Sugar Industry Companies Performance Evaluation and Grading, Operating In Tehran Stock Exchange Using Grey Shannon Entropy Technique and Grey Relational Analysis Theory

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Abstract

In today's competitive environment, which one of its hallmarks is the scarcity of resources, management and performance, plays a vital role for the organization. Since, a large number of companies operating in the sugar industry and parts have been member of the Tehran Stock Exchange and follow most of their business activities through Stock Exchange; this paper compares the functional role of these companies for each other and seeks companies with the best performance in the related industry and suggests a performance evaluation system.

To respond the dynamic requirements of today's markets and making effective decision, managers need more accurate and functional models for decision-making. Bu t generally, Information about the preferences of decision makers about the criteria are expressed based on their qualitative judgments for different reasons and also in practice, decision-makers judgment is often uncertain and cannot be expressed by exact numeric values .So to deal with the complexity of such decision problems, using new and interdisciplinary approaches are essential.

In this study, in addition to criteria which are based on accounting and value-based criteria, also corporate governance-based criteria have been formed to evaluate firms' performance and Shannon Grey entropy and Grey Relational Analysis have been used due to their ability to deal with ambiguity of data.

KEYWORDS: Performance evaluation, ranking, Grey Shannon entropy, Grey relational analysis

1. Introduction

Performance evaluation includes a process that measures, values, and judges the performance during specific period of time [3]. Each organization requires evaluation as a necessary element to be aware of the degree of desirability and quality of its activities

especially in complex and dynamic environments. However, lack of control and evaluation discipline in one system reveals no connection between internal and external environment of the organization resulting in aging and finally failure of the organization [1].

Regarding this important point that most of decision makings related to economical, industrial, financial, and even political areas have got several characteristics, considering the desirability and preference of decision makers in solving these issues is of utmost importance. In most conditions, due to lack of an optimized solution for multi-criterion evaluation, issues related to selection and ranking of the options cannot be easily solved [18]. Some researchers believe that one performance evaluation too that is suitable, can include a vast area of performance criteria. [17]. others state that tools applied for performance evaluation must provide the possibility of the implementation of comparative evaluations for organizations [16].

In the following, generalities of the present study are explained in the sense that background of the study is provided first, and statement of the problem and significance of the study are presented as well. Then, the model used in the current study with the methodology adopted is specified. Finally, discussion, conclusion, and references cited in the study are provided.

2. Background of the Study.

Fang (2004) benefitted from grey relational analysis (GRA) and TOPSIS to select employees deploying them to abroad missions. It was stated that due to relationship between employees' selection and considering various criteria, which are sometimes opposites, hence, these various criteria should be regarded for better decision making to dispatch employees leading to the most degree of desirability. Results suggest that grey relational analysis had better potential to fulfill the purpose of the study [6].

Dong (2006) carried out a study titled "grey decision making to select providers" to introduce a new approach for solving the issues related to multi-criteria decision making in uncertain conditions with the application of grey possibility degree and linguistic variables[5].

Kuo (2008) conducted a study to solve the problem of location with the application of grey relational analysis. It was revealed that the findings of grey relation analysis were to a large extent similar to the results of TOPSIS method, and the confirmation of the findings obtained by the two mentioned methods was a criterion showing the reality of the presented ranking in the study [10].

Taghizadeh and Fazli (2011) made an attempt to present a method for measuring the financial performance of companies in stock exchange in Tehran with the application of fuzzy multiple criteria decision making, and benefiting from grey relational analysis and FTOPSIS [14].

Das et al. (2012) aimed at introducing a framework for relative performance evaluation of technical and vocational institutes in India applying integrated approach. The researchers benefitted from FAHP and COPRAS and evaluated and ranked seven institutes. In order

to select and determine the degree of criteria significance and the formation of matrices of paired comparisons, a committee consisted of 15 experts in the field of education helped the researchers. In the study, the weights of criteria were determined by FAHP, and ranking of institutes was presented using COPRAS method [4].

3. Performance evaluation

3.1 Necessity of performance evaluation

It has been a long time that management theory and management in performance have considered a kind of relationship between effective performance measurement and effective management. Performance measurement is not the ultimate goal; rather it is a tool for the management of effective performance [11]. The effectiveness of performance measurement depends on its application, and performance measurement, as a management tool, requires including a wide range of performance criteria [17]. In line with the objectives of the organization, performance evaluation makes it possible for organizations to compare previous programs and implemented strategies with the design of future strategies and performance goals of employees [9]. According to Green and Kim (1983), performance evaluation is a tool reaching all goals [7].

