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Procedia Computer Science 31 (2014) 995 – 1004

Procedia Computer Science

Information Technology and Quantitative Management (ITQM 2014)

Application of Fuzzy AHP Approach for Financial Performance Evaluation of Iranian Petrochemical Sector

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Abstract

Organizational performance evaluation is a very vital and sensitive process in any industry. One of the most crucial aspects of performance assessment is consideration of financial performance evaluation. In this kind of evaluation, we face many criteria and index to performing and also designing a comprehensive and effective model. Thus, this situation can be regarded as a fuzzy multiple criteria decision-making (MCDM) problem, so the fuzziness and uncertainty of subjective perception should be considered. In this paper performance evaluation of seven active companies in the petrochemical industries was evaluated using combined method of fuzzy and analytic hierarchy process. In this paper at the first, Iranian petrochemical industry was studied and then the required framework for a good decision making model was introduced after that financial evaluation criteria and the main financial ratios used in this article was defined the criteria are as follows: current ratio, quick ratio, debt ratio, long term debt, EBIT, total asset, inventory turnover ratio, total asset turnover ratio, fixed asset turnover ratio, receivable accounting turnover ratio, net profit margin, ROI, ROE, asset growth, shareholder's equity growth are among the financial criteria that were used, in the nest stage fuzzy set and fuzzy AHP is described and results of analysis have been presented.

Keywords: Fuzzy analytic hierarchy process (FAHP), Multi-criteria decision making (MCDM), Performance evaluation, Financial ratios.

1. Introduction

Petrochemical industry as one of most strategic industries in Iran is faced with challenges that one of the most important of them is investment in. Forty percent of Iran non-petroleum exports is related to

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doi:10.1016/j.procs.2014.05.352

Petrochemical industry. Iran is one of the largest manufacturer and exporter of petrochemical producer and the fourth of polyethylene Manufacturer in the world (http://www.forum.boursekala.com). The petrochemical industry has ability and opportunity to produce and supply the products with high added value and can play an important role in improving Iran's economic position, eliminate unemployment, job creation and income. Looking at the petrochemical industry share in Iran's economic situation, can be find the real place of this industry in the economy of Iran.

A good decision-making model needs to tolerate vagueness or ambiguity because fuzziness and vagueness are common characteristics in many decision-making problems [1]. 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 sauciest and uncertainty should be considered in some or all pair wise comparison values [1]. Since the fuzzy linguistic approach can take the optimism/pessimism rating attitude of decision makers into account, linguistic values, whose membership functions are usually characterized by triangular fuzzy numbers, are recommended to assess preference ratings instead of conventional numerical equivalence method [2].

There are a lot of studies that applied fuzzy AHP methods to solve different managerial problems [3]. Yalcin et al proposed a new financial performance evaluation approach using fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries [4].

Yu et al developed an evaluation model based AHP, fuzzy sets and TOPSIS to rank e-commerce websites in e-alliance [5]. Shaverdi *et. al* also defined a fuzzy based evaluation model for evaluating Iranian banking performance [6].

In this paper, we apply fuzzy AHP model for performance evaluation of Iranian petrochemical industry based on financial index. Firstly, the financial ratios have extracted by consideration of literature review as well as financial experts ideas. Secondly, the hierarchical performance evaluation model is designed and some questionnaires distributed among academic and experimental experts. Thirdly, the filled questionnaires were gathered and by using of fuzzy AHP model, the final weights and accordingly the ranking of companies were calculated.

2. Financial Performance

To evaluate performance of these companies, here traditional financial performance measures will be used to evaluate this. Financial performance measures are divided into two groups.

