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Evaluation and Weighting Balanced Scorecard Critical Factors by Means of Fuzzy Analytic Hierarchy Process (A Case Study)

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Abstract: Complexity of environment of business competitive arena and increased customers' expectations has made necessity of getting awareness from strong and weak points of organization and consecutive improvement of efficiency clear and apparent more than before. Hence, attaining a comprehensive performance evaluation, confident, trustable and flexible method is one of major and basic concerns of current organizations, aimed at obtaining enough and accurate information about their status through resorting it. With their outlook to future, these organizations need a compressive flexible method to take lesson from their previous mistakes. With the application of a performance measurement system based on strategy, activities and affairs can be managed effectively, efficiently and degree of success, work output and work progress can be measured in materialization of strategic objectives. For identification and recognition of their current situation and getting progress and success in contemporary competitive world of today, organizations should take advantage of methods and patterns consecutively with the aim of consecutive evaluation and improvement of their performance and current activities at organization. Organizations' performance measurement systems are considered for controlling harmoniousness of programs and activities of the organization with the mission and outlook, which determines movement and growth trend of organization for attaining competitive advantage in processes, growth and success indicators. The objective in this study is to construct an approach based on the fuzzy analytic hierarchy process (FAHP) and balanced scorecard (BSC) for evaluating a manufacturing firm in Iran. The BSC concept is applied to define the hierarchy with four perspectives (financial, customer, internal business process and learning and growth) and performance indicators are selected for each perspective, then priority indexes. In this paper BSC and FAHP has been integrated together in case study that is one of the manufacturing company in context of mould making in glass industry of Iran.

Key words: Performance evaluation · Fuzzy analytic hierarchy process (FAHP) · Balanced Scorecard (BSC)

INTRODUCTION

Performance evaluation is an assessment model to compare past plans and executions of strategies, operating activities and target establishment of organizations with executive abilities, participating rate and competing rate of employees. Furthermore, this assessment model is helping organizations to plan future strategies and set up performance targets of employees in order to achieve the final target of the entire organization, Stated that ‘‘Performance evaluation is for achieving the entire target. It bases on the quantification standard made in advance or using subjective judgment to assess the result of daily operation [1].

Performance evaluation is one of the main duties of every organization and one of performance management aspects which has been carried out more in previous through the application of financial indicators. In recent two decades, subjects like organizational learning, creation of knowledge and capacity of innovation have been taken into consideration as determining factors of competitive advantage and such concentration has been related due to the emergence of globalization, intensification of competition and unprecedented progress of technology especially in the field of communications and information technology (IT). For this reason, organizations are under severe pressure for seeking comprehensive indicators measuring size of

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performance. Specifically, more emphasis has been carried out on indicators of soft or lenient performance, because the mentioned indicators have been defined with relation to human beings and processes i.e. the subjects which their weak or strong points are not displayed at the balance sheet [2].

The issue of evaluation of performance is for a long years that has steered researcher and users towards a challengeable or controversial problem. Trade or business organizations were using merely financial indicators in previous as a performance evaluation tool as long as Kaplan and Norton in early 1980s posed many of inefficacies and inefficiencies of these information for evaluation of performance of organization after studying and evaluating management accounting systems. Such inefficacy was resulted from increased complexities of organizations, dynamicity of environment and competition of market. Judgment, recollection and remembrance of performance with a glance to previous are the main aim of evaluation traditionally. Improvement and looking to future is taken into consideration in modern approach or growth and development [3].

There are different methods for the evaluation of performance of organizations, each of which has its advantage and disadvantage. If an equal approach is put into practice between various companies and organizations, hence, possibility of relative comparing among them will be provided. Such approach should have a systematic and comprehensive outlook to all performance fields of an organization and should consider all inputs, executive processes, outsource and results obtained from activity of organization, impact and effect of each one of them on others [4].

The Balanced Scorecard: The balanced scorecard (BSC), a performance measurement framework that provides an integrated look at the business performance of a company by a set of both financial and non-financial measures, seems to be a good solution. However, conventional BSC does not consolidate these performance measures and an incorporation of BSC and analytic hierarchy process (AHP) is an improvement. Since fuzziness and vagueness are common characteristics in many decision-making problems, a fuzzy AHP (FAHP) and BSC method should be able to tolerate vagueness or ambiguity and therefore, is proposed in this research [5].

Many companies have mission statements and visions, which are translated into business strategies. However, often these strategies never fully implemented in the organization. The balanced scorecard is a tool that can help translate visions and strategies into an integrated set of performance and action. Kaplan and Norton (1992) introduced. The balanced scorecard concept as a strategic performance management system. Kaplan and Norton (1996) define balanced scorecard concept as follows:

The balanced scorecard retains traditional financial measures. But financial measures tell the story of past events, an adequate story for industrial age companies for which investments in long-term capabilities and customer relationships were not critical for success. These financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology and innovation [6].

A strategic planning study such as balanced scorecard is very useful from vision to action. Kaplan and Norton state that ‘‘the balanced scorecard translates an organization’s mission, vision and strategy into a comprehensive set of performance measures and provides the framework for strategic measurement and management”. The balanced scorecard concept measures organizational performance across four balanced perspectives: financial perspective, customer perspective, internal business perspective and learning and growth perspective. They state that balanced scorecard tells you the knowledge, skills and systems that your employees will need (learning and growth perspective) to innovate and build the right strategic capabilities and efficiencies (internal processes perspective) that deliver specific value to the market (customer perspective) which will eventually lead to higher shareholder value (financial perspective) Fig. 1 [6].

