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Performance Evaluation of Tile and Ceramic Industries by Fuzzy Analytical Hierarchy Process on the Base of Balanced Score Card

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ABSTRACT

The aim of this study is finding the proper indicators for four measures of Balanced Scorecard (BSC) including financial, customer, growth and learning and internal business process by using the Delphi method. The ranking of these indicators is also conducted by FAHP process in order to reduce the disadvantages of subjectivity, impreciseness and bias vision of managers in performance evaluation. The present study is an applied descriptive study which uses questionnaires and survey method to collect the required data. The academic professors and top managers of the tile and ceramic industry of Yazd province compose our statistical population. Data analysis was performed in Matlab software. The findings reveal that customer and internal business process own the highest weights among the others. Additionally, management performance, personnel experience and innovation in products and services have the highest weights in terms of priority, respectively. The present paper might have various applications for different managers of the industries. This is because of providing useful information in the field of performance evaluation. Moreover, there could be some suggestions provided for the betterment and efficiency of the users.
KEYWORDS: Performance Evaluation, Balanced Score Card, Fuzzy Analytic Hierarchy Process.

INTRODUCTION

Tile and Ceramic industry hold a significant share of the non-oil exports from Iran. Lately, this industry played a vital role in employment and that is the reason for the great concentration on it. In recent years, the less efficiency of the manufacturing firms in the mentioned industry has led to excessive costs along with less production quality finally followed by supply surplus and sales decline. Existing comprehensive and reliable performance management models is an indicator of the development of the organizations and societies. It depends on establishing specific infrastructures and requirements especially in terms of governmental agencies. However, creating, maintaining and extending of them require extended supports. In the current situation, the great revolutions in management knowledge made the evaluation as a non-avoidable process. Lack of evaluation in different aspects of an organization is considered as a sign of their non-development. Performance evaluation for the purpose of identifying the utility level and activity quality is an essential factor for the organizations in today's competitive environment. Single dimension approaches in the performance evaluation process of quantity based ones are relatively weak; while BSC is a performance evaluation system which provides a total perspective of the performance [14]. Balanced scorecard firstly introduced by Kaplan and Norton tries to consider the benefits of all key stakeholders, managers, customers, employees and society as a whole [16]. Hence, the BSC driven approach is an effective step in promoting organization's insight about a comprehensive performance evaluation. According to the global competition, the effect of group successfulness in the organization achievements, the importance of customer relationship and product diversification, innovation and information value require a continuous development in strategies and competition. Developing competitive advantages of an organization lies in a performance measurement system to achieve the strategic goals. Performance measurement systems should control and monitor the strategy, its assumptions and performance of all the components of the organization. They should also be compatible with the best and most suitable characteristics of the organization and its strategies.

The present paper initially describes some definitions of balanced scorecard, fuzzy theory and fuzzy analytic hierarchy process according to the theoretical backgrounds. This is followed by the assumed relationship between BSC and FAHP in order to evaluate the performance of tile and ceramic industry. The findings of the study are provided in the last section.

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Balanced Score Card

Ho et al. (2002) believe that BSC is one of the most dominant approaches in performance evaluation. The traditional methods mainly based on financial measures are not constructive in describing the success factors. They are not also able to create a causal relationship between accomplishment factors and its consequences. That's why they are unable in supporting management plans especially strategic plans of the organization [4]. BSC was first introduced by Kaplan and Norton in 1992 and in a verified magazine titled Business Review Harvard. They found this approach to be helpful for management systems to define the visions and strategies and also interpreting their specific performance [3]. Balanced scorecard provides a feedback about the internal business process, performance and market conditions in order to investigate the future strategies and plans [9]. Maiga and Jacobs (2003) and Maiga and Jacobs, Tang(2001) asserted that balanced score card is not only a performance evaluation measure, but also a strategy measurement system: balanced scorecard resulted from managerial reports is a strategic tool created by executive teams in strategic sets which brings about functional balance and relationship between internal and external shareholders [17]. Achievements based on the non-financial key measures prior to the financial ones are regarded as one of the most essential principles of balanced scorecard. Taking non-financial measures into account leads the organization to a better performance and future prediction [7]. Balanced scorecard model includes four new management measures which finally relate long-term strategic goals to short-term activities and provides a pattern from business strategies to define evaluations of long-term aims [6].These measures include financial, customer, growth and learning, and internal business process [5,10,11,13]. Today, it's been proved that these perspectives might go further according to the strategic schemes [8, 12].