2-1- Traditional accounting-based financial performance measure:

Measures such as ROA, ROE, EPS and P/E are called traditional accounting-based financial performance measures which will be explained as follows:

2-1-1- Return on Assets (ROA):

This measure specifies the efficiency of using resources for make earning. This measure can be calculated using the following formula [7]:

$$ROA = \frac{Net\ Income\ Available\ to\ Common\ Stockholders}{Total\ Assets}$$

Also ROA can be calculated by multiplying profit margin by total assets turnover so (Brigham & Ehrhardt, 2011):

$$ROA = Profit\ margin \times Total\ assets\ turnover = \frac{Net\ Income}{Sales} \times \frac{Sales}{Total\ Assets}.$$

ROA shows how the profit a company is able to generate for each dollar of assets invested [8].

2-1-2- Return on equity (ROE)

ROE specifies the profitability with the invested money of shareholders and it is used to determine the real cost of spending money [9]. ROE can be calculated with different ways but the most common way to calculate ROE is as follows[10]:

$$ROE = ROA \times Equity\ multiplier = \frac{Net\ Income\ available\ to\ common\ stockholders}{Stockholders\ Equity}$$

ROE can be calculated by multiplying the ROA by the equity multiplier which is the ratio of assets to common equity so we have [11]:

$$ROE = ROA \times Equity\ multiplier = \frac{Net\ Income}{Total\ Assets} \times \frac{Total\ Assets}{Common\ equity} = \frac{Net\ Income}{Common\ equity}$$

Generally companies with relatively high ROE rates sell at higher multiple of book value than those with low returns.

2-1-3- Earnings per Share (EPS)

EPS is the indicator of each outstanding share of a company. The objective of basic EPS is to provide a measure of the interests of each ordinary share of a parent entity in the performance of the entity [12]. It can be used to answer the question of if a coany is growing and it can be calculated by [13]:

$$EPS = \frac{Net\ Income\ Available\ to\ Shareholders}{Number\ of\ Outstanding\ Shares}.$$

2-1-4- Price earnings ratio (P/E)

Under certainty and perfect markets, the price of a security is equal to the present value of the future cash flows and under assumptions of: 1. Constant dividend payout ratio (k), 2. Constant growth in earnings per share (g) and 3. A constant riskless rate (r), P/E can be calculated by Gordon-Shapiro valuation equation as follows [14]:

$$\frac{\mathrm{P}}{\mathrm{E}} = \frac{1-b}{\mathrm{r}-\mathrm{g}}.$$

But the formula usually can be modified in the absent of further investment and consider permanent earnings. The P/E ratio indicates how much investors are willing to pay for buying shares per dollar of current earnings. P/E ratio is the most popular measure for performance analysis while there are other factors that an investor should consider before making an investment decision. It can be calculated using the following formula [11]:

$$P/E = \frac{K}{r-g}.$$

-2-Modern Value-based Performance Measures

There are also some other criteria that are called modern value-based financial performance measures, performance measures such as EVA, CFROI, CVA are among them. The Modern Value-based financial performance measures are as follows:

2-2-1- Economic Value Added (EVA)

EVA is a developing concept for measuring financial performance [15]. Concept of EVA was presented by Stern Stewart for the first time [16] is the base for theory of evaluating enterprise value that is researched by many of researchers such as Franco Modigliani [17].The difference between net operating income of a company after taxes and its cost of capital of both equity and debt and many of giant corporate such as Coca-Cola and AT & T are very satisfied with EVA and it lead to sudden popularity of EVA [18]. EVA is an accounting-based, single period measure of corporate performance and there are some ways to calculate EVA that can be explained as follows [19]:

One way to calculate EVA for each year is to multiply company's economic book value of capital C at the beginning of the year by the difference between its return on Capital r and it cost of capital k and It can be written as follows:

$$EVA_t = (r_t - k_t) \times C_{t-1}$$

Another way which may make sense more is to think that EVA is the difference between net operating profit of a firm after taxes and its cost of capital:

$$EVA_t = NOPAT_t - (k_t \times C_{t-1})$$

2-2-2- Market Value Added (MVA)

MVA is a market-generated number and can be calculated as follows [18]:

It can be calculated by subtracting the capital invested in a company C from the sum V of the total market value of the firm's equity and the book value of its debt:

$$MVA_t = V_t - C_t$$

Generally MVA is the present value of a series of EVA values [20] or in the presence of excess of capital invested by shareholders it is a measure of value created by management [21].