Through the years, the balanced scorecard has evolved, from the performance measurement tool originally introduced by Kaplan and Norton in 1992, aimed at revealing problem areas within organizations and pointing out areas for improvement to a tool for implementing strategies and a framework for determining the alignment of an organization’s human, information and organization capital with its strategy [7].

Balanced scorecard evaluation method helps organizations overcome two basic and fundamental problems: Effective measurement of organizational performance and successful implementation of strategy. Traditionally, financial is the business performance measurement. At any rate, our dependency on the financial performance measurements have been criticized in recent years critics say that financial measurements are

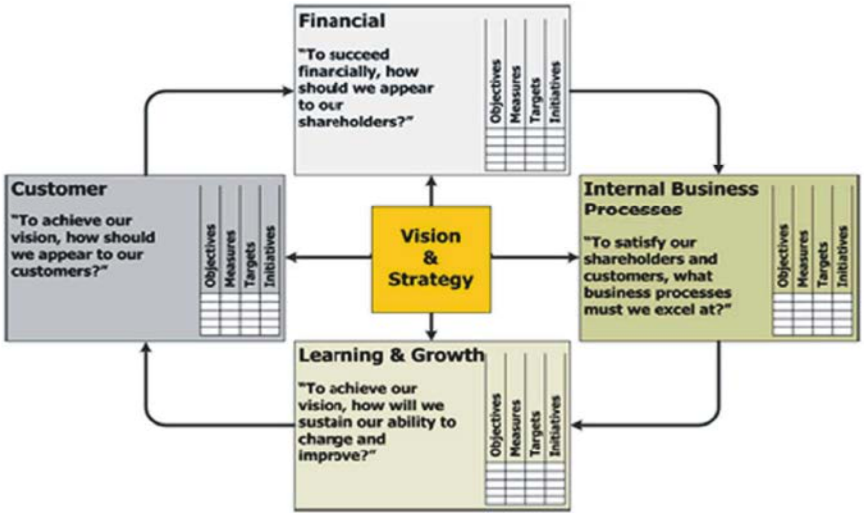

Fig. 1: The structure of balanced scorecard developed by Kaplan and Norton 1996

not in compatible with today business environment. Meanwhile, lack of foresighted and futurism power and emphasizing on duty-bound fields may cause sacrificing long-term interests and principally, these measurements are irrelevant in various levels of the organization. Successful implementation of strategy is also the other key issue which institutes has faced it [8].

The original balanced scorecard design identified the following four perspectives:

Financial Perspective: This perspective links the company to its shareholders with main attention to the question: ‘‘how do we look to our shareholders and those with a financial interest in the organization? Financial goals include achieving profitability, maintaining liquidity and solvency both short term as well as long-term, growth in sales turnover and maximizing wealth of shareholders.

Customer Perspective: This is the second external oriented perspective that takes a look at the organization’s customers, who are the crucial factor for financial success generating revenue by buying products and services. The question is: ‘‘How do our customers perceive us in term of products, services, relationships and value-added?”

Internal-Business-Process Perspective: Measures focus on the internal processes that will have the greatest impact on customer satisfaction and achieving an organization’s financial objectives. Firms should decide what processes and competencies they must excel at and specify measures for each of them.

Learning and Growth Perspective: This perspective identifies the infrastructure that the organization must build to create long-term growth and improvement. Intense global competition requires that organizations continually improve their capabilities for delivering value to customers and shareholders. Thus the question remains: ‘‘To achieve our future vision, how will we continue to improve and create future value for our stakeholders?” [9, 10].

The Balanced Scorecard is the tool, which permits presentation of the shape of the different areas of working of the organization, which gives exact information on the theme of the observed object; with this aim The Balanced Scorecard uses coherent system of financial and outside financial ratios to present the estimation of the state of the organization. By using this card, it is possible to present the organization’s strategy as a set of aims necessary for the realization of the firm’s mission. The Balanced Scorecard is simply the set of measures (ratios) selected from four areas: financial, customer, internal processes, development and learning [11].

Research Steps: The research executive steps and its levels are shown at the following flowchart:

Fuzzy Analytic Hierarchy Process: The analytic hierarchy process (AHP) pioneered in 1971 by Saaty [12] is a widespread decision-making analysis tool for modeling unstructured problems in areas such as political, economic, social and management sciences. Based on the pair-by-pair comparison values for a set of objects, AHP is applied to elicit a corresponding priority vector that

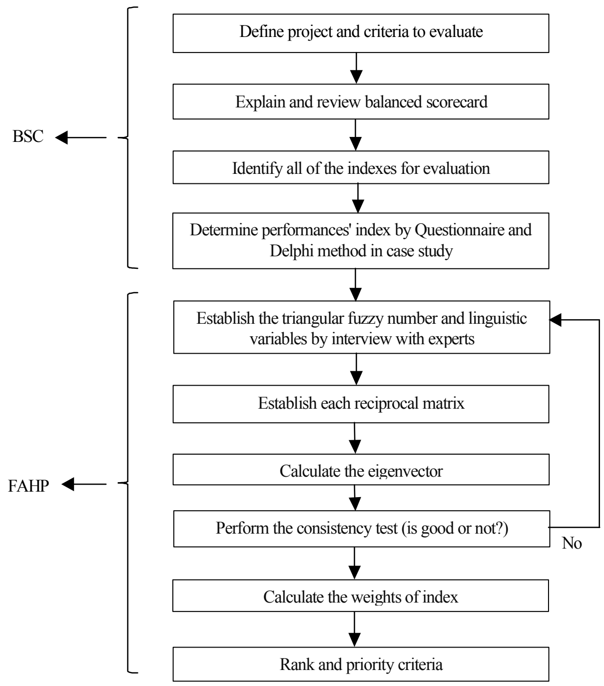

Fig. 2: Research executive levels

represents preferences. Since pairwise comparison values are the judgments obtained using a suitable semantic scale, it is unrealistic to expect that the decision-maker(s) have either complete information or a full understanding of all aspects of the problem [13, 14]. Many researchers [15, 16, 17], have also noted that fuzziness and vagueness are characteristics of many decision-making problems. It has been inferred that good decision-making models and decision-makers must tolerate vagueness or ambiguity and be able to function in such situations.