Fuzzy Theory and Fuzzy Analytic Hierarchy Process

Lotfi-AskariZadeh (1965) introduced fuzzy theory to solve those problems without a predefined clear measure [19]. Ignoring the vagueness of human decision making might lead to making errors and misstatements [17]. Fuzzy theory is growing in terms of different perspectives and is divided into two separate methods including fuzzy theory appliance for mathematical problems and linguistic variables [18]. The principle logic behind the linguistic approach explains that fuzzy sets are vague and the results are mostly approximated. Triangular fuzzy numbers are among the most well known fuzzy numbers [18]. A triangular fuzzy number shown by Ã=(l,m,u) has a membership function. In the present paper, we indicate the membership function of the fuzzy numbers as follows:

$$u_f(x) = \begin{cases} 0, & x < l \\ x - l/m - l, & l \le x \le m \\ u - x/u - m, & m \le x \le u \\ o, & x > u \end{cases} (1)$$

There are two indicators used in triangular fuzzy numbers: confidence level index and optimism index. Confidence level index (α) demonstrates the level of confidence that a decision maker owns in prioritizing and judging. Triangular fuzzy number according to the definition of (α) is as follows:

$$\forall \alpha \epsilon [0.1] M\alpha = [(M - l)\alpha + 1, -(u - m)\alpha + u] (2)$$

Additionally, μ as an optimism index is used to estimate the achievement degree determined for the decision maker. The higher the μ index, the higher optimistic level is. Optimism index is shown in the following formula which is a linear convex combination [18].

$$\tilde{a}_{ij}^{\alpha} = u a_{iju}^{\alpha} + (1 + u) a_{ijl}^{\alpha} \forall u \in [0, 1] (3)$$

Hence, the following matrix is obtained from pairwise comparisons.

$$\grave{A} = \begin{bmatrix} 1 & \tilde{a}_{12}^{\alpha} & \dots & \dots & \tilde{a}_{1n}^{\alpha} \\ \tilde{a}_{21}^{\alpha} & 1 & \dots & \dots & \tilde{a}_{2n}^{\alpha} \\ \dots & \dots & \dots & \dots & \dots \\ \tilde{a}_{n1}^{\alpha} & \tilde{a}_{n2}^{\alpha} & \dots & \dots & 1 \end{bmatrix} (4)$$

Fuzzy analytic hierarchy process was developed by Saati for the first time to allocate the scarce resources and planning requirements of the army [15]. Analytic Hierarchy Process (AHP) is becoming a very

popular Multi Criterion Decision Making (MCDM) process and it has been applied to solve free structural problems such as politics, economics and management [18]. AHP has been extensively used in real decision making problems. This method has been mostly criticized because of the non consideration of impreciseness and non confidence of perceived intrinsic of decision makers along with reflecting their opinions in terms of a definite number. This method also involves some advantages including simplicity and high efficiency. In a common hierarchical analysis, the opinions of the decision makers are described in the form of a definite number, but this might not be well achieved because of vagueness and uncertainty. This is because of the fact that many measures are intrinsically qualitative and subjective and it makes the decision makers unable to assign a definite and absolute figure to their evaluations. Hence, decision makers usually prefer fuzzy or interval numbers. Van Laarhoven and Pedrycz extended fuzzy analytic hierarchy process by substituting triangular fuzzy numbers in a pairwise comparison matrix and using the least square fuzzy logarithmic process. This extension was made based on a method extended by Graan and Lootsma by using the least logarithmic squares. Multiple estimations were made for any of the pairwise comparisons. The missing data problem is also perfectly managed [2]. Combining BSC and FAHP has been previously performed by Chen and Chung (2006) but using the Delphi method in order to determine the indicators based on BSC in tile and ceramic industry and their weights is known as the innovation aspect of this study.

Research Design

The present paper is a survey conducted and is classified as an applied research. In the first step, the statistical population of this study includes academic professors and experts of tile and ceramic industry including top managers with the sufficient information about the four indicators of the balanced scorecard. In the second step, it is composed of top managers of tile and ceramic industry with the sufficient knowledge and working background. We used questionnaires to collect the required data. A Delphi questionnaire was designed to determine proper indicators of the four perspectives of BSC and was distributed among 12 individuals of professors and top managers of tile and ceramic industry as the experts. Finally, a new questionnaire was designed by using the ascertained indicators and FAHP and pairwise comparison. The questionnaire included 29 measures rated by six scales linguistic terms according to the table 1. It was distributed among 11 top managers in order to pairwise comparisons.

