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An integrated approach for ranking strategic objectives of balanced scorecard

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Abstract

Strategic objectives that clarify the nature of macro goals are expressed in short and concise phrases and they are a basis for strategy map. The strategic objectives are the starting point of their debut. Effective goals can be a bridge between present and future and it is very important for strategic decisions. In many cases, managers seek to identify the most important strategic objectives of theirorganization. Given the frequency of strategic objectives as well as the uncertainty of the individuals' judgment in prioritizing them, this study aimed to prioritize the strategic objectives using a combination of qualitative methods (focus groups interviews) and quantitative methods (grey systems theory) which is a new technique of decision-making and mathematical evaluation of ambiguous and inconclusive data. In order to apply the method presented in this study, the strategic objectives of logistics and procurement system of Iranian Oil Terminals Company were prioritized.

Keywords: balanced scorecard, grey systems theory, strategic objectives, strategy map.

1- Introduction

Increasing advances in technology and communications have invited organizations to a hard and conscious competition and organizations have been successful in qualitative and quantitative competition that their managers adapt their organizations to environmental conditions. Considering environment, the awareness of the effect of environmental factors and a picture of future activity for organizations will justify the need for readiness to deal with the constant changes. Therefore, environmental uncertainties in organizational issues regarding the ambiguity and possible nature of future events and organizations' readiness for change necessitate strategic management [1]. Strategic management can be introduced as a series of decisions and actions that determine the long-term activities of the organization [2]. Balanced scorecard is a tool that is designed for strategic management. In 1992, Kaplan and Norton presented a balanced approach for performance measurement named balanced scorecard. This approach attempted to balance between financial and non-financial measures, incentives and performance, internal and external stakeholders and the long-term and short-term objectives [3]. Today, the balanced scorecard is used not only as a tool to evaluate the performance, but also as a tool for strategic management and convert the perspective into a series of clear goals [4]. Balanced scorecard is an excellent tool for achieving evaluation system supporting strategy that is connected to the operations and tactics. Balanced scorecard concept is displayed in two formats: strategy map and evaluation card. In strategy map, strategic objectives are written within oval shapes. Strategic objectives are short and concise expressions that clarify the nature of "macro goals" [5]. Strategic goals are located in the heart of scorecard aspects and they have a causal relationship with each other. On the other hand, the large number strategic objectives encourage managers to identify the most important goals. Given the above as well as, the qualitative nature of strategic objectives and the uncertainty of individuals' judgment in determining the importance of each goal, how can be prioritized strategic objectives?

Different analysis methods and multi-criteria decision-making have been entered into strategic planning stages to help managers make strategic decisions. Since the main component in this field is decision making with regard to multipleconsiderations, multi-criteria decision-making techniques are assigned themselves the highest usage. For example, group decision-making methods have been used to evaluate strategic alternatives in conditions that different criteria affect evaluation and decision-making [6]. Decision-making support models are also used to formulate strategy [7]. Nevertheless, previous research suggests that a specific research has not been conductedabout the prioritizationof strategic objectives of the balanced scorecard in theuncertainty state. Therefore, this study aimed to prioritize the strategic objectives of logistics and procurement system of Iranian Oil Terminals Company using grey systems theory, which is a new decision-making technique. So in this study, for the first time, grey systems theory will be used in balanced scorecard and particularly strategic objectives.

2-Literature review

If an organization fails to obtain the required knowledge through the organization's resources,itshould be focused on its purchase in the form of external service [8]. Many different methods such as scoring, ranking, mathematical optimization, and multi-criteria decision making have been ever used to select the best strategic objective as well as a new grey theory technique is used in different cases which is discussed in the following. In a study, Fang [9] used grey relational analysis approach and TOPSIS to select employees to send abroad missions. Staff selection is

accompanied by considering multiple criteria, so, the best decision must be made by including these criteria, and individuals should be selected who have the maximum utility. The results have shown that grey relational analysis approach has had more use to achieve this goal. In another study, Ping [10] used an integrated grey prediction and neural networks approach to predict the output of telecommunication companies. The results indicated that given the complex environment and in uncertain conditions governing this industry, this model could better predict the output of these companies.Inthis study "grey decision-making for suppliers' selection", Dong [11] attempted to introduce a new approach to solve multi-criteria decision-making problems in uncertain conditions using the concept of grey possibility degree and linguistic variables.

