Fuzzy Dematel approach to determining interrelationship factors affecting industrial enterprise performance

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Abstract

Today, in the competitive global economy, evaluating the financial performance of companies is very important not only for current and potential managers, creditors, and investors, but also for companies operating in a sector. Evaluating the financial performance of companies is very important not only for current and potential managers, creditors and investors, but also for companies active in a sector. The purpose of this research was to identify and prioritize the key factors affecting the company's financial performance. Therefore, by using the Fuzzy Dematel approach and gathering the opinions of experts with a pairwise comparison questionnaire, the relationship between the indicators affecting the enterprise financial performance has been discussed. The results showed Asset Management (WCC) has the most Prominence and interaction with at other criteria and since $(D_i - R_i)$ is negative for this factor, so this criterion is a net effect. Asset Management (OE) after Asset Management (WCC) has the most interaction with other criteria and since $(D_i - R_i)$ is negative for this factor, so this criterion is a net effect. Income Statement is net cause for $(D_i - R_i)$ is positive for this factor.

Keywords: fuzzy system, performance, Decision making trial and evaluation laboratory, industrial, SME
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1 Introduction

Nowadays, the world is full of complexities which imposes several issues to enterprises in the way of development and plenty of challenges to the managers as the planners, organizers and leaders of humans [25].

Fernandes et al. (2006) suggested that the enterprise performance is one of the most important agenda for managers; as the key or reaching standing improvement in continuous assessment is the enterprise performance. Many enterprises have already understood the matter of standing assessment of the performance and apply several performance assessment systems in their organizations [10].

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The process of using performance assessment could be useful and proper for companies and affiliated department [3]. The exploited financial ratios from income statement and balance sheet are considered as main tools for determining companies' financial performance and assessment. For many years, plenty of studies in financial literature have shown the benefits of financial ratios. These ratios facilitate the user to summarize and analyze relevant data to provide significant information for making decisions. Also, this significancy of financial ratios shows the pros and cons of the companies in terms of cash, development and profitability [29].

The indices of Return on Investment (ROI), Sale Growth and Earning Per Share (EPS) are of examples of financial performance profitability. It is given that these financial performance indices reflect achieving economic purposes of the company [12]. So the present study identifies the effective factors on performance and also determining mutual interaction of these factors by using fuzzy DEMATEL.

2 Enterprise performance

In such a comparative today world, it is one of the main goals of each individual and investor and investee enterprises to create value and fortune for shareholders. The investors intend to increase their assets day by day and makes it maximum, so they are looking for investment opportunities which creates most fortune for them [4].

The most famous identification of the performance has been suggested by Nili et al. [21]: "The process of explanation of effectiveness quality and efficiency of former measures". Based on this definition, the performance is divided into two components: 1) The efficiency that describes how the organization uses resources in order to manufacture services or products; i.e. the relation between the actual and favor combination of inputs to create certain outputs; 2) The effectiveness which describes the rate of achieving organizational goals. These goals are generally explained in form of appropriateness (conformity rate of outcomes with customer's needs), accessibility (aspects such as frequency, representation among priority groups and physical accessibility) and quality (the rate of achieving required standards) [8].

As a public believe, the most major financial goal of a commercial unit is maximizing shareholder's assets [17]. Obviously, each one of beneficiary groups of a commercial unit such as customers, management, personnel, creditors, banks and government have their own goals which could be naturally financial or non-financial, but amongst them the most effective beneficiary group to a company is the shareholders for which the senior managers are appointed and dismissed by the board of directors. Recently, the weight of the shareholders in order to manage the organization and financial strategic plan has been increased. Also, the concerns about intrinsic and important limitations of traditional performance assessment standards which are eventually resulted to improper financial decisions are caused to many critiques against these standards. Recently, the concepts of Economic Value Added (EVA) and market Value Added (MVA) have been mostly considered and supported by many researchers as the indices of shareholder and financial performance value. The different aspects of EVA and MVA such as different methods for calculating them and also their link loop with other financial concepts such as Net Present Value (NPV) have been assessed [14].

3 Factors affecting enterprise performance

In order to assess the enterprise performance, it has been used different standards up to now. As per Venkatraman and Ramanujam [28], the company performance is the index of its capacity to reach financial and non-financial goals and functions. The financial scales include economic factors and non-financial scales include success indices such as market share, quality, consent and market effectiveness. On the other hand, the ratio and contribution of personnel in their jobs are so important for enterprise development and success. The enterprises could gain comparative privileges more than their rivals by having talented and skillful personnel, so this study uses financial performance and personnel performance to measure the enterprise's performance [30].

