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Evaluation of Fuzzy Analytic Network Process Technique based Organizational Strategies

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ABSTRACT: This study aims for evaluating the performance of AMA's strategies, using balanced scorecard (BSC), analytic network, and fuzzy logic. For this purpose, at the first stage, perspectives, strategies, and indexes relevant to each perspective of the balance scorecard of AMA company are deteined. At the second stage, the weights of BSC perspectives and strategies indexes are determined, using network analysis as fuzzy mode. At the third stage, each index is scored based on the experts' comments. Finally, strategies performance of AMA Company was analyzed based on the computed weights and scores from one-sample t-test. According to the performed analyses, weights of the first, second, third, and fourth strategies were obtained equal to 0.78, 0.1, 0.06, and 0.06, respectively. In addition, the financial, customer, internal process, and learning weights of the balanced scorecard perspectives were obtained equal to 0.44, 0.32, 0.13, and 0.11, respectively. Moreover, using inferential statistics, it was determined that the strategies performance status of AMA' company is relatively favorable (i.e. the mean of statistical population is over the average).

***Keywords*:** Evaluation of strategies performance, Balanced scorecard, Analytic network process, Fuzzy logic.

INTRODUCTION

Performance evaluation is one of the main responsibilities of every organization and a perspective of performance management, which was mostly done in the past by using financial indexes. In the past two decades, issues such as organizational learning, knowledge creation, and innovation capacity have been taken into consideration as competitive advantages. This focus has been given due to the emergence of globalization, intensifying competition, and unprecedented technological advances, especially in the field of communication and information. Therefore, organizations are under pressure to find comprehensive indexes of performance evaluation, since these indicators relate to humans and processes, which are the subjects whose weaknesses or strengths are not shown in the balance sheet (Stewart and Sharif, 2006).

Although BSC framework investigates the performance at different levels from organizational to business to individual ones, its application is accompanied with traps and disadvantages. BSC does not provide, either relative or absolute, technique for estimating the degree of involvement of each perspective. It even does not estimate relative importance of each index based on a single perspective. Practically, BSC users should intuitively fulfill this assimilation. Analytic Hierarchy Process (AHP) can be integrated with BSC to eliminate this problem. Decision makers, under AHP, should present a hierarchy that reflects criteria, helping them in achieving their goals. Since BSC completely estimates the enterprise's performance from all four perspectives, a combination of BSC and AHP can appropriately solve the performance problem. (Haghshenas et al., 2007).

Literature Review

In this section, balanced scorecard is first introduced. In this schema, performance evaluation of the organization is investigated from four financial, customer, internal processes, and learning perspectives. In addition, fuzzy analytic

network is introduced in the next stage. Analytic network was used to evaluate interrelation between balanced scorecard perspectives. In addition, by using fuzzy method uncertainty in language variables are addressed.

Fuzzy Analytic Network Process (FANP)

For fuzzy hierarchical analysis, Chang (1996) introduced a sample that has been extensively used in several studies (e.g. Youksel and Dagderion, 2010; Tiseng, 2010; Sebsi, 2009; Lin et al., 2009) as the basis for making computations in fuzzy analytic network, taking inter-cluster relationships into consideration. The computation technique used in the present study for fuzzy analytic network is similar to Chang's method for fuzzy hierarchical analysis. In this method, if the subjects set and the target set are defined as X = {x_1, x_2, x_3,..., x_n} and G = { g_1, g_2, g_3,... , g_n} respectively, according to the Chang's method, each subject for each target is analyzed according to the order it is done. Therefore, set of triangular fuzzy numbers M is valuated for each target, which can be obtained from relation 1:

(1) $$M_{gi}^{1}, M_{gi}^{2}, M_{gi}^{3}, \dots, M_{gi}^{m}, i = 1,2, \dots, n$$

Where M^{m}_{gi} (j = 1, 2,..., m) are triangular fuzzy numbers. A triangular fuzzy number is shown as (l,m,u), where the parameters l, m and u are the least likely value, the most likely value and the maximum value, respectively. Steps of Chang's analysis are as follows (Youksel et al. 2010):

Step 1: Regarding to i^{th} subject, the fuzzy compound value is defined in form of Equation 2:

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

To obtain$\sum_{j=1}^{m} M_{gi}^{j}$, values sum operation for a certain matrix in done as Equation 3.

(3) $$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j \ , \sum_{j=1}^{m} m_j \ , \sum_{j=1}^{m} u_j\right)$$

To obtain$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$, Fuzzy values sum operation of Mjgi (j = 1, 2, ..., m) is computed according to Equation 4.

