profit margin | 0.278014 |
| | | ROA | 0.228911 |
| | | Income growth ratio | 0.192816 |
| | | Administrative cost-income ratio | 0.128258 |
| Customer | 0.2678 | Customer confidence level | 0.238994 |
| | | Attract new customer | 0.160726 |
| | | Preserving current customer | 0.132735 |
| | | Personnel attitude with customers | 0.105524 |
| | | Number of customers | 0.097426 |
| | | Growth rate of customer complains | 0.078174 |
| | | Innovation in products and services | 0.064725 |
| | | Customer loyalty | 0.055766 |
| | | The importance of customer comments and viewpoints | 0.036716 |
| | | Customer satisfaction from the employee treatment | 0.029214 |
| Learning and Growth | 0.1355 | Improved knowledge management professional | 0.385472 |
| | | Conducting educational courses in the company | 0.209842 |
| | | Order in managing the manufacturing process | 0.15549 |
| | | Increase staff skills | 0.12745 |
| | | Easy access to update information to the staff | 0.073755 |
| | | Managers qualifications | 0.047991 |
| Internal Process | 0.0750 | Employees job satisfaction | 0.327246 |
| | | Management performance | 0.208592 |
| | | Number of internal regulation | 0.152679 |
| | | Number of proposal | 0.124505 |
| | | Personnel experience level | 0.086836 |
| | | Programming system innovation | 0.054044 |
| | | Flexibility of systems and processes | 0.046104 |

*Source: The researcher's findings*

Table 5 shows the fuzzy analytic hierarchy process (AHP) questionnaire analysis where financial indicators, customer indicators, learning and growth indicators and internal process indicator are ranked from 1 to 4 according to companies' perspective. Also, the calculated weights for each sub-indicator of the four criteria of balanced scorecard are represented in the above table. Debt to asset ratio, net profit margin, ROA = operating profit / operating assets, income growth ratio, and administrative cost to income ratio were ranked 1 to 5 respectively in the financial criteria. Customer criteria include the customer confidence level, attract new customer, preserving current customer. In the customer criteria, customer confidence level has the most importance and customer satisfaction from the employee treatment has the least importance. Improved knowledge management professional, conducting educational courses in the company has the most importance and manager's qualification has the least importance in the learning and growth criteria. Employees job satisfaction, management performance, number of internal regulation, number of proposal, personnel experience level, programming system innovation and flexibility of systems and processes were ranked 1 to 7 respectively in the internal process criteria.

**Fuzzy VIKOR**

The fuzzy VIKOR method has been developed to determine the compromise solution of the fuzzy multi-criteria problem

$$D = \begin{array}{c|cccc} & \boldsymbol{x_1} & \boldsymbol{x_2} & \cdots & \boldsymbol{x_n} \\ \boldsymbol{A_1} & \boldsymbol{x_{11}} & \boldsymbol{x_{12}} & \cdots & \boldsymbol{x_{1n}} \\ \boldsymbol{A_2} & \boldsymbol{x_{21}} & \boldsymbol{x_{22}} & \cdots & \boldsymbol{x_{2n}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{A_m} & \boldsymbol{x_{m1}} & \boldsymbol{x_{m2}} & \cdots & \boldsymbol{x_{mn}} \end{array}$$

Matrix $A_{\mathrm{i}}$ represents option $i, x_{\mathrm{j}}$ indicate index $j$ and $x_{\mathrm{ij}}$ shows index value of $j$ for alternative $x$.

Fuzzy VIKOR method includes the following steps:

1. Normalized matrices are determined using the following equation:

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}$$

2. Determine the positive ideal solution ($A^+$) and determine the negative ideal solution ($A^-$) using the following relations:

$$A^+ = \{(max f_{ij} | j \in J) \; or \; (min f_{ij} | j \in \acute{J}) | i = 1, 2, \dots, m\}$$
$$= \{f_1^+, f_2^+, \dots, f_j^+, \dots, f_n^+\}$$

$$A^- = \{(min f_{ij} | j \in J) \; or \; (max f_{ij} | j \in \acute{J}) | i = 1, 2, \dots, m\}$$
$$= \{f_1^-, f_2^-, \dots, f_j^-, \dots, f_n^-\}$$

3. Calculate the optimal ($S_i$) and amount adverse ($R_i$)for each of these options using the following relations:

$$S_i = \sum_{j=1}^{n} w_j \left(f_j^+ - f_{ij}\right) \Big/ (f_j^+ - f_j^-)$$

$$R_i = Max_J \left[ W_j \left(f_j^+ - f_{ij}\right) \Big/ (f_j^+ - f_j^-) \right]$$

In above equations $S_i$and $R_i$ respectively are the amount of each of the favorable and unfavorable options and $w_j$, the weight of each measure.