Table1. Linguistic Variables Function for Comparing the Measures

Linguistic Terms	Fuzzy Triangular Number	Inverse Fuzzy Number
Equally Important	(1و 1و 1)	(1و 1و 1)
Moderately Important	(1/2و 1و 3/2)	(2/3و 1و 2)
More Important	(1و 3/2و 2)	(1/2و 2/3و 1)
Strongly Important	(3/2و 2و 5/2)	(2/5و 1/2و 2/3)
Extremely Important	(2و 5/2و 3)	(1/3و 2/5و 1/2)
Completely Important	(5/2و 3و 7/2)	(2/7و 1/3و 2/5)

Based on the collected responses, a pairwise comparison was formed for all the respondents and consistency rate was calculated. After converting a set of questionnaires by applying geometric mean and Excel software to BSC based indexes and measures, we performed Chang's extent analysis. All the stages of examining consistency rate and FAHP were performed by using the previous steps and Matlabsoftware.
Consistency rate is a technique for determining the consistency of the comparisons. It shows the level of confidence attributable to the priorities of group members and synthesized table. The experiences show that if the consistency rate is less than 0.10, then the consistency of the comparisons is acceptable [1]. Otherwise, the primary value of the alternative matrix should be substituted. Firstly, triangular fuzzy numbers are substituted by linguistic terms of pairwise comparisons and the consistency rate is calculated. After completing the pairwise comparisons, the weight vector is calculated as follows:

$$A.W = \lambda_{max} . W (5)$$

Where in it;
W is the weighted vector related to matrix A and λ_{max} is the largest value of matrix A. As the second step, the consistency index matrix is checked to ensure the consistency of the judgments in pairwise comparison. CI indicates the consistency index and CR shows consistency ratio defined as follows [15]:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (6)$$

$$CR = \frac{C.I}{RI} \quad (7)$$

RI shows the random index which is provided in table 2 by Saati and Harker and is calculated by *n* that shows the number of comparable indexes.

Table2. Random Consistency Index

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
RI	0	0	.58	.90	1.12	1.24	1.32	1.41	1.45	1.19	1.51	1.48	1.56	1.57	**1.59**

Chang's Extent Analysis Steps

1. M_k is a fuzzy triangular number and is calculated for each row of the pairwise comparison matrix. K is the number of matrix's row; L is the number of comparable choices and J shows the indicators.

$$M_k = \sum_{j=1}^{n} M_{KL} \times \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij}\right]^{-1} \quad (8)$$

2. The degree of bigness for each M_k is determined in relation to others. If M_1 and M_2 are two triangular fuzzy numbers, then:

$$M_1 = (L_1, m_1, U_1) \text{ و } M_2 = (L_2, m_2, U_2)$$

$$\boldsymbol{V(M_1 > M_2) = 1 M_1 > M_2}$$

$$\boldsymbol{V(M_1 > M_2) = \frac{U_1 - L_2}{(U_1 - L_2) + (m_2 - m_1)}} \quad (9)$$

$$\boldsymbol{V(M_1 > M_2) = 0 L_2 > U_1}$$

The possible degree of bigness of a convex fuzzy number (M) from another K number is separated as follows:

$$\boldsymbol{V(M_1 > M_2 \ldots\ldots > M_K) = \min\ [V(M_1 > M_2, \ldots, V(M_1 > M_K)]} \quad (10)$$

3. Weight of the indicators in the pairwise comparison is calculated as follows:

$$\boldsymbol{W'(x_i) = \min\ \{V(M_i \geq M_k)\}\, K = 1, 2, \ldots\ldots, nk \neq i} \quad (11)$$

4. Normalized weights are calculated by normalizing the weight vector ($\boldsymbol{W'}$).

$$\boldsymbol{W' = \left[W'_{C_1}, W'_{C_2}, \ldots, W'_{C_n}\right]^T} \quad (12)$$

5. Global weights of each indicator are resulted from multiplying the weight of each measure in the weight of each index as follows.

$$\boldsymbol{OW = \sum_{j=1}^{n}. W_f \otimes Wf_i} \quad (13)$$

Data Analysis

Table 1 summarizes the results of analyzing the first questionnaire which was resulted from two exchanges among the experts and finally concluded 29 indicators in terms of the four perspectives of the BSC.