Also is the best external measure of management performance in the long term and can be calculated as follows [22]:

MVA= Total Market Value-Total Capital Employed

2-2-3- Cash Flow Return on Investment (CFROI):

Cash flow return on investment (CFROI) is an internal rate of return and it provides a consistent basis for evaluating companies regardless of their size and this characteristic makes it very popular among money management community for comparing companies against each other to make investment decisions [23].

To calculate CFROI a five-step process is used that is described as follows [24]:

- Calculate the average life of the firm's assets
- Calculate gross cash flow
- Calculate gross cash investment
- Calculate sum of all non-depreciating assets such as land, working capital and other assets.
- Solve the equation for CFROI.

2-2-4- Cash Value Added (CVA)

CVA is a measure that can determine amount of cash a company generates through its operations. CVA can be calculated as follows [9]:

CVA=Gross Cash Flows (operating)-Economic Depreciation-Capital Charge

Current ratio: Current ratio is equal to current assets divided by current liabilities [25].

Quick Ratio: Quick ration is a variation of the current ratio while in the numerator include those current assets of the firm that could convert quickly into cash [25] (Stickney & Brown, 1999).

2-2-5-Debt Ratio

Debt Ratio is used to measure the amount of liabilities usually long-term debt and can be calculated by dividing total liabilities by total assets [25].

After defining all financial ratios, the proposed financial evaluation model should be identified. The final model of evaluation framework is shown in Fig. 1.