3.2 Criteria of performance evaluation

Different studies highlighted various criteria for financial performance evaluation of companies that is possible to apply suitable criteria depending on management understanding of the company. These ratios make it possible for users to provide a summary and analysis of the related data for the provision of significant data for decision making [12].

According to the comments of financial experts in the present study, four criteria of accountancy including return of assets (ROA), return of equity (ROE), operating profit growth (OPG), and price to earnings ratio (P/E) to evaluate financial performance of companies, uses seven value based financial performance criteria include economic value added (EVA), market value added (MVA), cash value added (CVA), refined value added (REVA), true value added (TVA), Tobin's Q, and created shareholder value (CSV) & corporate governance include the percentage of non-members' possession of board of directors and the percentage of institutional investors

4. Shannon Entropy

One of the methods of extracting the significance weight of criteria in decision making with multiple criteria is Shannon entropy. The benefit of this method in relation with other methods of extracting the significant weight is the fact that it is completely an objective method, and it does not include the orientation of experts' comments. Hence, if the conditions are in a way that the occurrence of error is probable in experts' judgment, application of this method can be as an appropriate alternative. In information theory, entropy shows the degree of uncertainty in the expected content of information of a message. In other words, entropy is a criterion for the stated degree of uncertainty by a discrete probability distribution (pi), in the sense that when uncertainty distributes, it is more than the cases in which frequency distribution is sharper [13].

5. Grey relational analysis

Grey relational analysis was first proposed by Deng. This theory is applied to solve ambiguous questions and those containing discrete data and incomplete information. The mentioned theory provides satisfactory and desirable outputs with the application of relatively little information and high rate of changeability in criteria. The grey theory, similar to Fuzzy theory, is an effective math model for solving unknown and ambiguous questions [12]. It has been applied in many fields, like solving the questions of multiple criterion decision making, named grey relational analysis. Grey relational analysis is part of grey theory used in questions with complex relationships between factors and their variables [15].

6. Method

The present study is descriptive and applied investigating the evidenced and repeated phenomenon in the environment and new conditions in specific period of time. Data were collected using library, documents, and reports and it was a field research (questionnaire). Regarding the environmental and inscribed conditions governing sugar companies in stock exchange in Tehran, not only was grey Shannon technique applied to determine the weight sub-criteria of performance evaluation, but it also benefited from grey relational analysis as it is able to face ambiguity and due to its provision of new platform, it was used to evaluate and rank the sugar companies in stock exchange in Tehran as well.

Since the aim of the study is to evaluate the performance of active companies in stock exchange in Tehran during 2003-2012, the population of the study includes two different ones: active companies in stock exchange in Tehran and financial experts who were give questionnaire to fill it out.

6.1 Determination of significance degree of sub-criteria with grey Shannon entropy

"Decision making matrix" includes information that entropy can be applied as a criterion for its evaluation. Assume that decision making matrix is as follows:

indicator / option	C_1	C_2	...	C_n
A_1	$\left[a_{11}^L, a_{11}^U\right]$	$\left[a_{12}^L, a_{12}^U\right]$	…	$\left[a_{1n}^L, a_{1n}^U\right]$
A_2	$\left[a_{21}^L, a_{21}^U\right]$	$\left[a_{22}^L, a_{22}^U\right]$	…	$\left[a_{2n}^L, a_{2n}^U\right]$
⋮				
A_m	$\left[a_{m1}^L, a_{m1}^U\right]$	$\left[a_{m2}^L, a_{m2}^U\right]$	…	$\left[a_{mn}^L, a_{mn}^U\right]$

Table 6.1 evaluation of options in each indicator

$\left[a_{ij}^{L}, a_{ij}^{U}\right]$ is the i score of indicator i that was determined in grey color.