Table3. Selected Indicators

Financial	*Customer*	*Growth and Learning*	*Internal Business Process*
Debt to asset ratio	Customer's confidence level	Promoting professional management knowledge	Employee's job satisfaction
Gross profit margin	New customer acquisition	Interior training period	Management performance
ROA	Customers retention	Discipline in activities and production process	The number of internal rules
Revenue growth ratio	Personnel vision related to the customers	Improving employee's skills	The number of received and checked suggestions
Administration expenses to revenue ratio	The number of customers	Ease of employee's availability to update information	Personnel experience
ROE	Growth rate of customer's complaints	Manager's education degree	Innovation in production planning system
	Innovation in productions and services		Flexibility of systems and production process
	Customers loyalty		
	Attention to the visions and requirements of the customers		
	Customers satisfaction with employee's behavior		

The results of analyzing the second questionnaire which was based on the pairwise comparison between the resulted indicators and indexes led to weights for each one of them. The weight of each indicator and index is shown in table4. The findings of the present paper show that "Customer" (0.3877 weight) perspective is the most significant indicator among the other perspectives of BSC in tile and ceramic industry; and internal business process, growth and learning and financial perspectives ranked the highest with the weights of (0.2534), (0.2372) and (0.1217), respectively. Innovations in products and services (0.1215) and Attention to the visions and requirements of the customers (0.1179) have the most significance. This is an indicator of the necessity to pay attention to innovation of products and services in accordance with customer's requirements. Additionally, management performance (0.0510), personnel experience (0.0494) and innovation in products and services (0.0471) have the highest priority, respectively.

Table4. Weight of Measures and Indicators

Financial 0.1277	*Growth and Learning 0.2372*	*Internal Business Process 0.2534*	*Customer 0.3877*
Debt to asset ratio 0.1169	Promoting professional management knowledge 0.1815	Employee's job satisfaction0.1143	Customer's confidence level 0.1070
Gross profit margin 0.2239	Interior training period 0.1578	Management performance 0.2013	New customer acquisition 0.915
ROA 0.1500	Discipline in activities and production process 0.1905	The number of internal rules 0.0858	Customers retention 0.898
Revenue growth ratio 0.1829	Improving employee's skills 0.1642	The number of received and checked suggestions 0.0790	Personnel vision related to the customers0.0955
Administration expenses to revenue ratio 0.1355	Ease of employee's availability to update information 0.1737	Personnel experience 0.1951	The number of customers 0.0792
ROE 0.1907	Manager's education degree 0.1324	Innovation in production planning system0.1700	Growth rate of customer's complaints0.0844
		Flexibility of systems and production process 0.1546	Innovation in productions and services 0.1215
			Customers loyalty0.1044
			Attention to the visions and requirements of the customers0.0955
			Customers satisfaction with employee's behavior0.1086

Conclusion

Top managers are always looking forward to find a solution to ensure that the strategies are properly executed and performance measurement is also in line with achieving the strategic goals of the organization. Management quality has a direct effect on the organizational success. It depends on the quality of the decision and organizational perceives; while these two ones are dependent on information quality which is itself in line

with the quality of evaluation. Hence, the evaluation system and its preciseness play key roles in the organizational achievements. The present paper aimed to provide a model for evaluating the tile and ceramic industry by identifying the indicators proper in the industry based on BSC. The priority of these indicators by FAHP leads to a comprehensive performance system in order to obtain the competitive advantage. The findings of this study reveal that most managers of the tile and ceramic industry are more concentrated on customer and internal business process measures than growth and learning. It indicates that emphasizing on customer and internal business process perspectives might cause a higher quality product and consistent with customers' requirements. It is a path for achieving the main goal of the organization which is more sale and profitability. It is also a key factor in maintaining the organization. A ranking of the indicators related to each measure provides a plan for achieving the predefined goals and leads to the creation of a tool for performance evaluation according to the priorities. The following suggestions are made for the future researches:

- Executing the provided pattern in this study for the other corporations and manufacturing firms.
- Applying Fuzzy TOPSIS technique for ranking the manufacturers of tile and ceramic industry.
- Applying VIKOR or SAW techniques for ranking the manufacturers of the tile and ceramic industry

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