The earliest work in fuzzy AHP appeared in [18], which compared fuzzy ratios described by triangular membership functions. Buckley [19] determines fuzzy priorities of comparison ratios whose membership functions are trapezoidal. Liang and Wang [20] suggested a model in order to select personnel by means of FMCDM algorithm. Stam, Minghe and Haines [21] explore how recently developed artificial intelligence techniques can be used to determine or approximate the preference ratings in AHP. They conclude that the feed-forward neural network formulation appears to be a powerful tool for analyzing discrete alternative multi-criteria decision problems with imprecise or fuzzy ratio scale preference judgments. Chang [22] introduces a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pair-wise comparison scale of fuzzy AHP and the use of the extent analysis method for the synthetic extent values of the pair-wise comparisons.

Ching-Hsue [23] proposes a new algorithm for evaluating naval tactical missile systems by the fuzzy analytical hierarchy process based on grade value of membership function. Weck, Klocke, Schell and Rüenauver [24] presents a method to evaluate different production cycle alternatives adding the mathematics of fuzzy logic to the classical AHP. Any production cycle evaluated in this manner yields a fuzzy set. The outcome of the analysis can finally be defuzzified by forming the surface centre of gravity of any fuzzy set and the alternative production cycles investigated can be ranked in order in terms of the main objective set. Kahraman, Ulukan and Tolga [25] use a fuzzy objective and subjective method obtaining the weights from AHP and make a fuzzy weighted evaluation. Deng [26] presents a fuzzy approach for tackling qualitative multicriteria analysis problems in a simple and straightforward manner. Lee, Pham and Zhang [27] review the basic ideas behind the AHP. Based on these ideas, they introduce the concept of comparison interval and propose a methodology based on stochastic optimization to achieve global consistency and to accommodate the fuzzy nature of the comparison process. Cheng, Yang and Hwang [28] propose a new method for evaluating weapon systems by analytical hierarchy process based on linguistic variable weight. Zhu, Jing and Chang [29] make a discussion on extent analysis method and applications of fuzzy AHP. Chan, Chan and Tang [30] present a technology selection algorithm to quantify both tangible and intangible benefits in fuzzy environment. They describe an application of the theory of fuzzy sets to hierarchical structural analysis and economic evaluations. By aggregating the hierarchy, the preferential weight of each alternative technology is found, which is called fuzzy appropriate index. The fuzzy appropriate indices of different technologies are then ranked and preferential ranking orders of technologies are found. From the economic evaluation perspective, a fuzzy cash flow analysis is employed. Chan, Jiang and Tang [31] report an integrated approach for the automatic design of FMS, which uses simulation and multi-criteria decision-making techniques. The design process consists of the construction and testing of alternative designs using simulation methods. The selection of the most suitable design (based on AHP) is employed to analyze the output from the FMS simulation models. Intelligent tools (such as expert systems, fuzzy systems and neural networks) are developed for supporting the FMS design process. Active X technique is used for the actual integration of the FMS automatic design process and the intelligent decision support process. Leung and Cao [32] propose a fuzzy consistency definition with consideration of a tolerance deviation. Essentially, the fuzzy ratios of relative importance, allowing certain tolerance deviation, are formulated as constraints on the membership values of the local priorities. The fuzzy local and global weights are determined via the extension principle. The alternatives are ranked on the basis of the global weights by application of maximum-minimum set ranking method. Kuo and Chen [33] develop a decision support system for locating a new convenience store. The first component of the proposed system is the hierarchical structure development for fuzzy analytic process. A good decision-making model needs to tolerate vagueness or ambiguity because fuzziness and vagueness are common characteristics in many decision-making problems. Since decision-makers often provide uncertain answers rather than precise values, the transformation of qualitative preferences to point estimates may not be sensible. Conventional AHP that requires the selection of arbitrary values in pair-wise comparison may not be sufficient and uncertainty should be considered in some or all pair-wise comparison values [34]. Kahraman, Ruan and Doğan [35] present four different fuzzy multi-attribute group decision-making approaches including fuzzy AHP on a facility location selection problem. Bozdağ, Kahraman and Ruan [36] implements fuzzy AHP to select best computer integrated manufacturing system by taking into account both intangible and tangible factors. Ong, Sun and Nee [37] introduces an AHP method to assign weights to features to reflect their functional importance of a design for manufacturability system. Sheu [38] presents a hybrid fuzzy-based method that integrates fuzzy-AHP and fuzzy-MADM approaches for identifying global logistics strategies and applies its model to integrated circuit manufacturers in Taiwan. Kahraman, Cebeci and Ruan [39] implement the fuzzy AHP to compare catering firms via customer satisfaction. There are also much more systematic fuzzy-AHP methods proposed by various authors such as Mikhailov [40]. These methods are systematic approaches to the alternative selection and justification problem by using the concepts of fuzzy set theory and hierarchical structure analysis. Decision-makers usually find that it is more confident to give interval judgments than fixed value judgments. This is because usually he/she is unable to explicit about his/her preferences due to the fuzzy nature of the comparison process. Cheng, Chen and Yu [41] implement the fuzzy AHP method to help telecom carriers evaluate and plan their future broadband Metropolitan Area Network access strategy. Kulak and Kahraman [42] compares the fuzzy AHP method and the fuzzy multi-attribute axiomatic design approach.