If one of these numbers are negative, they must be positive with any method. In the present study, domain of each indicator was determined (the least quantity of lower limit of each column subtracted the most quantity of higher limit of each column) quantities of lower and higher limit were added to them. As to this matrix, p_{ij} is calculated as follows:

Relation 1:

$$\left[P_{ij}^{L}, P_{ij}^{U}\right] = \frac{\left[a_{ij}^{L}, a_{ij}^{U}\right]}{\sum_{i=1}^{m} a_{ij}^{U}} \quad ; \quad \forall_{i,j}$$

and entropy of indicator i is calculated with the following relation:

Relation 2:

$$\left[E_j^{L}, E_j^{U}\right] = -k\sum_{i=1}^{m}\left[Min\left(P_{ij}^{L} \times LnP_{ij}^{L}, P_{ij}^{U} \times LnP_{ij}^{U}\right),\ Max\left(P_{ij}^{L} \times LnP_{ij}^{L}, P_{ij}^{U} \times LnP_{ij}^{U}\right)\right] \ ; \ \forall_j$$

Uncertainty or deviation degree of $\tilde{d}_j$ obtained for indicator j states that how much useful information for decision making the related indicator j provides for the decision maker. $\tilde{d}_j$ is calculated as the follwing:

Relation 3:

$$\left[d_j^{L}, d_j^{U}\right] d_j = 1 - \left[E_j^{L}, E_j^{U}\right] = \left[1 - E_j^{U}, 1 - E_j^{L}\right] \quad ; \quad \forall_j$$

Then weigh is calculated:

Relation 4:

$$\left[w_j^{L}, w_j^{U}\right] w_j = \frac{\left[d_j^{L}, d_j^{U}\right]}{\sum_{j=1}^{n} d_j^{U}} = \left[\frac{d_j^{L}}{\sum_{j=1}^{n} d_j^{U}}, \frac{d_j^{U}}{\sum_{j=1}^{n} d_j^{U}}\right] \quad ; \quad \forall_j$$

The following table presents the results of determination of significance degree of sub-criteria of performance evaluation of sugar companies in stock exchange in Tehran calculated in line with coinciding with grey Shannon entropy algorithm, which was designed in software environment by the researcher.

Sub-criteria of performance evaluation		***Wj***	**Sub-criteria of performance evaluation**		***Wj***
X1	return of assets(ROA)	*[0.0008 , 0.0787]*	X9	Refined value added (REVA)	*[0.0002 , 0.1281]*
X2	Return of equity(ROE)	*[0.0035 , 0.0302]*	X10	(Tobin's Q)	*[0.0022 , 0.0854]*
X3	Operating Profit (OPG) Growth	*[0.0001 , 0.057]*	X11	Created Shareholder (CSV) Value	*[0.0024 , 0.0813]*
X4	Price earnings ratios	*[0.0042 , 0.0324]*	*X12*	Percentage of non-	*[0.0021 , 0.0149]*

	(P/E)			members managers	
X5	Economic Value (EVA) Added	*[0.0013 , 0.0901]*	*X13*	Percentage of institutional investors	*[0.0003 , 0.0603]*
X6	Market Value Added (MVA)	*[0.0026 , 0.0962]*			
X7	Cash Value Added (CVA)	*[0.0006 , 0.0762]*			
X8	True Value Added (TVA)	*[0.0001 , 0.17]*			

Table 6.2 Weight of sub-criteria of Accountancy based, value based, and corporate governance financial performance of sugar companies

6.2 Evaluation and ranking with grey relational analysis

6.2.1 Grey relational analysis

Grey system theory, is an algorithm that analyzes uncertain relationship of member of a system with a reference member and it has the ability of solving multiple criteria decision making. Grey relational analysis process is detailed as follows:

6-2-2- Grey Relational Generating

When the measurement units of performance of different indicators characteristics are various, effects of some indicators may be ignored. Also when some of the performance indicators have wide range, such event may happen. Also, if the target or direction of these indicators varies, incorrect results arise in the analysis [6]. Therefore, conversion of all performance values of each option to a comparative series seems necessary in a process like normalizing. This processing is called gray relationships generating step in gray systems theory.