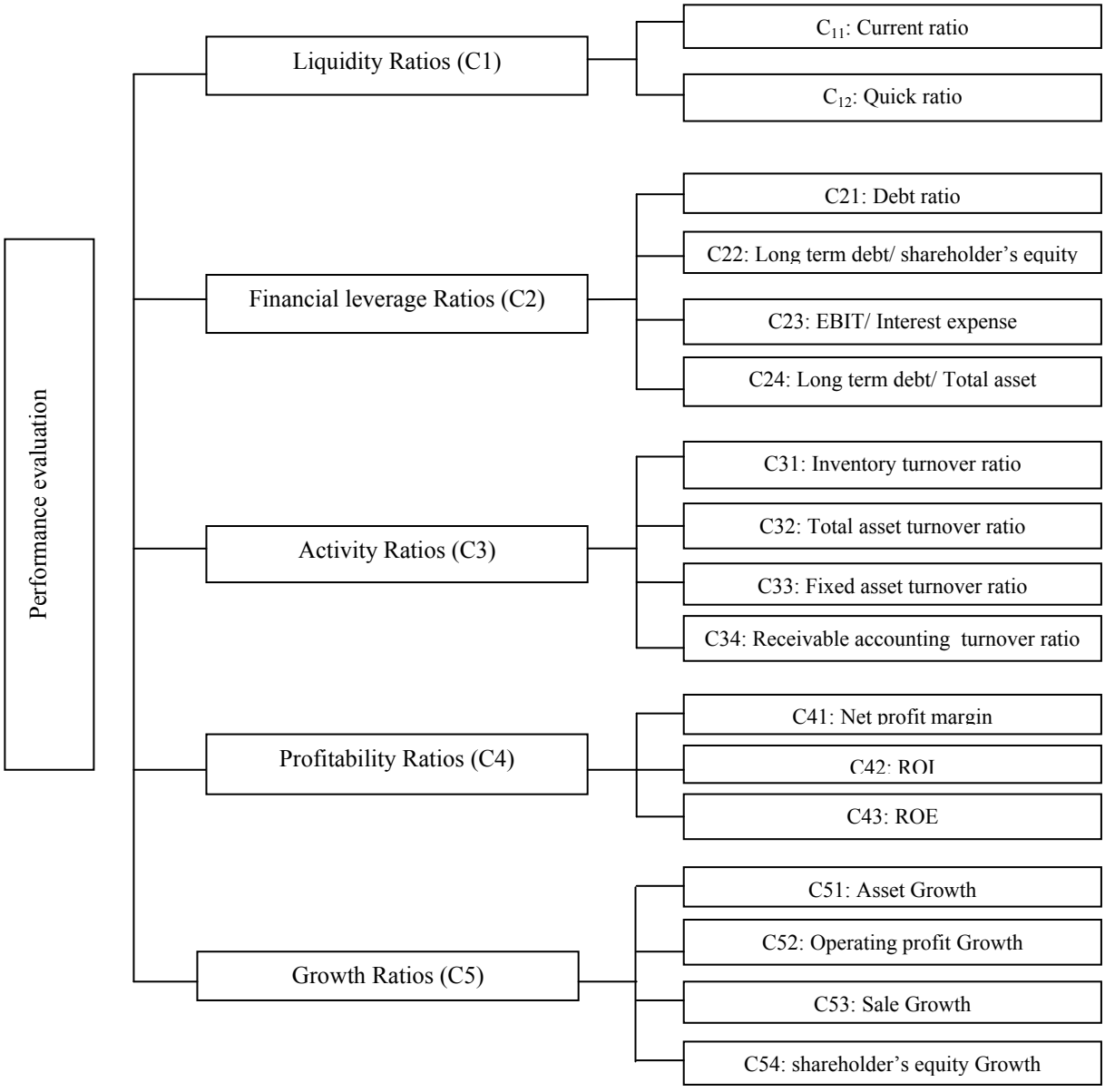

Fig. 1. Proposed evaluation framework

3. Fuzzy Sets and Fuzzy AHP

The fuzzy set theory was introduced by Zadeh [26]. Fuzzy set theory provides a strict mathematical framework in which vague conceptual phenomena can be precisely and rigorously studied [27]. Fuzzy set theory is a suitable tool to reinforcement the comprehensiveness and correctness of the decision making stages. Fuzzy set theory is an important approach to provide measuring the uncertainly of concepts that are associated with human beings' subjective judgments including linguistic terms, satisfaction level and importance level that are often vague. A linguistic variable is a variable whose values are not quantitative but phrases in a natural language. The concept of a linguistic variable is very beneficial in dealing with situations, which are too complicated or not well defined to be rationally described in usual quantitative expressions [27]. For example, lingual expressions, such as satisfied, fair, dissatisfied, are usually regarded as natural representations of preferences or judgments of humans. Herrera and Herrera-Viedma shown that linguistic terms are intuitively more convenient to use when decision makers express the subjectivity and imprecision of their evaluation [28]. For these reasons, the fuzzy set theory is used in the assessment of bank performances in this paper.

In this study the extent FAHP is utilized, which was originally introduced by Chang [29]. Let $X = \{x_1, x_2, ..., x_n\}$ an object set, and $G = \{g_1, g_2, ..., g_n\}$ 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:

$M_{g_i}^{1}, M_{g_i}^{2}, ..., M_{g_i}^{m}, i = 1, 2, ..., n$

Where $M_{g_i}^{j} (j = 1, 2, ..., m)$ all are triangular fuzzy numbers or TFNs. The steps of Chang's extent analysis can be given as in the following [29]:

Step 1. The value of fuzzy synthetic extent with respect to the *i*th object is defined as:

$$S_k = \sum_{j=1}^{n} m_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} m_{g_i}^{j} \right]^{-1} \tag{1}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$, the fuzzy addition operation of m extent analysis values for a particular matrix is performed such as

$$\sum_{j=1}^{m} M_{gi}^{j} = \left[\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right] \tag{2}$$

and to obtain $\left[\sum_{j=1}^{m}, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right]^{-1}$, the fuzzy addition operation of $M_{g_i}^{j} (j = 1, 2, ..., m)$ values is performed such as:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{3}$$

and then the inverse of the vector above is computed, such as:

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

Step 2. As $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as:

$$V(M_2 \geq M_1) = \sup\left[\min(\mu_{m_1}(x), \mu_{m_2}(y))\right]$$

and can be expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) \tag{5}$$

$$= \begin{cases} 1 & m_2 \geq m_1 \\ 0 & l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{6}$$

The formulas 5 and 6 are based on [30]. Chang [29] illustrates Eq. (6) where *d* is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2}. To compare M_1 and M_2, we need both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Step 3 . The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $M_i (i = 1, 2, ..., k)$ numbers can be defined by

$$V(M \geq M_1, M_2, ..., M_k) = V\left[(M \geq M_1) and (M \geq M_2) and ... (M \geq M_k)\right]$$
$$= \min V(M \geq M_i), \quad i = 1, 2, 3, ..., k \tag{7}$$

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

$$W' = (d'(A_1), d'(A_2, ..., d'(A_n)))^T \tag{8}$$

Where $A_i = (i = 1, 2, ..., n)$ are *n* elements.

Step 4. Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2, ..., d(A_n)))^T \tag{9}$$

where *W* is a non-fuzzy number.

The structural framework of the study is shown in Fig. 2.

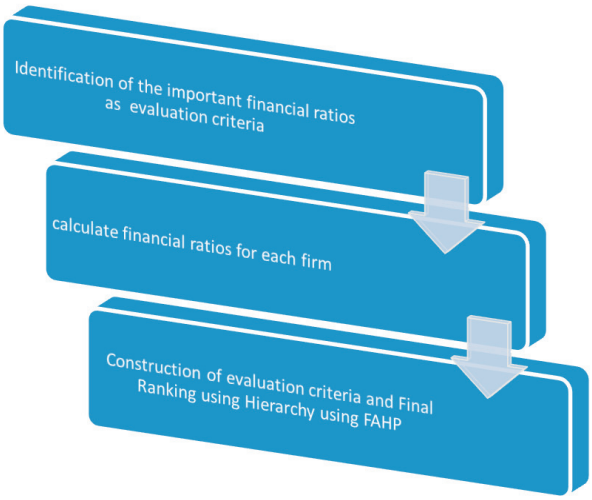

Fig. 2. Structural framework of the study

After gathering pair-wise comparison questionnaires, the fuzzy AHP method has applied to identify the ranking of companies regarding to their performance. The final results can be show as follows in Table 1.

Table 1- Final result

Petrochemical Companies	Final weights	Ranking
Arak	0.144851	1
Abadan	0.144507	2
Fanavaran	0.144232	3
Khark	0.143018	4
Isfahan	0.142228	5
Farabi	0.142009	6
Shiraz	0.139155	7

Regarding to result, Arak petrochemical company, Abadan petrochemical company and Fanavaran petrochemical company has been selected as the best companies in term of financial performance respectively.

4- Conclusion

This paper focuses mainly on the financial criteria for performance evaluation of petrochemical companies in Iran based on the triple bottom line concept. A comprehensive analysis of financial performance measuring should consider all financial ratios and index simultaneously. In this paper we have introduced a fuzzy MCDM approach for supplier selection decisions with consideration of financial ratios to exemplify the proposed framework. First, the criteria for evaluating performance are identified based on the literature and also by help of some financial experts. Second, by designing the pair-wise comparison questionnaires, the experts provide linguistic ratings to the ratios in any company. Finally, after integrating the result of filled questionnaires, using the fuzzy AHP method, the final weights and ranking of each company have been identified.

Financial ratios are useful quantitative financial information for investors and for customers so companies can

be evaluated over time and within a special sector. In this context the fuzzy model proposed for the financial performance evaluation of the seven companies of petrochemical industry in Tehran exchange. For future studies, applying other MCDM methods, such as TOPSIS, ELECTRE, VIKOR etc would be recommended. Moreover, application and developing of the proposed model in other industries can be another suggestion for improving the model.

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