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An Integrated Assessment of Companies Based on Value based Measures in Fuzzy Environment

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abstract: In today's world economy, firms focused on the maximization of shareholder value need to ensure that all activities yield positive net present values. Value based financial performance measures have been developed in an attempt to guide management actions towards achieving this objective. In this study, a hybrid approach is proposed for value based financial performance evaluation of automotive parts manufacturer companies of Tehran stock exchange (TSE). For this purpose, in this study based on eight value based measures an integrated fuzzy multi criteria decision making approach is presented for value based financial performance evaluation of companies. In current approach Fuzzy Analytic Hierarchy Process (FAHP) is applied to determine the weights of the criteria. Then the companies are ranked by Fuzzy Complex Proportional Assessment (Fuzzy COPRAS), simultaneously. The results represented the importance of each value based measures in financial evaluation of fourteen Iranian companies and ranking companies by applying the proposed approach.

Key Words: Assessment of companies, Value based measures, Fuzzy Analytic Hierarchy Process (FAHP), Fuzzy Complex Proportional Assessment (Fuzzy COPRAS)

Contents

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1. Introduction

The choice of financial performance measures is one of the most critical challenges facing organizations. Performance measurement systems play a key role in developing strategic plans, evaluating the achievement of organizational objectives, and rewarding managers [1]. In a competitive environment, characterized by the scarcity of resources, performance measurement and management play a crucial role [2]. Value based measures are presented by their proponents as a major improvement over the traditional performance measures. Most importantly, by including the firms cost of capital in their calculation they could be applied in order to evaluate the value creating potential of a firm. These measures also attempt to overcome some of the problems associated with the traditional measures by removing the accounting distortions contained in the financial statements [3].

On the other hand most of the economical, industrial, financial or political decision problems are multi attribute. Multiple Criteria Decision Making (MCDM) is an advanced field of operation research. It provides decision makers and analysts with a wide range of methodologies, which are overviewed and well-suited to the complexity of economical decision problems [4]. The application of multi-criteria decision making methods significantly improves the robustness of financial analysis and business decisions in general [5]. MCDM is considered as a complex decision-making tool involving both quantitative and qualitative factors, it has grown as a part of operations research, concerning with designing computational and mathematical tools for supporting the subjective evaluation of performance criteria by decision makers [6]. In recent years, several fuzzy MCDM tools have been developed to ranking the various alternative in one problem.

In the current research, multi-criteria model based on value based measures is presented, also a hybrid approach of MCDM methods in Fuzzy environment for an integrated financial assessment of Iranian companies is provided. At first FAHP (Fuzzy Analytic Hierarchy Process) is used to determine the weights of the main criteria and sub criteria. Fuzzy COPRAS (Fuzzy Complex Proportional Assessment) are applied simultaneously for ranking the automotive parts manufacturer companies traded on Tehran stock exchange in 2002-2011.

2. Review Of Some Studies On Financial Performance Assessment By Using MCDM Techniques

Several studies on financial performance assessment are focused on ranking the alternatives according to their financial performance measures, included in their comparison environments. Secme et al. (2009) used FAHP and TOPSIS for evaluating of five Turkish banks [7]. Wang and Lee (2010) evaluated three shipment companies in their study by using Grey Relation Analysis (GRA) [8]. Kung et al. (2011) applied fuzzy MCDM methods for selecting the best company, based on financial report analysis. The approach used FAHP to select weighting indicators and FTOPSIS (Technique for Order Preference by Similarity to Ideal Solution) for outranking the five major airlines [9]. Balezentis et al. (2012) used FTOPSIS, FVIKOR and FARAS methods for integrated assessment of Lithuanian economic in