Kuo et al [12] solved a location problem using grey relational analysis and shown that grey relational analysis results are largely close to the results of TOPSIS method and they have considered the results of these two methods confirmed by each other as a measure of the actual ranking.In another study, Chang [13] used grey system approach for ranking of commercial banks in Taiwan. In this study, banks' rankings are determined using financial ratios as evaluation indices. In the next step, the properties affecting the performance of these banks have been studied. The results of this study indicate that grey systems approach can assess the performance of studied banks compared to common statistical methods such as regression analysis, factor analysis and other multivariate statistical methods because it lacks the limitations of these methods i.e. the availability of large amounts of data. A combination of multiple criteria decision-making methods to select the best strategy in the textile industry [14] and to provide decision support system has been used in the strategic planning process [15]. Approaches of implementing strategic decision-making are also discussed for designing prospect and reporting the future [16].Tashkar et al have outlined a strategy map using ISM technique [17].Therefore, given the research carried out for the evaluation and ranking in various fields, we can concluded that grey systems approach has two major advantages compared to other methods. One advantage of this method is the need for little data, while using many multivariate statistical techniques like principal components analysis requires massive amounts of data. Another major advantage of this system is the ability to deal with ambiguity in the data because the exact amount of parameters is unclear in the real conditions.According to the capabilities of this method and a new context this is provided by this approach as well as the lack of a certain research about the prioritization of strategic objectives of the balanced scorecard in uncertainty, therefore, this study aimed to prioritize the strategic objectives of logistics and procurement system of Iranian Oil Terminals Company using grey systems theory, which is a new decision-making technique. So in this study, for the first time, grey systems theory will be used in balanced scorecard and particularly strategic objectives.

3-Material and methods

Grey systems theory:

In the late 1960s, Deng carried out several studies on economic and fuzzy systems forecasting and control and he was concerned with systems with high uncertainty. Indices these systems were described hardly with fuzzy mathematics or statistics and probabilities. In general, in fuzzy mathematics we deal with problems that experts can representits uncertainty using discrete/continuous membership functions. In solving problems using probability and statistics, we need to know the relevant distribution function or high volume of samples to achieve required validity. In such a case, if the number of experts and experience level are low in a problem and no membership functions can be extracted or we have a few samples, what should we do? For optimal solution of systems in these circumstances, in 1982 Deng published an article entitled "the problems of grey systems control" in *International Journal of Systems & Control Letters*, andintroduced grey systems theory [18] which today its applications can be classified in five areas of evaluation, modeling, prediction, decision-making and control.Grey possibility degree is one of the proposed methods of this theory in decision-making. Grey systems theory is called based on the color of under investigation topics. For example, in control theory, the darkness of colors indicates the amount of information and data transparence. Accordingly, systems with quite known information are called "white systems", systems with unknown information or without data are "black systems", and systems with partially known and partially unknown information are referred to greysystems. A grey set is defined as a series of inconclusive data, which is described through grey numbers, grey equations, grey matrices, etc.Grey number is a number that its exact value is notclear but a range in which it is placed is specified i.e. a grey number is an interval or a set of numbers. Suppose X is a reference set, then grey set G of reference set X with two symbols$\overline{\mu}_G(X)$and $\underline{\mu}_G(X)$ as upper and lower limits of membership function G is defined as follows:

$$\overline{\mu}_G(X):X \quad [0,1] \quad \rightarrow \quad \underline{\mu}_G(X):X \quad [0,1]$$

It is noteworthy that $\overline{\mu}_G(X) \geq \underline{\mu}_G(X)$and in equal mode grey set G is converted into fuzzy set which represents the inclusion of grey theory in fuzzy modes and its flexibility in dealing with the fuzzy issues, and the relationship between the grey numbers are expressed in terms of the following definitions: [19]