There are many fuzzy AHP methods proposed by various authors. These methods are systematic approaches to the alternative selection and justification problem by using the concepts of fuzzy set theory and hierarchical structure analysis. Decision-makers usually find that it is more confident to give interval judgments than fixed value judgments. This is because usually he/she is unable to explicit about his/her preferences due to the fuzzy nature of the comparison process [43]. Chan and Kumar[14] proposed a model for providing a framework for an organization to select the global supplier by considering risk factors. They used fuzzy extended analytic hierarchy process in the selection of global supplier. Lee, Chen, & Chang [44], implied that the fuzzy-AHP should be more appropriate and effective than conventional AHP in real practice where an uncertain pair-wise comparison environment exists. Also Chang, Wu and Cheng [5] used FAHP to select unstable slicing machine to control wafer slicing quality.

Gumus [46] empolyed FAHP method as an input for TOPSIS to evaluate hazardous waste transportation firms in 2009. Güngör, Serhadlıoğlu and Kesen [47], showed that FAHP method is a systematic approach to the alternative selection and justification problem, exactly like Bozbura *et al*., The decision maker can specify preferences in the form of natural language or numerical value about the importance of each performance attribute. The system combines these preferences using FAHP with existing data. In the FAHP method, the pair-wise comparisons in the judgment matrix are fuzzy numbers and use fuzzy arithmetic and fuzzy aggregation operators, the procedure calculates a sequence of weight vectors that will be used to choose main attribute. In some situations, the decision maker can specify preferences in the form of AHP numerical pair-wise comparison introduced by Saaty in the form of nine point of scale of importance between two elements. Triangular fuzzy numbers were introduced into the conventional AHP in order to enhance the degree of judgment of decision maker. The central value of a fuzzy number is the corresponding real crisp value. Finally, Ertugrul and Karakasoglu [48] utilized both FAHP and TOPSIS methods for performance evaluation of Turkish cement firms. Zare Naghadehi, Mikaeil and Ataei [49] examined the application of FAHP in order to select the optimum underground mining method in IRAN. And finally in the year 2011 Manekar, Nandy, Sargaonkara, Rathia and Karthik [50] addressed performance assessment of eight conventional and advanced pretreatment modules implemented for wastewater management in a textile cluster in South India.

Table 1: The comparison of different fuzzy AHP methods [39]

Sources	The main characteristics of the method	Advantages (A) and disadvantages (D)
Van Laarhoven and Pedrycz (1983)	Direct extension of Saaty's AHP method with triangular fuzzy numbers and the reciprocal matrix Lootsma's logarithmic least square method is used to derive fuzzy weights and fuzzy performance scores	(A) The opinions of multiple decision-makers can be modeled in (D) There is not always a solution to the linear equations (D) The computational requirement is tremendous, even for a small problem (D) It allows only triangular fuzzy numbers to be used
Buckley (1985)	Extension of Saaty's AHP method with trapezoidal fuzzy numbers Uses the geometric mean method to derive fuzzy weights and performance scores	(A) It is easy to extend to the fuzzy case (A) It guarantees a unique solution to the reciprocal comparison matrix (D) The computational requirement is tremendous
Boender, De Grann and Lootsma (1989)	Modifies van Laarhoven and Pedrycz's method Presents a more robust approach to the normalization of the local priorities	(A) The opinions of multiple decision-makers can be modeled (D) The computational requirement is tremendous
Chang (1996)	Synthetical degree values Layer simple sequencing Composite total sequencing	(A) The computational requirement is relatively low (A) It follows the steps of crisp AHP. It does not involve additional operations (D) It allows only triangular fuzzy numbers to be used
Cheng (1996)	Builds fuzzy standards Represents performance scores by membership functions Uses entropy concepts to calculate aggregate weights	(A) The computational requirement is not tremendous (D) Entropy is used when probability distribution is known (D) The method is based on both probability and possibility measures

The ranking and interdependence of the pretreatment modules were analyzed through fuzzy analytical hierarchy process (FAHP) with MATLAB software.

In this study, the research team preferred Chang [22] extent analysis method due to the fact that steps of this approach are easier than the other fuzzy-AHP approaches.

Table 1 gives the comparison of the fuzzy AHP methods in the literature, which have important differences in their theoretical structures. The comparison includes the advantages and disadvantages of each method. In this paper, the authors prefer Chang's extent analysis method [22, 51], since the steps of this approach are relatively easier than the other fuzzy AHP approaches and similar to the conventional AHP.

Fuzzy Sets and Fuzzy Numbers

Fuzzy Sets: In order to deal with vagueness of human thought, Zadeh [52] first introduced the fuzzy set theory. A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or no membership at all, whereas fuzzy sets allow partial membership. In other words, an element may partially belong to a fuzzy set.

The classical set theory is built on the fundamental concept of set of which is either a member or not a member. A sharp, crisp and unambiguous distinction exists between a member and non-member for any well-defined set of entities in this theory and there is a very precise and clear boundary to indicate if an entity belongs to the set. But many real world applications cannot be described and handled by classical set theory [53]. Zadeh [52] proposed to use values ranging from 0 to 1 for showing the membership of the objects in a fuzzy set. Complete non-membership is represented by 0 and complete membership as 1. Values between 0 and 1 represent intermediate degrees of membership [54].