2007-2010 periods, based on financial ratios [5]. Ergul and Seyfullahogullari (2012) applied ELECTRE III for ranking of retail companies trading in Istanbul stock exchange (ISE), based on their financial performance in 2008-2010 [10]. Lee et al. (2012) performed a comparative study on financial positions of shipping companies in Taiwan and Korea. At first the study applied Entropy to find the relative weights of financial ratios of four companies, and then it used grey relation analysis to rank the companies [11]. Yalcin et al. (2012) constructed a hierarchical structure of the financial performance model for ISE's manufacturing company. The approach used FAHP, VIKOR and TOPSIS [12]. Bayrakdaroglu and Yalcin (2012) proposed to use MCDM for strategic financial performance evaluation of ISE. The research applied FAHP for determining the relative significances of criteria and used VIKOR for best company selection [13]. Ignatius et al. (2012) surveyed financial performance of Iran's Automotive Sector based on PROMETHEE II in the study [14]. Cheng et al. (2012) developed an approach combining fuzzy integral with Order Weight Average (OWA) method for evaluating financial performance in the semiconductor industry of Taiwan in 2008 [15]. Khalili Esbouei and Safaei Ghadikolaei (2013) in their study to ranking ten parts manufacturer companies based on six value based measures and accounting measures, used FAHP to calculate the weights of criteria and used ARAS method to ranking alternatives [16]. Safaei Ghadikolaei et al. (2014) in their study about financial performance evaluation of companies with applying fuzzy MCDM methods used FAHP to determine the weights of criteria and fuzzy VIKOR, fuzzy ARAS and fuzzy COPRAS to select best alternative among six Iranian companies [17]. Khalili Esbouei et al (2014) for ranking manufacturing companies used Fuzzy ANP for calculating weight of criteria and Fuzzy VIKOR for evaluation ofalternatives in their study [18].

3. Value Based Measures For Companies Assessment

In this study, for assessment of companies, several value based measures is selected with help of the financial experts and presented in the different studies. An integrated approach of MCDM methods in Fuzzy environment for financial assessment of companies also provided.

In this study, eight value based measures are determined as the criteria. These measures are Value based Added (EVA), Market Value Added (MVA), Refined Value based Added (REVA), True Value Added (TVA), Cash Value Added CVA, Equity Value based Added (EEVA), Created Shareholder Value (CSV) and Tobin's Q . Formulation of These criteria measures are briefly explained in the Table 1.

Table 1: Formulation of value based measures

Value based measures	Formula	Study
Value based Added (EVA)	$EVA_t = Net\ operating\ profit\ after\ tax_t$ $-(Weighted\ average\ cost\ of\ capital_t \times Capital\ employed_{t-1})$	[12]
Market Value Added (MVA)	$MVA = Total\ market\ value - Total\ capital\ employed$	[13]
Cash Value Added (CVA)	$CVA = Gross\ cash\ flows - Economic\ depreciation - Capital\ charge$	[12]
True Value Added (TVA)	$TVA = Free\ cash\ flow + Capital\ gains - Market\ value \times (1 + Weighted\ average\ cost\ of\ capital))$	[13]
Refined Value based Added (REVA)	$REVA_t = Net\ operating\ profit\ after\ tax_t - Weighted\ average\ cost\ of\ capital(Mcapital_{t-1})$	[19]
Equity Value based Added (EEVA)	$EEVA = Net\ operating\ profit\ less\ adjusted\ tax - Cost\ of\ equity$	[13]
Tobin's Q	$Tobin's\ Q = \frac{Market\ value + Book\ value\ of\ Liabilities}{Book\ value\ of\ assets}$	[20]
Created Shareholder Value (CSV)	$CSV = Market\ value\ of\ equity \times (Shareholder\ return - Cost\ of\ equity)$	[21]

4. Fuzzy Analytic Hierarchy Process (FAHP)

Analytic Hierarchy Process (AHP) was introduced by Saaty (1971) [22]. In the current research the weights of financial performance criteria are obtained by using extent FAHP method. That is because of the computational easiness and efficiency [12].

Calculation of FAHP can be described as follows:
Assume that $O = \{o_1, o_2, o_3, ..., o_n\}$, be an object set, and $G = \{g_1, g_2, g_3, ..., g_m\}$, be a goal set. 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: $\tilde{Q}^1_{g_i}, ..., \tilde{Q}^2_{g_i}, ..., \tilde{Q}^m_{g_i}$, $i = 1, 2, ..., \alpha$,where all the $\tilde{Q}^m_{g_i}(j = 1, 2, \ldots, m)$ are triangular fuzzy numbers (TFNs).

The further steps of extent FAHP can be given as follows.