Definition 1: Moore [20] extended relationships between interval operators, which according to [15] and [21] for two grey numbers it defined as follows:

$$\otimes G_1=[\underline{a_1},\overline{a_1}] \quad \otimes G_2=[\underline{a_2},\overline{a_2}] \quad (1)$$

$$\otimes G_1+\otimes G_2 = [\underline{a_1}+\underline{a_2}\,,\ \overline{a_1}+\overline{a_2}] \quad (2)$$

$$\otimes G_1-\otimes G_2 = [\underline{a_1}-\overline{a_2},\ \overline{a_1}-\underline{a_2}] \quad (3)$$

$$\otimes G_2 = [\min(\underline{a_1}\underline{a_2},\ \underline{a_1}\overline{a_2},\ \overline{a_1}\underline{a_2},\ \overline{a_1}\overline{a_2})\ ,\ \max(\underline{a_1}\underline{a_2},\ \underline{a_1}\overline{a_2},\ \overline{a_1}\underline{a_2},\ \overline{a_1}\overline{a_2})] \quad (4)$$

$$\otimes G_1/\otimes G2= [\underline{a_1}\ ,\ \overline{a_1}] * [\ 1/\underline{a_2}\ ,\ 1/\overline{a_2}] \quad (5)$$

Definition 2: If K is a positive real number, its scalar multiplication in grey set G can be defined as:

$$k.\otimes G_1 = [\,k\,\underline{a_1}\ ,\ k\,\overline{a_2}\,] \quad (6)$$

Definition 3: Other additive and divisibility rules for real numbers can be generalized to sets of grey intervals [20].

Definition 4: the length of grey number that is shown with ,L (⊗G) is as follows:

$$L(\otimes G) = [\bar{a} - \underline{a}] \quad (7)$$

Definition 5: Less possibility degree of grey set G_1 and $G_2$is defined as follows: [3]

$$P\{\otimes G_1 \leq \otimes G_2\} = \max(0, L^* - \max(0, \underline{a_1} - \bar{a_2})) / L^* \quad (8)$$

$$L^* = L(\otimes G_1) + L(\otimes G_2) \quad (9)$$

Given the ratio between G_1 and G_2, four modes may be occurred:

1) If the lower limit and upper limit of two grey numbers are equal, then two grey numbers will be equaled and in this case, grey possibility degree is 0.5.

2) If the lower limit of the second grey number is larger than the upper limit of the first grey number, then the second grey number will be larger number. In this case, grey possibility degree is 1.

3) If the lower limit of the first grey number is larger than the second grey number, the first grey number will be higher and the grey possibility degree equals 0.

4) If there is an overlap between them, then if $P\{\otimes G_1 \leq \otimes G_2\}>0.5$, then $\otimes G_1<\otimes G_2$, and if $P\{\otimes G_1 \leq \otimes G_2\}<0.5$, then $\otimes G_1>\otimes G_2$.

4-Results

In this study, a hybrid research method is used. One of the characteristics of research is the sequence of qualitative and quantitative research methods in which one of the following three cases can occur:

1. Quantitative then qualitative
2. Qualitative then quantitative
3. Both types of quantitative and qualitative data are collected at the same time.

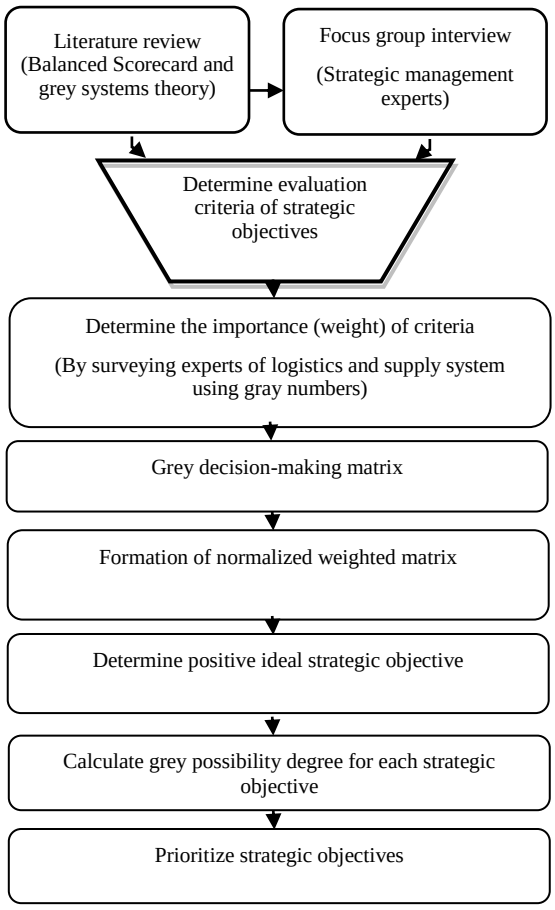
Hybrid methods are conducted by combining two sets of qualitative and quantitative research methods. Using qualitative research methods including case studies, focus groups interviews, data-driven theory, action research, etc. just investigate the quantitative aspects of phenomena and it cannot itself reveal the reality of phenomena related to managementand also meet all the goals of the study. Therefore, using both qualitative and quantitative research methods are necessary to realize management issues and understanding the reality of organization's components [22]. Qualitative-quantitative sequence is used to conduct the study.Since the answer to all the purposes of this study was not possible simply by applying a quantitative technique, for deeper understanding of the studied topic, to realize the holistic view about it and for elimination of ambiguity, first, qualitative questionnaire of the experts was used and then a quantitative technique "mathematics and grey systems theory" is used which can be applied for evaluating and ranking various alternatives the uncertainty and makes it possible to achieve the mentioned objectives.