''Not very clear'', ''probably so'', ''very likely'', these terms of expression can be heard very often in daily life and their commonality is that they are more or less tainted with uncertainty. With different daily decision making problems of diverse intensity, the results can be misleading if the fuzziness of human decision making is not taken into account [55, 56]. Fuzzy sets theory providing a more widely frame than classic sets theory, has been contributing to capability of reflecting real world [57]. Fuzzy sets and fuzzy logic are powerful mathematical tools for modeling: uncertain systems in industry, nature and humanity; and facilitators for common-sense reasoning in decision making in the absence of complete and precise information. Their role is significant when applied to complex phenomena not easily described by traditional mathematical methods, especially when the goal is to find a good approximate solution [58]. Fuzzy set theory is a better means for modeling imprecision arising from mental phenomena which are neither random nor stochastic. Human beings are heavily involved in the process of decision analysis. A rational approach toward decision making should take into account human subjectivity, rather than employing only objective probability measures. This attitude, towards imprecision of human behavior led to study of a new decision analysis filed fuzzy decision making [59].

Fuzzy Numbers: A fuzzy number $\tilde{M}$ is a convex normalized fuzzy set $\tilde{M}$ of the real line R such that [60]:

It exists such that one $x_0 \in R$ with $\mu_{\tilde{M}}(x_0) = 1$
(x_0 is called mean value of $\tilde{M}$)
$\mu_{\tilde{M}}(x)$ is piecewise continuous.

It is possible to use different fuzzy numbers according to the situation. Generally in practice triangular and trapezoidal fuzzy numbers are used [61]. In applications it is often convenient to work with triangular fuzzy numbers (TFNs) because of their computational simplicity and they are useful in promoting representation and information processing in a fuzzy environment. In this study TFNs in the FAHP are adopted.

Triangular fuzzy numbers can be expressed as (l,m,u). The parameters l,m and u respectively, indicate the smallest possible value, the most promising value and the largest possible value that describe a fuzzy event. A triangular fuzzy number $\tilde{M}$ is shown in Fig. 1 [26]. There are various operations on triangular fuzzy numbers. But here, three important operations used in this study are illustrated. If we define, two positive triangular fuzzy numbers (l_1, m_1, u_1) and (l_2, m_2, u_2) then:

$$(l_1, m_1 u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
$$(l_1, m_1, u_1).(l_2, m_2, u_2) = (l_1.l_2, m_1.m_2, u_1 u_2)$$
$$(l_1, m_1, u_1)^{-1} \approx (1/u_1, 1/m_1, 1/l_1)$$

Methodology of FAHP: At the base of calculations the matrices must be compatible; in fact CI must be less than 0.1 or:

With the maximal eigenvalue λ_{max}, a consistency index (CI) [62] can then be determined by

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

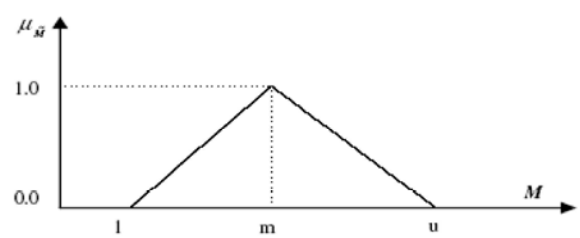

Fig. 3: Triangular fuzzy number, $\tilde{M}$

In the above said Equation, if CI = 0, the evaluation for the pair-wise comparison matrix is implied to be completely consistent. Notably, the closer of the maximal eigenvalue is to n the more consistent the evaluation is. Generally, a consistency ratio (CR) [62] can be used as a guidance to check for consistency.

$$CR = CI/RI$$

Where RI denotes the average random index with the value obtained by different orders of the pair-wise comparison matrixes. If the value of CR is below than the threshold of 0.1, then the evaluation of the importance degrees of customer requirements is considered to be reasonable.

In this study the extent FAHP is utilized, which was originally introduced by Chang [22];

Let X = {x_1, x_2, x_3,..., x_n} an object set and G = {g_1, g_2, g_3,..., g_n} be a goal set. According to the method of Chang's extent analysis, each object is taken and extent analysis for each goal is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs:

$$M_{gi}^1, M_{gi}^m, ..., M_{gi}^m \quad i - 1, 2, ..., n$$

Where M_{gi}^j all are TFNs. The steps of Chang's extent analysis [22] can be given as in the following:

At first group AHP ought to be employed [62]:

$$\tilde{M}_1 = (a_1, b_1, c_1), \tilde{M}_2 = (a_2, b_2, c_2), ..., \tilde{M}_k = (a_k, b_k, c_k)$$

$$\Rightarrow \text{Geometric Average } (M_1, M_2, ..., M_k) = ((\prod_{i=1}^{k} a_i)^{\frac{1}{k}}, (\prod_{i=1}^{k} b_i)^{\frac{1}{k}}, (\prod_{i=1}^{k} c_i)^{\frac{1}{k}}$$

Perform the fuzzy addition operation of m extent analysis values for a particular matrix, then perform the fuzzy edition operation of m extent analysis values for a particular matrix and after it compute the inverse of the vector.

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1}, \sum_{j=1}^{m} M_{gi}^j = (\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j)$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j = (\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i), \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} = (\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i})$$

Table 2: The relationship between RI and n (Saaty,1980)

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59	1.6

The degree of possibility is defined as:

$V(M_2 \geq M_1) = \sup l[\min(\mu_{M1}(x), \mu_{M2}(y))]$, $V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M2}(d)$ (1)

$$= \begin{cases} 1 & m_2 \geq m_1, \\ 0 & l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise.} \end{cases}$$

$V(M \geq M_1, M_2,..., M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and ... and $(M \geq M_k)]$, $= V(M \geq M_i)$, $i = 1,2,.., k$

Chang [22] illustrates Eq. (1) where d is the ordinate of the highest intersection point D between μ_{M1} and μ_{M2}.