In a multi indicators decision making problem which has m options and n indicators, Ith option can be expressed as $y_i = (y_{i1}, y_{i2}, \dots, y_{ij}, \dots, y_{in})$ *so that* y_{ij} is performance vale of indicator j for option i. Yi can be change into $\mathbf{X_i} = (x_{i1}, x_{i2}, \dots, x_{ij}, \dots, x_{in})$comparative series with help of one of the (10),(11) or (12) relations.

$$x_{ij} = \frac{y_{ij} - Min\{y_{ij}, i=1,2,\dots,m\}}{Max\{y_{ij}, i=1,2,\dots,m\} - Min\{y_{ij}, i=1,2,\dots,m\}} \quad (10)$$

$$i = 1,2,\dots,m \qquad j = 1,2,\dots,n$$

$$x_{ij} = \frac{Min\{y_{ij}, i=1,2,\dots,m\} - y_{ij}}{Max\{y_{ij}, i=1,2,\dots,m\} - Min\{y_{ij}, i=1,2,\dots,m\}} \quad (11)$$

$$i = 1,2,\dots,m \qquad j = 1,2,\dots,n$$

$$x_{ij} = \frac{|y_{ij} - y_j^*|}{Max\left\{Max\{y_{ij}, i=1,2,\dots,m\} - y_{ij}^*, y_{ij}^* - Min\{y_{ij}, i=1,2,\dots,m\}\right\}} \qquad 12)$$

$$i = 1,2,\dots,m \qquad j = 1,2,\dots,n$$

Relation (10) is used for indicator "larger, better" relation is used 11 for indicator "smaller, better" and relation 12, is used for the case which is near to desirable value of y_j^* is better.

6-2-3- Reference Sequence Definition

After generating gray relationships using 10, 11 and 12 equations all of the performance values put into [1,0] scale. If for an indicator *j* in option I, x_{ij}

Value, which is obtained from gray relational generating, is equal with 1 or be near to 1 more than other values ,it means that option I performance in j indicator is better than other options.so if for all the options the performance value equals to 1 ,this option will be the best choice. This paper defines reference sequence definition as $\mathbf{X_0} = (x_{01}, x_{02}, \dots, x_{0j}, \dots, x_{0n}) = (1,1,\dots 1,\dots,1)$ and then searches an option which its comparative series are nearer to this reference sequence definition.

6-2-4-Grey Relational Coefficient Calculation

Grey Relational Coefficient is used to determine xij proximity to x0j. When the gray relational coefficient is larger, xij is nearer to x0j. Grey Relational coefficient can be calculated using relation (13):

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta Min + \zeta \Delta \mathrm{Max}}{\Delta_{ij} + \zeta \Delta \mathrm{Max}} \qquad i = 1,2,\dots m \quad j = 1,2,\dots,n$$

In relation (13) γ (x0j, xij) shows Grey Relational Coefficient between xij and x0j in which:

$$\Delta_{ij} = x_{0j} - x_{ij}$$

$$\Delta Min = Min\{\Delta_{ij}, i = 1,2,\dots,m; j = 1,2,\dots,n\}$$

$$\Delta Max = Max\{\Delta_{ij}, i = 1,2,\dots,m; j = 1,2,\dots,n\}$$

Differentiation Coefficient: $-\zeta \epsilon [0,1]$

The purpose of the application of the differentiation coefficient is to extend or limit the gray relational coefficient scope.

6-2-5- Grey Relational Grade Calculation

After calculating $\gamma(x_{0j}, x_{ij})$ of all gray relational coefficients, Grey's relational grade can be calculated using relation (14):

$$\Gamma(x_0, x_i) = \sum_{j=1}^{n} w_{jy}(x_{0j}, x_{ij}) \qquad i = 1,2,\dots,m$$

Relation (14) shows the Grey's relational grade between x_i andx_0. In fact, this relation shows the correlation between the reference sequence definition and the comparative series. w_j Is j weight that usually depends on decision maker's judgment or the structure of the proposed issue. In addition, $\sum_{j=1}^{n} wj = 1$ [2]. As it was mentioned earlier, on each indicator, reference sequence definition shows the best performance that can be achieved between comparative series. Hence,

If a comparative series has the highest gray relational grade with reference sequence definition for an option, it means that this comparative series, has the highest similarity with the reference sequence definition and so this option is the best choice.

The following table shows performance evaluation and grading of sugar companies operating in Tehran Stock Exchange based on Grey relational analysis algorithm which is calculated in software environment designed by researcher.