(7)

(8)

(9)

Figure (1) the stages of doing research



Strategic objectives evaluation method:

If $V=\{v_1,v_2,\ldots..,v_m\}$ is a V If a discrete set of *m* strategic objective (alternatives set) and $Q=\{Q_1, Q_2,\ldots., Q_n\}$ is *n* sets of criteria for assessing the strategic objectives, strategic objectives ranking model can be presented in two the following sections:

Identifying criteria and their weights:

First, given the literature through the library study and using the strategy map, which has been already designed in Iranian Oil Terminals Company by Taghavi et al [23], the initial criteria are extracted. Then focus groups interview technique is used to determine strategic objectives prioritization indices (criteria). During this interview, five faculty members' views that have teaching or writing experience in strategic management and planning have been recorded and collected. The results of this unstructured interview that lasted 70 minutes indicated that there was the

possibility of prioritizing strategic objectives. On the other hand, experts reviewed criteria collected from the literature and they were grouped into four major criteria:

a) Mission
b) Customer
c) Internal processes
d) Growth and learning

According to the qualitative criteria and uncertainty of individuals' judgments to determine the importance of them, in this study, strategic management experts' views are collected through questionnaire and grey numbers (table1) and criteria weights $\otimes w = \{\otimes w_1, \otimes w_2, \ldots, \otimes w_n\}$ are calculated as follows [11]. If decision-makers (experts) group includes *k* people, the following equation can be used to calculate criteria weights:

$$\otimes w_j = 1/k \{\otimes w_j^1, \otimes w_j^2, \ldots, \otimes w_j^k\} \quad (10)$$

Table (1) Scale for determining criteria weights

Very Low	*Low*	*Medium Low*	*Medium*	*Medium High*	*High*	*Very High*	*Scale*
VL	*L*	*ML*	*M*	*MH*	*H*	*VH*	
[0.0,0.1]	[0.1,0.3]	[0.3,0.4]	[0.4,0.6]	[0.6,0.7]	[0.7,0.9]	[0.9,1.0]	⊗W

In which $\otimes w_j^k (j=1,2,\ldots,n)$ is the weight of *j-th* criteria in *k-th* decision-maker's view, which is expressed through grey number $\otimes w_j^k = [\underline{w}_j^k, \overline{w}_j^k]$. By considering k=5, the analysis results of experts' views can be summarized in table (2).

Table (2) criteria weights

Criteria	*D1*	*D2*	*D3*	*D4*	*D5*	*Grey number*
Customer	H	M	MH	ML	ML	(0.46,0.6)
Mission	VH	H	VH	H	VH	(0.82,0.96)
Internal processes	M	ML	ML	L	M	(0.3,0.46)
Growth and learning	VH	MH	MH	MH	H	(0.68,0.8)

Evaluation and ranking of strategic objectives:

In this section, after determining criteria and their weights and using this method, evaluation and ranking of strategic objectives are described. To evaluate alternatives in terms of each criterion grey numbers ranged 1-10 scale can be used as shown in table (3) [24].

Table (3) alternatives evaluation scale

Very Poor	*Poor*	*Medium Poor*	*Fair*	*Medium Good*	*Good*	*Very Good*	*Scale*
VP	*P*	*MP*	*F*	*MG*	*G*	*VG*	
[0, 1]	[1,3]	[3,4]	[4,6]	[6,7]	[7,9]	[9,10]	⊗W

For evaluation using a grey number, we use the following equation:

$$\otimes G_{ij} = 1/k [\otimes G_{ij}^1 + \otimes G_{ij}^2 + \ldots + \otimes G_{ij}^k] \quad (11)$$

In which $\otimes G_{ij}^k$ is the evaluation value of *k-th* decision-maker for *i-th* alternative compared to *j-th* criteria and it can be represented with a greynumber $\otimes G_{ij}^k = [a_{ij}^k, ß_{ij}^k]$. Then the grey decision matrix is form D.