Assume that:

$d'(A_i) = \text{Min } V(S_i \geq S_k)$ For $k = 1,2,...,n; k \neq i$

Then the weight factor is given by:

$W' = (d'(A_1), d'(A_2),...,d'(A_n))^T$

Via normalization, the normalized weight vectors are:

$W' = (d(A_1),d(A_2),...,d(A_n))^T$

Performance Measurement Criteria - Balanced Scorecard Method: Specifically, measurements can be defined convertible standards (usually and not always) into quantity which are used for exchanging information related to its performance and evaluation in comparison with the expected results.

At any rate, if performance measurements are set accurately and communicated precisely at organization, they will gain more power and strength in a way that not any definition is able to state it accurately. Measurements transfer subjects related to value-creation in such a way that are even beyond power of the most influential senior executive managers. Measurements are tools for progress and promotion of expected activities [8].

Financial Perspective Measurements: Measurements, determined at financial perspective, are tantamount to the guidance for the determination of measurements in other balanced scorecard system aspects.

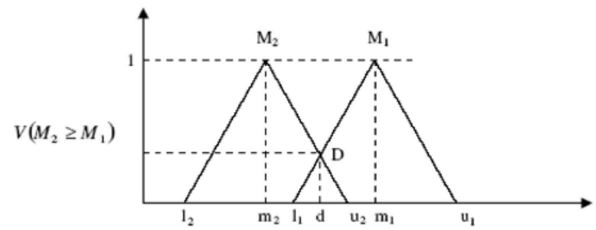

Fig. 4: The intersection between M1 and M2

Hence, it is necessary to assure that financial measurements reflect objectives, determined at strategic program, accurately and precisely. It should be noted that measurements at every organization should be set based on specific nature and specifications of the desired organization.

Common Financial Measures:

- Proportion of value added to the number of staff
- Return On Investment (ROI)
- Cash flow
- Profitability
- Total assets
- Return On Equity (ROE)
- Income obtained from new products

Customer Perspective Measures: Most organizations can determine a great number of measures of customers' perspective without facing any serious problems. Gaining customers' satisfaction, getting lion's share of market share, preserving and profitability of customers are of the measures which are taken into consideration at this perspective. Since all these measures are valuable and are of paramount significance, appropriate and favorable result will not be obtained as a result of their application as long as their progressive and stimulant factors of these measures are not specified.

In other words, it should be specified that which are conductive indicators related to these measures.

Sample of Customer's Perspective Measures:

- Satisfaction of customer
- Loyalty to customer
- Profitability of customer
- Number of customers
- Number of customers' re reference times,
- Responding time to the request of customer
- Competitive price

Internal Processes Perspective Measures: At the initial stages of determination of performance measures for the balanced evaluation system, predetermined financial objectives were translated to the appropriate measures. Then, target customers and the way of rendering services to them were set. Determination of the way of presenting services to customers was used as a guide for determination of successful conductive indicators in perspective of customer. Also, functional measures were defined as complementary indicators in perspective of customers. With the aim of materialization of predetermined objectives in perspective of customers and eventually, the desired financial objectives, performance measures should be determined at this stage for supervising on main internal processes and the activities which will make rendering the desired services to customers possible [8].

Internal Processes Measures:

- Average waiting time for receiving goods and commodities
- On-time delivery
- Reduction of wastes,
- Increased production rate
- Introduced new products
- Consecutive improvement
- Responding time to the requests of customer
- Inventory turnover

Learning and Growth Measures: As a matter of fact, learning and growth perspective measures are tantamount to advancing factors of objectives of other perspective. Motivated staff and personnel who enjoy appropriate combination of skills and also required tools and are active at appropriate organizational ambience for sustainable improvements are considered as main required factors for improvement of processes, meeting demands of customers and finally, attaining the desired financial efficiencies [8].

Table 3: Performance Indicators

Perspective	Performance Indicator
Financial	- Return On Investment (ROI)
	- Cash flow
	- Profitability
Customer	- Satisfaction of customer
	- Number of attracted customers
Internal process	- On-time delivery of goods
	- Increased production
Growth and learning	- Per capita training investment
	- Staff job satisfaction

Staff Learning and Growth Perspective Measures:

- Per capita training investment
- Average years of staff service term
- Percent of staff holding higher academic degrees,
- Per capita value added
- Quality of work environment
- Productivity of staff
- Training hours
- Communications planning
- Satisfaction of staff

Selected criteria by Statistical Sample Experts At the first stage, the predetermined indicators were set with interviewing and with the help of Delphi method with questionnaire and holding various sessions with domestic and foreign experts and then through consensus screened method and in view of balanced scorecard perspectives separately according to the below Table 3:

Final Calculations: At the end of the research, the pair-wise matrix of Expert 5 and final decision making matrix have been brought as the following tables:

The below table shows weight of each indicator based on fuzzy matrix calculations and through Chang method obtained at each one of four perspectives of balanced scorecard:

Table 4: Expert 5 sample matrix

(1,1,1)	(8,9,10)	(8,9,10)	(3,4,5)	(3,4,5)	(4,5,6)	(1,2,3)	(1,2,3)	(1/3,1/2,1)
(1/10,1/9,1/8)	(1,1,1)	(1,1,2)	(1/3,1/2,1)	(1/5,1/4,1/3)	(1/4,1/3,1/2)	(1/7,1/6,1/5)	(1/4,1/3,1/2)	(1/6,1/5,1/4)
(1/10,1/9,1/8)	(1/2,1,1)	(1,1,1)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1/4,1/3,1/2)	(1/9,1/8,1/7)	(1/4,1/3,1/2)	(1/4,1/3,1/2)
(1/5,1/4,1/3)	(1,2,3)	(2,3,4)	(1,1,1)	(1/3,1/2,1)	(1,1,2)	(1/7,1/6,1/5)	(1,1,2)	(1,1,2)
(1/5,1/4,1/3)	(3,4,5)	(2,3,4)	(1,2,3)	(1,1,1)	(2,3,4)	(1/4,1/3,1/2)	(1,1,2)	(1/3,1/2,1)
(1/6,1/5,1/4)	(2,3,4)	(2,3,4)	(1/2,1,1)	(1/4,1/3,1/2)	(1,1,1)	(1/3,1/2,1)	(1/5,1/4,1/3)	(1,1,2)
(1/3,1/2,1)	(5,6,7)	(7,8,9)	(5,6,7)	(2,3,4)	(1,2,3)	(1,1,1)	(1,2,3)	(1,2,3)
(1/3,1/2,1)	(2,3,4)	(2,3,4)	(1/2,1,1)	(1/2,1,1)	(3,4,5)	(1/3,1/2,1)	(1,1,1)	(4,5,6)
(1,2,3)	(4,5,6)	(2,3,4)	(1/9,1/8,1/7)	(1,2,3)	(1/2,1,1)	(1/3,1/2,1)	(1/6,1/5,1/4)	(1,1,1)

Table 5: Final decision making matrix

	X1			X2			X3			X4			X5			X6			X7			X8			X9		
X1	1	1	1	1.138	1.379	1.839	1.187	1.569	2.105	1.107	1.423	2.113	1.318	1.595	2.3	1.44	1.885	2.36	1.107	1.661	2.312	1.758	2.3	3.211	1.377	1.725	2.527
X2	0.544	0.725	0.879	1	1	1	0.98	1.144	1.636	0.956	1.251	1.793	1.379	1.75	2.138	1.318	1.627	2.129	1.27	1.621	1.971	1.286	1.603	2.036	1.26	1.627	1.982
X3	0.475	0.637	0.843	0.611	0.874	1.02	1	1	1	0.52	0.755	1.013	0.735	1.062	1.403	0.814	1.015	1.484	0.933	1.202	1.481	1.158	1.395	1.87	1.251	1.423	2.071
X4	0.473	0.702	0.903	0.558	0.799	1.046	0.987	1.324	1.923	1	1	1	0.738	1.032	1.629	1.08	1.403	2.05	0.987	1.292	1.854	1.292	1.702	2.387	1.286	1.553	2.26
X5	0.435	0.627	0.759	0.468	0.571	0.725	0.713	0.942	1.361	0.614	0.969	1.355	1	1	1	1.015	1.489	2.068	0.985	1.204	1.817	0.987	1.182	1.793	1.054	1.413	1.898
X6	0.424	0.531	0.694	0.47	0.615	0.759	0.674	0.985	1.229	0.488	0.713	0.926	0.484	0.672	0.985	1	1	1	0.735	1.066	1.597	1.038	1.286	1.781	1.26	1.682	2.553
X7	0.432	0.602	0.903	0.507	0.617	0.788	0.675	0.832	1.072	0.539	0.774	1.013	0.55	0.83	1.015	0.626	0.938	1.361	1	1	1	1.08	1.608	2.289	1.046	1.615	2.273
X8	0.311	0.435	0.569	0.491	0.624	0.778	0.535	0.717	0.863	0.419	0.587	0.774	0.558	0.846	1.013	0.562	0.778	0.963	0.437	0.622	0.926	1	1	1	0.811	1.01	1.434
X9	0.396	0.58	0.726	0.504	0.615	0.794	0.483	0.702	0.799	0.443	0.644	0.778	0.527	0.708	0.949	0.392	0.594	0.794	0.44	0.619	0.956	0.697	0.99	1.232	1	1	1

S1	(11.4316	14.5355	19.7659)	⊗	(0.0087	0.0115	0.0147) =	S1	(0.09946	0.1673	0.2923)
S2	(9.99175	12.3493	15.564)	⊗	(0.0087	0.0115	0.0147) =	S2	(0.08694	0.1421	0.2302)
S3	(7.49646	9.36412	12.1853)	⊗	(0.0087	0.0115	0.0147) =	S3	(0.06522	0.1078	0.1802)
S4	(8.39996	10.8075	15.0536)	⊗	(0.0087	0.0115	0.0147) =	S4	(0.07309	0.1244	0.2226)
S5	(7.27005	9.39754	12.7768)	⊗	(0.0087	0.0115	0.0147) =	S5	(0.06325	0.1082	0.1889)
S6	(6.57131	8.5491	11.5238)	⊗	(0.0087	0.0115	0.0147) =	S6	(0.05718	0.0984	0.1704)
S7	(6.45713	8.81671	11.7146)	⊗	(0.0087	0.0115	0.0147) =	S7	(0.05618	0.1015	0.1732)
S8	(5.12354	6.61852	8.32054)	⊗	(0.0087	0.0115	0.0147) =	S8	(0.04458	0.0762	0.1231)
S9	(4.8816	6.45212	8.02847)	⊗	(0.0087	0.0115	0.0147) =	S9	(0.04247	0.0743	0.1187)
SUM	67.6234	86.8904	114.933								