Step 1. The value of fuzzy synthetic extent with respect to the ith object is defined as

$$\tilde{S}_i = \sum_{j=1}^{m} \tilde{Q}^j_{g_i} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{Q}^j_{g_i} \right]^{-1}, \tag{4.1}$$

to obtain $\sum_{j=1}^{m} \tilde{Q}^j_{g_i}$, perform the fuzzy addition operation of β extent analysis values for a particular matrix such that:

$$\sum_{j=1}^{m} \tilde{Q}_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right), \tag{4.2}$$

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{Q}_{g_i}^{j}\right]^{-1}$, perform the fuzzy addition operation of $\tilde{Q}_{g_i}^{j}$ ($j = 1, 2, \ldots, \beta$) values such that

$$\sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \tilde{Q}_{g_i}^{j} = \left(\sum_{i=1}^{\alpha} l_i, \sum_{i=1}^{\alpha} m_i, \sum_{i=1}^{\alpha} u_i \right). \tag{4.3}$$

Then the inverse of the vector above is computed:

$$\left[\sum_{i=1}^{\alpha} \sum_{j=1}^{\beta} \tilde{Q}_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{\alpha} u_i}, \frac{1}{\sum_{i=1}^{\alpha} m_i}, \frac{1}{\sum_{i=1}^{\alpha} l_i} \right). \tag{4.4}$$

Step 2. As $\tilde{Q}_1 = (l_1, m_1, u_1)$ and $\tilde{Q}_2 = (l_2, m_2, u_2)$are two triangular fuzzy numbers, the degree of possibility of $\tilde{Q}_2 \geq \tilde{Q}_1$ defined as

$$V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right) = \sup_{y \geq x} \left[\min\left(\mu_{\tilde{Q}_1}(x), \mu_{\tilde{Q}_2}(y) \right) \right], \tag{4.5}$$

and can be equivalently expressed as follows:

$$V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right) = hgt\left(\tilde{Q}_1 \cap \tilde{Q}_2\right) = \mu_{\tilde{Q}_2}(d) = \begin{cases} 1, & if\, m_2 \geq m_1 \\ 0, & if\, l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & O.W \end{cases} \tag{4.6}$$

where d is the ordinate of the highest intersection point D between $\mu_{\tilde{Q}_1}$and $\mu_{\tilde{Q}_2}$ (see Fig.2).

To compare $\tilde{Q}_1$ and $\tilde{Q}_2$, we need both values of $V\left(\tilde{Q}_1 \geq \tilde{Q}_2\right)$ and $V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right)$.

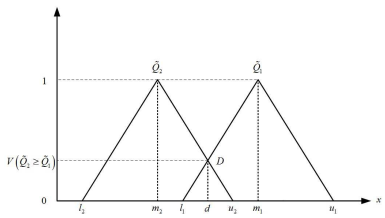

Figure 1: The intersection between $\tilde{Q}_1$ and $\tilde{Q}_2$.

Step 3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $\tilde{Q}_i$ (i = 1, 2, … , k) numbers can be defined by

$$V\left(\tilde{Q} \geq \tilde{Q}_1, \tilde{Q}_2, ..., \tilde{Q}_k\right) = V\left[\left(\tilde{Q} \geq \tilde{Q}_1\right) and \left(\tilde{Q} \geq \tilde{Q}_2\right) ...and \left(\tilde{Q} \geq \tilde{Q}_k\right)\right] = \min V\left(\tilde{Q} \geq \tilde{Q}_1\right), i = 1, 2, 3, ..., k. \tag{4.7}$$

Assume that $d'(P_i) = \min V(S_i \geq S_k)$ for $k = 1, 2, ..., n;\ k \neq i$. Then the weight vector is given by

$$W' = (d'(P_1), d'(P_2), ..., d'(P_n))^T, \tag{4.8}$$

where $P_i\,(i = 1, 2, ..., n)$ are n elements.

Step 4. Via normalization, the normalized weight vectors are

$$W = (d(P_1), d(P_2), ..., d(P_n))^T, \tag{4.9}$$

where W is a non-fuzzy number.

5. Fuzzy COPRAS

Let us assume the fuzzy decision making matrix $\tilde{Y} = \tilde{y}_{ij}$, where $i = 1, 2, ..., m$ and $j = 1, 2, ..., n$ represent the number of alternatives and criteria, respectively. In this study $m = 6andn = 11$. The jth criterion of the ith alternative is represented by triangular fuzzy number $\tilde{y}_{ij} = (y_{ij_1}, y_{ij_2}, y_{ij_3})$. Also each jth criterion is assigned with respective coefficient of significance w_j, that it obtained by FAHP. Benefit criteria are members of benefit criteria set B, while cost criteria are members of respective set C.

COPRAS method was first put forward by Zavadskas and Kaklauskas (1996) [23]. Fuzzified COPRAS was presented by Zavadskas and Antucheviciene (2007) [24]. It is used to prioritize the alternatives on the basis of several criteria along with the associated criteria weights. This method works on a stepwise ranking and evaluation procedure of the alternatives in terms of their significance and utility degree. Crisp or modified method for uncertain environment has been successfully applied in for maintenance strategy or performance evaluation, for selection of effective decisions in construction or management ([25]; [26]; [27]; [28]; [29]; [30]; [31]; [32]).