Since all evaluation criteria in balanced scorecard are positive, normalized decision-making matrix can be formed D^*.

$$\otimes G_{ij}^* = [a_{ij}/G_j^{max}, ß_{ij}/G_j^{max}], \quad G_j^{max} = \max_{1 \le i \le m} \{ß_{ij}\}$$

Then grey normalized weighted matrix is formed $\otimes N_{ij}$:

$$\otimes N_{ij} = \otimes G_{ij}^* \times \otimes W_{ij} \quad (12)$$ (10)

Among the strategic objectives set of the relevant organization that are actually alternative sets, optimal alternative can be defined based on the following equation:

$$V^{max} = \{\otimes G_1^{max}, \otimes G_2^{max}, \ldots, \otimes G_n^{max}\} \quad (13)$$

$$V^{max} = \{[\max a_{i1}, \max ß_{i1}], [\max a_{i2}, \max ß_{i2}], \ldots, [\max a_{in}, \max ß_{in}]\} \; 1 \le i \le m \quad (14)$$

$$\otimes N_{ij} = [a_{ij}, ß_{ij}] \quad (15)$$

Then, using the following equation grey possibility degree between each of strategic objectives from the alternative sets is calculated with the supposed optimal alternative, which is called V^{MAX}.

$$P\{v_i \le v^{max}\} = 1/n \Sigma p\{\otimes N_{ij} \le G_j^{max}\} \quad (16)$$

By obtaining the results of proposed equation, the strategic objectives of this organization can be ranked. The less possibility degree of *i-th* strategic objectives is compared to ideal value, the higher rank it has. The strategic objectives of logistics and procurement system in Iranian Oil Terminals Company are as follows:

1. Increased suppliers' satisfaction
2. Increased internal customers' satisfaction
3. Improved inventory control process
4. Reduced cycle time of purchasing inside and outside goods
5. Conforming buying to the requested product specification
6. Development of domestic manufacturing of key items
7. Developing the employees' knowledge and skills
8. Improving employees' satisfaction and attachment

5-Discussion

In this section, to show an example of the application of strategic objectives evaluation that was presented in section 3, strategic objectives of balanced scorecard of procurement and supply system of Iranian Oil Terminals Company are

ranked. The population consisted of five managers and experts of procurement and supply system of Iranian Oil Terminals Company. While they are familiar with concepts of strategic management, they are also aware of the topics related to the balanced scorecard. A questionnaire was designed to collect theses experts' views about evaluating each of eight strategic objectives regarding each criterion and experts' views were obtained using linguistic variables, which were defined in terms of grey numbers. Finally, questionnaires were completed and used for analysis which its results are presented in table (4) using the proposed equations.

Table (4) Evaluation of alternatives compared to criteria

V_i	Q_j	D_1	D_2	D_3	D_4	D_5	$\otimes G_{IJ}$
V_1	Q_1	VG	G	G	MG	G	(7.2,8.8)
	Q_2	MG	F	MP	VP	F	(3.4,4.8)
	Q_3	VP	P	P	VP	VP	(0.4,1.8)
	Q_4	F	F	MP	MP	P	(3.0,4.6)
V_2	Q_1	VG	G	VG	VG	G	(8.2,9.6)
	Q_2	F	F	MG	MG	MG	(5.2,6.6)
	Q_3	P	P	P	VP	VP	(0.6,2.2)
	Q_4	MP	F	MP	VP	P	(2.2,3.6)
V_3	Q_1	F	MG	MP	VP	MP	(3.2,4.4)
	Q_2	F	MP	MP	MG	F	(4.0,5.4)
	Q_3	VP	VP	VP	VP	VP	(0.0,1.0)
	Q_4	G	G	G	VG	VG	(7.8,9.4)
V_4	Q_1	G	MG	G	F	MP	(5.4,7.0)
	Q_2	VG	G	MP	MG	G	(6.4,7.8)
	Q_3	P	VP	VP	VP	P	(0.4,1.8)
	Q_4	MP	G	VG	VG	VG	(7.4,8.6)
V_5	Q_1	MG	MG	G	MG	MG	(6.2,7.4)
	Q_2	VG	G	MG	MG	MG	(6.8,8.0)
	Q_3	P	VP	P	VP	P	(0.6,2.2)
	Q_4	MG	G	VG	VG	G	(7.6,9.0)
V_6	Q_1	G	F	MP	P	P	(3.2,5.0)
	Q_2	MG	F	MP	G	MG	(5.2,6.6)
	Q_3	VG	VP	P	VP	P	(2.2,3.6)
	Q_4	MG	MG	G	VG	G	(7.0,8.4)
V_7	Q_1	F	P	F	MP	MP	(3.0,4.6)
	Q_2	P	VP	MP	MP	MP	(2.0,3.2)
	Q_3	VG	VG	G	VG	VG	(8.6,9.8)
	Q_4	F	F	P	F	MP	(3.2,5.0)
V_8	Q_1	MP	P	MP	VP	VP	(1.4,2.4)
	Q_2	P	VP	MP	MP	P	(1.6,3.0)
	Q_3	VG	VG	VG	VG	VG	(9.0,10.0)
	Q_4	F	F	P	F	MP	(3.2,5.0)