Table6-3. Grey relational matrix with sugar industry 0.5 differentiation coefficient

	X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*X9*	*X10*	*X11*	*X12*	*X13*
Piranshahr sugar	0.76	0.34	0.647	0.337	0.871	0.831	1	0.376	0.994	0.946	0.629	0.714	0.823
Lorestan sugar	1	0.344	0.389	0.334	0.995	0.481	0.564	0.471	0.556	0.454	0.999	0.5	0.988
Hegmataneh sugar	*0.58*	*0.35*	*0.403*	*0.336*	*0.59*	*0.806*	*0.38*	*0.674*	*0.49*	*0.761*	*0.4*	*0.668*	*0.997*
Khurasan sugar	*0.336*	*0.338*	*0.382*	*0.998*	*0.333*	*0.42*	*0.548*	*0.579*	*0.361*	*0.342*	*0.359*	*1*	*0.736*
Marvdasht sugar	*0.61*	*0.37*	*0.443*	*0.338*	*0.512*	*0.542*	*0.34*	*0.576*	*0.422*	*0.994*	*0.389*	*0.745*	*0.335*
Naghsh jahan sugar	*0.449*	*0.341*	*0.376*	*0.335*	*0.526*	*0.997*	*0.651*	*0.427*	*0.373*	*0.356*	*0.334*	*0.862*	*0.565*

shahd	*0.479*	*0.34*	*1*	*0.379*	*0.417*	*0.432*	*0.594*	*0.334*	*0.334*	*0.439*	*0.345*	*0.608*	*0.609*
Torbat jam sugar	*0.342*	*0.992*	*0.352*	*0.333*	*0.439*	*0.334*	*0.357*	*1*	*0.415*	*0.343*	*0.38*	*0.333*	*0.542*
Shahrood sugar	*0.372*	*0.341*	*0.548*	*0.349*	*0.464*	*0.405*	*0.337*	*0.487*	*0.409*	*0.4*	*0.37*	*0.862*	*0.535*
Neyshaboor sugar	*0.36*	*0.338*	*0.336*	*0.344*	*0.452*	*0.372*	*0.347*	*0.465*	*0.423*	*0.386*	*0.51*	*0.937*	*0.505*
Shirin khurasan sugar	*0.38*	*0.342*	*0.991*	*0.358*	*0.394*	*0.368*	*0.403*	*0.389*	*0.409*	*0.334*	*0.358*	*0.5*	*0.402*

Table 6-4. Sugar companies grading

differentiation coefficient 0.5		
company	*Degree*	*Grade*
Piranshahr sugar	*0.713*	*1*
Lorestan sugar	*0.621*	*2*
Hegmatan sugar	*0.572*	*3*
Sabet khorasan sugar	*0.518*	*4*
Marv dasht sugar	*0.509*	*5*
Naghsh jahan sugar	*0.507*	*6*
Shahd	*0.485*	*7*
Torbat jam sugar	*0.474*	*8*
Shahrood sugar	*0.452*	*9*
Neyshaboor sugar	*0.444*	*10*
Shirin khurasan sugar	*0.433*	*11*

According to the results in the above tables Piranshahr sugar Company is chosen as a company with best performance and maximum grading in sugar Industry in the Tehran Stock Exchange during the years 1382-1391.

7. Discussion and conclusions

Generally, in the financial analysis, one or two key indicators such as each stock interest or investment rate yield are considered as decision-making criteria. However, not only some relations are existed but also these criteria, in addition to Inherent conflict, have different desirability levels. In addition, capital and financial markets are constantly a fluctuating market that naturally there is change and lack of knowledge in them and also influence on them significantly. Grey relational analysis method considers inputs as interval numbers for multi-criteria decision making in addition to investigating the relationship between various parameters and options which, in fact, will display the uncertainty in the input structure and decision-making system; In addition, it is a simple and practical model which covers the above methods simultaneously.

In this method, unlike most of the decision-making procedures, first, it is not necessary to have accurate information and Gray theory, using Gray number concept provides acceptability and use of unreliable information. Second, in this method multiple criteria are expressed simultaneously and the relationships between them are applied in the model. To determine the importance of Criteria degree Grey Shannon entropy has this advantage that determines weights in the intervals to use in the Gray relational analysis and it is an objective method and there are not private expert opinions in it; Thus, if the conditions are such that there is probability of error in the judgment of experts, using of this method can be a good and acceptable alternative. In information theory entropy shows uncertainty in expected information content of a message. In other words, entropy is a criterion for amount of uncertainty expressed by a discrete probability distribution (pi), Such that if the distribution spreads, this uncertainty is more than the time in which frequency distribution is sharper.

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