Calculations of Fuzzy COPRAS can be described as follows [17]:

Step 1. Normalize the values of $\tilde{d}_{ij}$by using the following formula:

$$\bar{\tilde{y}}_{ij} = \frac{\tilde{y}_{ij}}{\sum_{i=1}^{m} \tilde{y}_{ij}}, \; j = 1, 2, ..., n\,. \tag{5.1}$$

Step 2. Determine the weighted normalized decision matrix:

$$\hat{\tilde{y}}_{ij} = \bar{\tilde{y}}_{ij} \times \tilde{w}_j, \forall j, i, \tag{5.2}$$

where $\bar{\bar{y}}_{ij}$ is the normalized performance value of ith alternative on jth criteria and w_j is the associated weight of the jth criteria.

Step 3. The sums $S_i^+$and $S_i^-$of weighted normalized values are calculated for both beneficial and non-beneficial criteria, respectively. For benefit criteria, higher value is better and for cost criteria, lower value is better for the attainment of goal. S_i^+ and S_i^- are calculated using the following equations:

$$\begin{aligned} \tilde{S}_i^+ &= \textstyle\sum_{j=1}^{k} \hat{\tilde{y}}_{ij} \ \ \forall j \in B, \\ \tilde{S}_i^- &= \textstyle\sum_{j=K+1}^{k} \hat{\tilde{y}}_{ij}, \forall j \in C. \end{aligned} \tag{5.3}$$

Step 4. Determine the relative importance or priorities of the candidate alternative by the following equation:

$$\tilde{H}_i = \tilde{S}_i^+ + \frac{\sum_{i=1}^{m} \tilde{S}_i^-}{\tilde{S}_i^- \sum_{i=1}^{m} \frac{1}{\tilde{S}_i^-}}. \tag{5.4}$$

Step 5. Since $\tilde{H}_i = (h_{i1}, h_{i2}, h_{i3})$, $i = 0, 1, ..., m$, is a fuzzy number, the COA method is applied for defuzzification:

$$H_i = \frac{h_{i1} + h_{i2} + h_{i3}}{3}, \ i = 0, 1, ...m, \tag{5.5}$$

The relative importance H_i of an alternative shows the extent of satisfaction attained by that alternative. Among the alternatives, one with the highest H_i value is the best alternative.

Step 5. Calculate the performance index (PI_i) of each alternative as

$$PI_i = \frac{H_i}{H_{\max}} \times 100\% \,. \tag{5.6}$$

Here H_{max} is the maximum value of relative importance. PI_i value is utilized to get complete ranking of the alternatives.

6. Financial Assessment Process

The aim of this study is to present an integrated approach to assessment the performance of the companies in the Iran, traded on TSE, by using value based measures in a fuzzy environment. This approach was applied for evaluation of automotive parts manufacturer companies of TSE in 2002-2011, i.e. in a period of ten years. Fourteen companies were selected for this study. For this period of the research, annual financial statements of companies which passed independent external auditing are considered. Data was gathered from the TSE's Database and using Rahavard Novin software.

6.1. Determining The Weights Of Criteria

To evaluate the importance of the criteria and compose the fuzzy pairwise matrix, expert group (decision makers) utilized the membership function of linguistic scale. The scale is presented in Table 2.

The pairwise comparison scores have been carried out by three financial experts. Experts were asked to make pairwise comparisons for all evaluation criteria based on Table 2. In this study for testing the consistency ratio (CR) of fuzzy pairwise matrix, Lin (2010) approach was used. If the CR is greater than 0.1, the result is not consistent, and the pair-wise comparison matrix must be revised by the evaluator. Let $\tilde{Z} = [\tilde{z}_{ij}]$ be a fuzzy judgment matrix with triangular fuzzy number $\tilde{z}_{ij} = (\alpha_{ij}, \beta_{ij}, \gamma_{ij})$ and form $Z = [\beta_{ij}]$. If Z is consistent, then $\tilde{Z}$ is consistent [34].