4. Fuzzy VIKOR index was calculated using the following equation:

$$Q_i = v \left[\frac{S_i - S^+}{S^- - S^+}\right] + (1 - v) \left[\frac{R_i - R^+}{R^- - R^+}\right]$$

In above equation, $Q$is the amount of fuzzy VIKORfor options *i*.

$S^+ = \mathrm{Min}S_i$ ; $S^- = \mathrm{Max}S_i$ ; $R^+ = \mathrm{Min}R_i$ ; $R^- = \mathrm{Max}R_i$ and v

As a group utility maximum weight is usually considered to be (0.5).

5. Ranking options: The option which has the lowest weight assigned to a fuzzy VIKOR technique is the best option.

Therefore, comments of decision makers are evaluated by fuzzy VIKOR technique and the results for different values are seen in the table below.

**Table 6. Values of Si ،Ri ،Qi**

| | Qi | Si | Ri |
|---|---|---|---|
| **Company A** | 0.0196721 | 0.3901175 | 0.659891 |
| **Company B** | 0.2238338 | 1.4580328 | 0.6508207 |
| **Company C** | 0.4319978 | 1.4539662 | 0.7471925 |
| **Company D** | 0.5346364 | 0.9698996 | 0.8412967 |
| **Company E** | 0.5668729 | 1.6070597 | 0.7945847 |
| **Company F** | 0.6371106 | 2.1627267 | 0.7732695 |
| **Company G** | 0.7247438 | 1.8899414 | 0.8400369 |
| **Company H** | 0.9245292 | 2.4155545 | 0.8813571 |
| **Company I** | 0.9766357 | 2.7267264 | 0.8753103 |
| **Company J** | 0.9868852 | 2.7756271 | 0.8753103 |

By using this method, the ranks for the ten companies in different values of *Qi*, *Ri*, *Si* are calculated and presented in the table below (Kackar, 1985).

**Table 7. Ranking company in different values of Qi, Ri, Si**

| | *Qi* | *Si* | *Ri* |
|---|---|---|---|
| **Company A** | 1 | 1 | 2 |
| **Company B** | 2 | 4 | 1 |
| **Company C** | 3 | 3 | 3 |
| **Company D** | 4 | 2 | 7 |
| **Company E** | 5 | 5 | 5 |
| **Company F** | 6 | 7 | 4 |
| **Company G** | 7 | 6 | 6 |
| **Company H** | 8 | 8 | 10 |
| **Company I** | 9 | 9 | 9 |
| **Company J** | 10 | 10 | 8 |

As it can be seen after computing fuzzy data, two necessary conditions for approval of fuzzy VIKOR method are established:

First condition (Compliance features):

$$Q(A_2) - Q(A_1) \geq \frac{1}{10-1}$$

Means:

$$\mathrm{Q}(0.22383) - \mathrm{Q}(0.01967) = 0.20416 \geq 0.1111$$

Second condition (Acceptance stability of the decision-making):

Company A has the second in *Ri* and the first rank in *Si* (Huang et al., 2009).

Also, in this stability condition the decision will also be accepted. Thus tile companies ranking are as follows:

**Table 8. Ranking company based on fuzzy VIKOR**

| companies | Qi |
|---|---|
| Company A | 1 |
| Company B | 2 |
| Company C | 3 |
| Company D | 4 |
| Company E | 5 |
| Company F | 6 |
| Company G | 7 |
| Company H | 8 |
| Company I | 9 |
| Company J | 10 |

## Conclusion

To take the advantages of the compound approach and provide an approach with greater reliability, the present research has combined common method of decision making by compensating the weakness of each with the strengthens of others to provide a solution for ranking problem and offering classification of tile and ceramic companies in Yazd. This approach is applicable to all financial and non-financial

decisions, because the indicators studied are related to balanced scorecard and all financial and non-financial aspects are considered. As stated in this study, using the fuzzy Delphi technique, the indicators and sub-indicators were selected and weights corresponding to each were distinguished by fuzzy hierarchical analysis. The data analysis results showed that among four aspect of balanced scorecard, the financial indicators are the most important and when evaluating performance of the companies more attention has to be given to these indicators. After financial indicator, the indicators of customer, learning and growth, internal process are considered in performance evaluation of the companies. This result shows that when evaluating performance of the companies more importance has to be given to financial indicators in order to have best performance between competing firms. Also, according to the sub-indicator weights acquired and determining the importance of each, the company's managers during their performance evaluation must consider debt to asset ratio more significant among financial sub-indicators, customer confidence level among customer sub-indicators, improved knowledge management professional among learning and growth sub-indicators, and finally employees job satisfaction among internal process indicators in order to improve their performance and suitable position among the competing firms. The administrative cost-income ratio in the financial criteria, customer satisfaction from the employee treatment in customer criteria, manager qualification in learning and growth criteria and flexibility of system and process in internal process criteria with low weights have least importance for managers and experts of ceramic and tile industry and managers can instead of paying attention to these sub-indicators focus on sub-indicators with more weights.