Considering the positivity of all criteria, normalized grey decision matrixis obtained using the above equations.

Then, the normalized grey weighted matrix is formed

Then, the normalized grey weighted matrix is formed.

Now, we should obtain the positive optimal alternative as follows:

V_{MAX}={[0 .08 ,0.15],[0 .12 , 0.22],[0.08 ,0.21],[0 .1 ,0.18]}

Grey possibility degree for each of the strategic objectives can be presented.

$P(V_1<=V_{MAX})$= 0.878 , $P(V_2<=V_{MAX})$= 0.795 , $P(V_3<=V_{MAX})$= 0.837 , $P(V_4<=V_{MAX})$= 0.711

$P(V_5<=V_{MAX})$= 0.683 , $P(V_6<=V_{MAX})$= 0.813 , $P(V_7<=V_{MAX})$= 0.879 , $P(V_8<=V_{MAX})$= 0.87

Table (5) strategic objectives ranking of BSC in Iranian Oil Terminals Company

Rank	***Strategic objectives***	***Grey possibility degree***
1	Conforming buying to the requested product specifications	0.683
2	Reduced cycle time of purchasing inside and outside goods	0.711
3	Increased internal customers' satisfaction	0.795
4	Development of domestic manufacturing of key items	0.813
5	Improved inventory control process	0.837
6	Improving employees' satisfaction and attachment	0.875
7	Increased suppliers' satisfaction	0.878
8	Developing the employees' knowledge and skills	0.879

In table (5), thegrey possibility degree values are provided which indicate the proximity of strategic objectives to the supposed desired objectives. As mentioned before, we can explain based on greypossibility degree values about the ranking of strategic objectives. This means that the less possibility degree of strategic objectives is compared to optimal value, the higher degree it has. Thus, it can be concluded that one of the closest strategic objectives to the ideal is the most important strategic objective of conforming buying to requested goods specifications. The results of qualitative study of experts' responses also indicate this strategic objective except the fourth criteria (learning and growth perspective) has obtained high ranking. Rankings of other strategic objectives are listedin the same manner in table (5).

6-Conclusion

In this study, an approach was presented to prioritize the strategic objectives of balanced scorecard and it was implemented in procurement and supply system of Iranian Oil Terminals Company. In this study, a hybrid (qualitative and quantitative) research method was used, such a way that qualitative interview and questionnaire techniques in combination with quantitative technique ofgrey possibility degreewere used.For multi-criteria decision-making in addition to examine the relationshipsbetween different criteria and alternatives, grey possibility degree method considers inputs as interval numbers that in fact display the uncertainty in the system structure and the inputs of decision-making system; furthermore, it is a simple and practical model which simultaneously covers all above methods. In this method, firstly, it is not necessary to have

accurate information and grey theory using grey numbers provides the acceptability and application of insecure data. Secondly, in this method, several criteria are considered simultaneously and the relationships between them are applied in the model. The results of the prioritization of strategic objectives were so that senior management must put growth and learning in the first priority of company's work programs for strategic decision-makings. It is recommended that ideal results can be achieved in different quantitative evaluations and decision-making issues using grey possibility degree method along with techniques such as fuzzy multi-criteria decision-making, multi-objective decision-making, multi-attribute utility theory and DEA. The method presented in this paper can also be used to compare the strategic objectives of other organizations.

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