Table 2: Membership function of linguistic scale [33]

Linguistic scale	Positive triangular fuzzy numbers	Positive reciprocal triangular fuzzy numbers
Absolutely importance	(8, 9, 10)	(1/10, 1/9, 1/8)
Intermediate	(7, 8, 9)	(1/9, 1/8, 1/7)
Very strongly	(6, 7, 8)	(1/8, 1/7, 1/6)
Intermediate	(5, 6, 7)	(1/7, 1/6, 1/5)
Strong	(4, 5, 6)	(1/6, 1/5, 1/4)
Intermediate	(3, 4, 5)	(1/5,1/4,1/3)
Weakly	(2, 3, 4)	(1/4,1/3,1/2)
Intermediate	(1, 2, 3)	(1/3, 1/2, 1)
Equally importance	(1, 1, 1)	(1, 1, 1)

After computing the result of expert groups assessment, Lin (2010) approach was used to obtain the consistency ratio of each expert's pare wise matrix. Consistency ratio values are less than the acceptable threshold value (i.e., CR < 0.1).

Table 3 shows the weights of the criteria were obtained by FAHP. CVA, TVA, REVA have highest weight among criteria, respectively, so TSE's companies should Pay special attention to this measures about their value based financial performance.

6.2. Ranking The Alternatives

The following approach was used for convert crisp numbers of financial measures into fuzzy numbers. As for time series data, a fuzzy number can represent the dynamics of certain indicator during past t=10 periods [5]:

$$\left(Min(x_{ij}), \frac{\sum_{i=1}^{10} x_{ij}}{10}, Max(x_{ij}) \right), \forall i, \forall j, \tag{6.1}$$

Where x_{ij} is the value of jth criterion of the ith alternative in each year (2002-2011).

Table 3: Weights of criteria obtained from FAHP

Criteria	Weights	Rank
EVA	0.0957	6
MVA	0.1461	4
CVA	0.1921	1
TVA	0.1703	2
REVA	0.1514	3
Tobin's Q	0.0444	8
EEVA	0.1221	5
CSV	0.0778	7

Let assume $\tilde{Y}_{ij} = (z_{ij_1}, z_{ij_2}, z_{ij_3})$ are the initial values of each criterion, obtained using Eq. 22. As some of values in each criteria were negative, for preventing of any problem in computation, all the values in each criterion are transformed to positive values by the following equation:

$$\tilde{y}_{ij} = (z_{ij_1} - \min z_{ij_1} + 1, z_{ij2} - \min z_{ij_1} + 1, z_{ij3} - \min z_{ij_1} + 1), \forall i, \forall j. \tag{6.2}$$

Indeed the above equation is the same as $\tilde{y}_{ij} = (y_{ij_1}, y_{ij_2}, y_{ij3})$ in the computation steps of methods.

As it was mentioned, fourteen Iranian automotive parts manufacturer companies are analyzed.

Table 4 shows the results obtained from Fuzzy COPRAS. In this proposed model all the criteria are of benefit, while for applying COPRAS a cost criterion is necessary. Hence values of one criterion (Tobin's Q) for all alternatives have been reversed for feasibility of using Fuzzy COPRAS method for this study.

As it shown in table 4, among fourteen companies, GHAT had best performance based on proposed model in ten years.

7. Conclusion

In today's world economy, firms should focus on the maximization of shareholder value, for this aim they need to ensure that all activities yield positive net present values. Value based financial performance measures have been developed in an attempt to guide management actions towards achieving this objective. In this context, this study displays an integrated fuzzy approach for the financial performance assessment based on eight value based measures.

In the proposed approach, at first FAHP is used to determine the weights of the criteria. Then Fuzzy COPRAS are used for ranking the companies based on value based measures, simultaneously.

Results showed to achieve better performance evaluation, companies should pay more attention to CVA, TVA , REVA and other measures in line with calculated their relative significances.

Table 4: Fuzzy COPRAS ranking results

Company	H	PI	Rank
ATIR	0.02850	85.54	6
KRIR	0.02931	87.96	4
RADI	0.02784	83.53	8
RTIR	0.02953	88.60	3
ZMYD	0.03057	91.73	2
AZIN	0.02519	75.59	14
RIIR	0.02734	82.03	10
KFAN	0.02726	81.82	11
FNAR	0.02707	81.25	12
GHAT	0.03332	100.00	1
LENT	0.02906	87.21	5
MESI	0.02811	84.35	7
NMOH	0.02755	82.66	9
INDM	0.02623	78.72	13

A case study of automotive parts manufacturer companies traded on TSE in 2002-2011 is presented. The proposed approach is applied for measuring value based performance of companies in uncertain environment with respect to multiple criteria.

Further study can include some other value based measures, in addition to the proposed methods in this study, some other Fuzzy or Gray MCDM methods can be used in this subject.

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