Finally, to determine company's status, fuzzy VIKOR technique is used to rank these ten companies. The results showed Tile Company A with highest rank has the best performance among the companies evaluated. This analysis helps companies to know their status among leading tile and ceramic companies as well as to improve their performance and planning the weaker indicators and indicators with good scores leading to take advantage from the market opportunities and to overtake the competitors. Determining the company's position

besides being beneficial for companies to be able to identify their strength and weakness, has special importance for their customers, because the customer knowing the position of companies and recognizing the leading ceramic and tile company can plan better to invest in the future.

The study results show that corporate managers to evaluate performance of their companies comprehensively, in addition to the financial indicator must also consider the customer criteria, learning and growth criteria and internal process criteria so as to find the insight of what is happening inside and outside the organization and to improve the company performance in ceramic and tile industry. To improve company's performance in financial criteria and to have suitable assessment of the company's financial performance, it is recommended that the managers have special attention to debt to asset ratio, net profit margin, and ROA in account to the highest ranking of these three criteria in the mentioned indicators. To improve the company's competitive performance and to find a suitable position from customer's perspective, it is recommended to the owners and managers to pay attention to the criteria of customer confidence level, attract new customers and preserving current customers, so as to be able to preserve the current customer and attract new customer to the company.

In learning and growth criteria with regard to the importance to promote professional management knowledge, to conduct educational training inside the company and manage manufacturing process, the corporate owners paying attention to the mentioned issues should put extra effort to attract and preserve skilled managers and employees so that by having work forces, they can acquire a competitive position in ceramic and tile industry.

Finally, the research findings suggest that from internal process's perspective, companies should give special attention to employee job satisfaction, performance management and amount of internal regulations. To be successful in this field, the managers have to pay special attention to their employees as their internal customers and to meet their materialistic and non-materialistic demands and needs and to provide satisfaction which could cause the employee to put their entire effort to improve the company's performance and acquire competitive advantage in the industry.

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# ارائه مدل جامع برای ارزیابی عملکرد سازمان‌ها با استفاده از تکنیک‌های FAHP-FVIKOR بر مبنای کارت امتیازی متوازن؛ (مورد مطالعه: شرکت‌های کاشی و سرامیک استان یزد)

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## چکیده

هدف تحقیق حاضر ارائه یک مدل جامع برای ارزیابی عملکرد شرکت‌های کاشی و سرامیک استان یزد می‌باشد. در تحقیق حاضر کارت امتیازی متوازن برای ارزیابی عملکرد به عنوان یک مدل جامع ارزیابی که هم جنبه مالی و هم جنبه غیرمالی را در نظر می‌گیرد، مورد استفاده قرار گرفته است؛ علاوه بر این جهت جامع‌تر شدن نتایج تحقیق هر چهار جنبه کارت امتیاز متوارن و زیر شاخص‌های آن مورد استفاده قرار گرفته است. سپس با استفاده از تکنیک دلفی فازی زیر شاخص‌های استاندارد هریک از چهار شاخص کارت امتیاز متوازن طی دو مرحله و با کسب اجماع نظر خبرگان مشخص گردید. برای تعیین اهمیت هر یک از ابعاد از فرآیند تحلیل سلسله مراتبی فازی استفاده شد که نتایج نشان می‌دهد از بین چهار جنبه کارت امتیازی متوازن، شاخص مالی بیشترین اهمیت را داراست و بعد از این شاخص، شاخص مشتری در جایگاه دوم، رشد و یادگیری در جایگاه سوم و فرآیندهای داخلی در جایگاه چهارم قرار دارند؛ در مرحله بعد با استفاده از تکنیک ویکورفازی، شرکت‌های مورد بررسی در مرحله قبل با توجه به شاخص‌های مورد بررسی رتبه‌بندی شده‌اند، که نتایج حاصل از تحلیل داده‌ها نشان می‌دهد که شرکت کاشی ۱ بهترین عملکرد را در بین ده شرکت مورد بررسی از منظر چهار شاخص کارت امتیاز متوازن دارد.

## واژگان کلیدی

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