V(S1≥S2)	1	V(S2≥S1)	0.8385665	V(S3≥S1)	0.5756365	V(S4≥S1)	0.74162	V(S5≥S1)	0.6021023
V(S1≥S3)	1	V(S2≥S3)	1	V(S3≥S2)	0.7307862	V(S4≥S2)	0.88434	V(S5≥S2)	0.7501699
V(S1≥S4)	1	V(S2≥S4)	1	V(S3≥S4)	0.8657311	V(S4≥S3)	1	V(S5≥S3)	1
V(S1≥S5)	1	V(S2≥S5)	1	V(S3≥S5)	0.9967218	V(S4≥S5)	1	V(S5≥S4)	0.8771432
V(S1≥S6)	1	V(S2≥S6)	1	V(S3≥S6)	1	V(S4≥S6)	1	V(S5≥S6)	1
V(S1≥S7)	1	V(S2≥S7)	1	V(S3≥S7)	1	V(S4≥S7)	1	V(S5≥S7)	1
V(S1≥S8)	1	V(S2≥S8)	1	V(S3≥S8)	1	V(S4≥S8)	1	V(S5≥S8)	1
V(S1≥S9)	1	V(S2≥S9)	1	V(S3≥S9)	1	V(S4≥S9)	1	V(S5≥S9)	1
MINIMUM	1	MINIMUM	0.8385665	MINIMUM	0.5756365	MINIMUM	0.74162	MINIMUM	0.6021023

V(S6≥S1)	0.507340218	V(S7≥S1)	0.528492	V(S8≥S1)	0.2055867	V(S9≥S1)	0.17153
V(S6≥S2)	0.656198953	V(S7≥S2)	0.6797587	V(S8≥S2)	0.3537785	V(S9≥S2)	0.31897
V(S6≥S3)	0.918126933	V(S7≥S3)	0.9448855	V(S8≥S3)	0.6466142	V(S9≥S3)	0.61484
V(S6≥S4)	0.789229279	V(S7≥S4)	0.8138141	V(S8≥S4)	0.5088953	V(S9≥S4)	0.47657
V(S6≥S5)	0.916486154	V(S7≥S5)	0.942701	V(S8≥S5)	0.6514899	V(S9≥S5)	0.62069
V(S6≥S7)	0.97374565	V(S7≥S6)	1	V(S8≥S6)	0.7477633	V(S9≥S6)	0.71833
V(S6≥S8)	1	V(S7≥S8)	1	V(S8≥S7)	0.7254926	V(S9≥S7)	0.6968
V(S6≥S9)	1	V(S7≥S9)	1	V(S8≥S9)	1	V(S9≥S8)	0.97482
MINIMUM	0.5073402	MINIMUM	0.528492	MINIMUM	0.2055867	MINIMUM	0.17153

Table 6: Final weights according to FAHP method

Four perspective of Balanced Scorecard	Growth and Learning		Internal Processes		Customer		Financial Perspective		
Indexes	Job satisfaction of employee X_9	Per capita training investment X_8	Increased production X_7	On-time delivery of goods X_6	Number of attracted customers X_5	Satisfaction customer X_4	Profitability X_3	Cash flow X_2	Return On Investment (ROI) X_1
Weight of each indicator	0.0331	0.0397	0.102	0.0981	0.1164	0.1434	0.1113	0.1621	0.1933
Overall weights	0.0728		0.2001		0.2598		0.4667		

CONCLUSION

The present research has studied an approach based on balances scorecard and process of analysis of fuzzy hierarchy for the evaluation of performance of company. At this part, general conclusion of research is presented based on questionnaire and predetermined criteria and also process of analysis of fuzzy hierarchy. Performance of company was studied at four perspectives of balanced scorecard. At each one of dimensions of balanced scorecard, a series of indicators (measures) was defined. These indicators were screened according to the sessions carried out in the presence of experts of statistics sample in many turns, details of which were defined based on their views as follows:

According to the calculations carried out with the process of fuzzy hierarchical analysis, total weights of financial indicators grabbed the first priority among four dimensions of balanced scorecard. That is to say that figure 0.466 percent has been obtained as result of whole study of this field. In financial perspective, increased market share and increased profitability and also increased owner's equity has been considered as main objective of the company. Therefore, financial ratios have been used for the evaluation of performance. In financial perspective and according to the carried out calculations, efficiency and performance the company has been placed in favorable and pleasant condition. Generally speaking, performance of the company is found favorable in period of study, based on which, the company has managed to attain its predetermined objectives. In customer's perspective, according to the calculations carried out with fuzzy hierarchical analysis, total weights of customer's indicators grabbed second priority among four dimensions of balanced scorecard. According to these calculations, total weight of indicators at this field stands at 0.259 percent. At this mode, increasing satisfaction of extant customers and also attraction of new customers has been main objective of the company. At internal processes mode, development of product, reduction of percentage of wastes in production and on-time delivery of goods have been considered as the main objective of the company. Generally, as far as internal processes mode is concerned, since production indicator and on-time delivery of goods has been improved consecutively during this year, hence, they are considered as strong point of company at this state. According to the calculations carried out with fuzzy hierarchical analysis, this mode has been prioritized as the third rank and generally, total weight of indexes of this perspective stands at 0.2. As far as staff growth and learning state is concerned, boosting manpower capabilities, increased motivation and coordination and unification of objectives of individuals with objectives of the company are considered as main objective of company. According to the calculations carried out at Fourth chapter, total weight of indicators of this perspective stands at 0.072. Totally, training per capita staff skill indicators and staff job satisfaction indicator are identified as strong points of performance of company in growth and learning mode. With the studies made in this regard, job satisfaction has been found acceptable in staff job satisfaction indicator. Generally, in growth and learning mode, indicators of training per capita staff skill and staff job satisfaction indicator are recognized as strong points of performance of company. According to the studies made in this regard, staff job satisfaction has been found acceptable.

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