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

And then, above vector reverse is computed using Equation 5:

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

In that, l_i ,m_i >0 u_i

Finally, to obtain S_i, multiply operation is done using Equation 6:

(6) $$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\sum_{j=1}^{m} l_{ij} * \frac{1}{\sum_{i=1}^{n} u_i} \ , \sum_{j=1}^{m} m_{ij} * \frac{1}{\sum_{i=1}^{n} m_i}, \sum_{j=1}^{m} u_{ij} * \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

Step 2: If M1 = (l1, m1, u1) and M2 = (l2, m2, u2), probability degree of M1= (l1, m1, u1) ≤ M2= (l2, m2, u2) is defined by Equation 7.

(7) $$V(M_2 \geq M_1) = sup_{y \geq x}\left[min\left(\mu_{M_2}(y)\right)\right]$$

This equation can also be expressed in form of Equation 8.

(8) $$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_1 \geq u_2 \\ l_1 - u_2 \Big/ (m_2 - u_2) - (m_1 - l_1) & \text{otherwise} \end{cases}$$

3. Research Objectives and Hypothesis

Research Objectives:

- Identification of en effective method for evaluation of the performance of the balanced scorecard and fuzzy analytic network based strategies.

- Identification and evaluation of AMA's strategies.
- Prioritization of the aspects and indexes related to AMA's strategies.
- Performance evaluation of AMA's company based on the determined indexes.
- Provision of solution to senior managers of the Property Organization in order to improve the performance of its strategies.
- Comparison of the current and desired strategies performance

***Research Hypothesis**:* Strategies performance of AMA is satisfactory.

4. Research Method

This applied study is methodologically a descriptive survey. AMA has used the model introduced in the present article to evaluate its strategies. The statistical population contains two parts.

A. The first statistical population includes the organization's elites including AMA's senior managers (i.e. 7 subjects). This population is used to determine the perspectives, strategies, and indexes, and paired comparison analysis is used to determine the weight of each of these factors. Since all statistical population is questioned, no sampling method is used.

B. The second statistical population includes 600 AMA's personnel, with at least master degree and six month work experience. This statistical population is used for data collection to evaluate the indexes of strategies performance of the organization. In this research population, random classified sampling was used. In addition, Cochran's equation was employed to determine the sample size.

It is worth mentioning that the required data was obtained from interviewing and distributing questionnaires between the elites including managers and experts.

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2.4. Constructing hierarchical analytic process model

In order to make analytic network model, the model's clusters should be first determined.

Cluster 1: Perspective

Cluster 2: Strategies

Cluster 3: Balanced Scorecard Perspectives

Cluster 4: Performance Indexes

With respect to the Kaplan and Norton balanced scorecards, each cluster of perspective, strategy, balanced scorecard perspectives, and performance indexes have descending hierarchal relationship. In addition, the clusters of balanced scorecard are interrelated. Therefore, research model is as Figure 1.

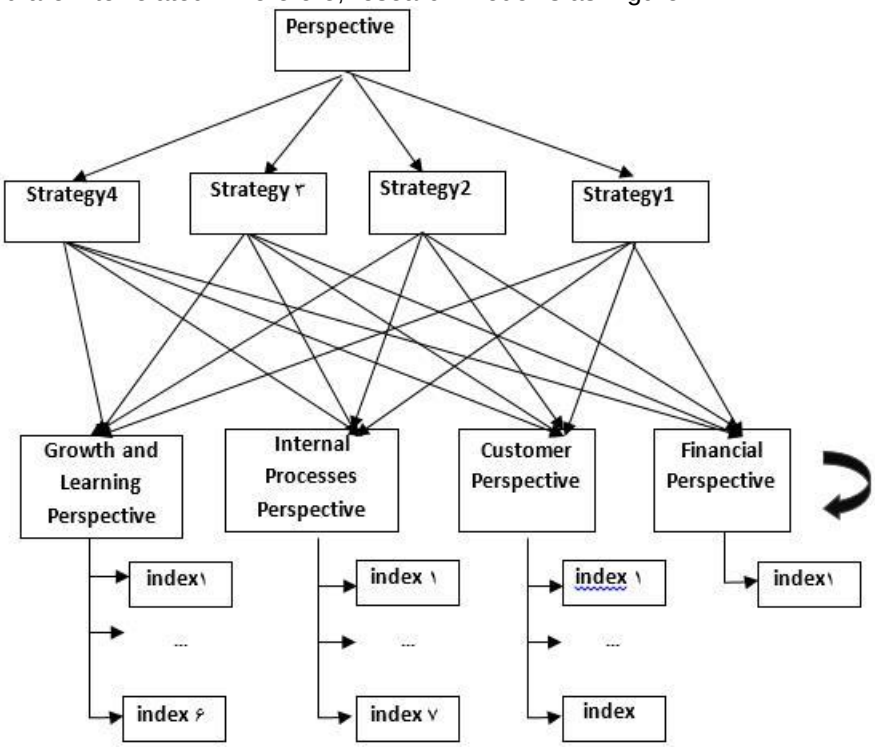

Figure 1. Hierarchal Analytic Process Model based on th Balanced Scorecard

Determination of the Local Weight

Determination of the Local Weight of the Strategies:

With respect to the paired comparison table and using Chang method (1996), the local weights of the strategies are represented by Vector 1.

$$\begin{bmatrix} ST1 \\ ST2 \\ ST3 \\ ST4 \end{bmatrix} = \begin{bmatrix} 0.78 \\ 0.1 \\ 0.06 \\ 0.06 \end{bmatrix}$$ =Local Weights of the Strategies (1)

Where: Strategy 1= ST1 ،Strategy 2= ST2 ،Strategy 3= ST3 ،Strategy 4= ST4

B. Determination of the Local Weights of the Perspectives based on the strategies

With respect to the paired comparison table and using Chang method (1996), the local weights of the strategies are represented by Matrix 2.

(2) ST4 ST1 ST2 ST3

$$\begin{bmatrix} fi & fi & fi & fi \\ cu & cu & cu & cu \\ pr & pr & pr & pr \\ le & le & le & le \end{bmatrix} = \begin{bmatrix} 0.56 & 0.15 & 0.12 & 0.25 \\ 0.29 & 0.40 & 0.35 & 0.27 \\ 0 & 0.10 & 0.14 & 0.22 \\ 0.16 & 0.35 & 0.40 & 0.26 \end{bmatrix}$$

Where:

Financial perspective= fi ،customer perspective= cu ،process perspective= pr ،growth and learning perspective= le ، strategy 1= ST1 ،strategy 2= ST2 ،strategy 3= ST3 and strategy 4= ST4

Determination of the Local Weights of Perspective Indexes

Using the paired comparison table and Chang method, local weights of financial, customer, internal processes, and growth and learning perspectives indexes are, respectively represented in following vectors:

$$[kp1] = [0.47]\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \end{bmatrix} = \begin{bmatrix} 0.25 \\ 0.24 \\ 0.05 \\ 0.22 \\ 0.24 \end{bmatrix}\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \\ kp6 \\ kp7 \end{bmatrix} = \begin{bmatrix} 0.13 \\ 0.15 \\ 0.13 \\ 0.26 \\ 0.2 \\ 0.07 \\ 0.06 \end{bmatrix}$$, and $$\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \\ kp6 \end{bmatrix} = \begin{bmatrix} 0.23 \\ 0.19 \\ 0.1 \\ 0.04 \\ 0.21 \\ 0.23 \end{bmatrix}$$.

Where kpi represents the i^{th} index.

Determination of the Dependency Matrix of the Clusters (Super Matrix)

As mentioned before, just the balanced scorecard perspectives cluster is independent. Therefore, in this section, interdependency between the balanced scorecard perspectives is determined as a matrix with interdependency between the clusters of the balanced scorecard.

(3)
$$\begin{bmatrix} fin & fin & fin & fin \\ cu & cu & cu & cu \\ pr & pr & pr & pr \\ le & le & le & le \end{bmatrix} = \begin{bmatrix} 1 & 0.65 & 0.5 & 1 \\ 0.73 & 1 & 0 & 0 \\ 0.27 & 0.35 & 1 & 0 \\ 0 & 0 & 0.5 & 1 \end{bmatrix}$$

Calculation of the Overall Weights of the Perspectives

The local and overall weights of the strategies are equal, due to their independencies. To obtain overall weights of the balanced scorecard perspective, local weights of the balanced scorecard perspective should be first obtained through multiplication of the local weights matrix of each perspective based on each strategy to the vector of the local weights of the strategies, according to the following equation:

Overall Weights of the Perspectives= $$\begin{bmatrix} fi \\ cu \\ pr \\ le \end{bmatrix} = \begin{bmatrix} 0.56 & 0.15 & 0.12 & 0.25 \\ 0.29 & 0.40 & 0.35 & 0.27 \\ 0 & 0.10 & 0.14 & 0.22 \\ 0.16 & 0.35 & 0.40 & 0.26 \end{bmatrix} \times \begin{bmatrix} 0.78 \\ 0.10 \\ 0.06 \\ 0.06 \end{bmatrix} = \begin{bmatrix} 0.47 \\ 0.30 \\ 0.03 \\ 0.20 \end{bmatrix}$$ (4)

To obtain the overall weights for the balanced scorecard perspectives, it is adequate to multiply internal dependency matrix (Matrix 3) by the local weights vector obtained for the perspectives.

Overall Weights of the Perspectives= $\begin{bmatrix} fi \\ cu \\ pr \\ le \end{bmatrix} = \begin{bmatrix} 1 & 0.65 & 0.5 & 1 \\ 0.73 & 1 & 0 & 0 \\ 0.27 & 0.35 & 1 & 0 \\ 0 & 0 & 0.5 & 1 \end{bmatrix} \times \begin{bmatrix} 0.47 \\ 0.30 \\ 0.03 \\ 0.20 \end{bmatrix} = \begin{bmatrix} 0.89 \\ 0.65 \\ 0.27 \\ 0.22 \end{bmatrix}$ (5)

After normalization of the obtained weight vector, based on $w_i = \frac{w'_i}{\sum w'_i}$, we finally have:

Normalized overall weights of the perspectives= $\begin{bmatrix} fi \\ cu \\ pr \\ le \end{bmatrix} = \begin{bmatrix} 0.44 \\ 0.32 \\ 0.13 \\ 0.11 \end{bmatrix}$ (6)

After obtaining overall weights for the balanced scorecard perspectives, to obtain overall weights of each perspective's indexes, it is adequate to multiply the overall weight of every perspective, represented in vector 6, by the local weight obtained for each index of that perspective. Therefore, we have:

(7) 0.44 =kp1 =overall weight of financial index

(8) $\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \end{bmatrix} = 0.32 \times \begin{bmatrix} 0.25 \\ 0.24 \\ 0.05 \\ 0.22 \\ 0.24 \end{bmatrix} = \begin{bmatrix} 0.08 \\ 0.08 \\ 0.02 \\ 0.07 \\ 0.08 \end{bmatrix}$ = overall weight of customer indexes

(9) $\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \\ kp6 \\ kp7 \end{bmatrix} = 0.13 \times \begin{bmatrix} 0.13 \\ 0.15 \\ 0.13 \\ 0.26 \\ 0.2 \\ 0.07 \\ 0.06 \end{bmatrix} = \begin{bmatrix} 0.02 \\ 0.02 \\ 0.02 \\ 0.03 \\ 0.03 \\ 0.01 \\ 0.01 \end{bmatrix}$ = overall weight of internal processes indexes

(10) $\begin{bmatrix} kp1 \\ kp2 \\ kp3 \\ kp4 \\ kp5 \\ kp6 \end{bmatrix} = 0.11 \times \begin{bmatrix} 0.23 \\ 0.19 \\ 0.1 \\ 0.04 \\ 0.21 \\ 0.23 \end{bmatrix} = \begin{bmatrix} 0.03 \\ 0.02 \\ 0.01 \\ 0.00 \\ 0.02 \\ 0.03 \end{bmatrix}$ = overall weight of growth and learning indexes

Performance Evaluation of Strategies of AMA Company

In this stage, with multiplication of the weight coefficients obtained from the indexes by the performance for indexes given by the sample respondents, strategies performance of AMA was obtained from the respondents' perspectives. The results from descriptive and inferential analysis of data are as follows.

B. Inferential Analysis of Data

To obtain the strategies performance, researcher investigated it by using one-sample statistical t-test. Test value is considered equal to 0.5 and if the computed t for the performance is more than t in the table (1.671), performance of the strategies is satisfactory; otherwise, this performance is unsatisfactory. The results from this test are presented in Table 4.

Table 4. Results from t-test for strategies performance

Variable	Number	Mean	Standard Deviation	Test Value	Computed t	Degrees of Freedom	T of the table at the level of 0.05 x=
Strategies Performance	155	7071/0	08623/0	5/0	902/29	154	1.671

As Table 4 shows, performance mean is equal to 0.7071 which is bigger than the test value (0.5). Since the computed t (11.018) is bigger than t of the table (1.971), at the confidence level of 95% it could be said that the performance of the strategies of AMA is satisfactory.

CONCLUSION

This study caused clarification of the organization's strategies performance in the past and would help the organization in modifying its future plans by overcoming its weaknesses in implementation and its previous programs, considering its performance in the past. The present research is in accordance with studies conducted by Youksel and Dagderion (2010), RAv et al. (2005), Benker et al. (2004), Asha'ari (2008), Heidari & Rahimi (2008), Mansouri (2007), Stewart and Sharif (2006), Zandi and Tavana (2011), and Absolahi (2007), as they all applied Balanced Scorecard for performance evaluation. However, since this research has employed fuzzy analytic network for weighing the perspectives, it is different from the mentioned research and is innovative.

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