Some firm-level characteristics that affect their financial performance are as follows:

1. Based on the theories of uncertainty and risk, business risk has a small but significant relationship with financial structure and financial performance. In a sense, there is a relationship between business risk and profitability (financial performance) and financial leverage. The relationship between business risk and financial performance and structure is also consistent with the trade-off theory, because a company can bear less debt based on avoiding business risk and in other words, the higher the level of business risk, the less leveraged the company is [13].

2. If a company provides a lot of tangible assets, debt service costs can be reduced. Because in case of need, real estate assets can be traded or exchanged easily. Therefore, the reduction of debt costs affected by agency

costs will create more productivity in the company's value, so, the company's asset structure affects its financial performance [23].

3. Based on the theory of resources, companies that have better liquidity have better short-term payment power and can be more successful in the short term in terms of fulfilling obligations or current expenses. Therefore, it is expected that there is a direct positive relationship between the company's liquidity level based on each of these criteria and leverage and financial performance. In other words, a company with better liquidity will be able to face short-term or long-term financial problems [24].

4. Chen et al. [6]argue that there is an inverse relationship (negative effect) between size and financial leverage in companies. The basis of this claim is that smaller companies have more limited access to their own capital and more than loans or larger size enables companies to earn more income for their assets and sales, and this makes them have stronger financial performance to be able to generate more added value.

If we define enterprise environment as a common perception from main factors of the organization, we can say that the working environment of an enterprise which are felt by personnel is an effective factor in enterprise performance [15]. Khandekar and Sharma [16] researches showed the effect of organizational learning on enterprise performance. In this research, they reviewed human resource-based strategies of organizational learning based on learning, training, performance valuation, bonus and motivation, supporting, team work, knowledge creation, quality management and flexibility. The results of Chand et al. [5] shows that the measures of human resource management (human forces' planning, appointment, job design, training and improvement, quality loop and proper payment system) are effective in enterprise performance. Human force variety is defined as a combination of differences in which some of them are visible (such as race, sex or age) but some are less visible (such education, mental orientation, order of individual believes and values). It is a comparative privilege to have variety of working forces. As the varied visions could result in creative and exclusive procedures in solving issues and then the creativity and innovation will be increased which shall be resulted in better enterprise performance [1].

Financial ratios are categorized based on provided information:

Cash ratio: Cash is the ability of company to reach short-term goals on due date. Cash ratios show the company's potential to gain cash by operations during further months [18]. Current ratio, quick ratio and cash ratio are as follows:

$$\text{Current ratio} = \frac{\text{current asset}}{\text{current liabilities}}$$

$$\text{Quick ratio} = \frac{\text{current asset} - \text{inventories}}{\text{current liabilities}}$$

$$\text{Cash ratio} = \frac{\text{Cash+short term investment}}{\text{current liabilities}}$$

Leverage ratios: Leverage ratios show the company's potential to fulfill short-term and long-term obligations [9]. Liability ratio, shareholder's equity to total asset ratio and fixed asset to long-term debts ratio are of leverage ratios:

$$\text{Liability ratio} = \frac{\text{Total liabilities}}{\text{Total Assets}}$$

$$\text{Shareholder's Equity to Total Assets ratio} = \frac{\text{Shareholder's Equity}}{\text{Total Assets}}$$

$$\text{Fixed Assets to Shareholder's Equity ratio} = \frac{\text{Fixed Assets}}{\text{Shareholder's Equity}}$$

$$\text{Fixed Assets to Long Term Liabilities ratio} = \frac{\textit{Fixed Assets}}{\text{Long Term Liabilities}}$$

Activity ratios (asset return ratios): One of the purposes of financial management is the matter of distributing company's resources between different assets. The activity ratios show that how a company invests in assets which makes profit [18]. Accounts receivable turnover, inventories turnover, current assets turnover rate, total assets turnover rate and accounts payable turnover are as follows:

$$\text{Accounts receivable turnover} = \frac{\text{net sale}}{\text{receive accounts}}$$

$$\text{Inventories turnover} = \frac{\text{cost of good sold}}{\text{average inventory during the year}}$$

Table 1: Factors Affecting Enterprise Performance

	BALANCE SHEET RATIOS: Stability (Staying Power)	
1	Current	The current ratio indicates how well the company can liquidate its current assets to pay off its current liabilities.
	1.1	Current Assets
	1.2	Current Liabilities
2	Quick	The quick ratio is similar to the current ratio. The only difference between quick and current ratios is that quick ratios must exclude inventory.
	2.1	Cash + Accts. Rec.
	2.2	Current Liabilities
3	Debt-to-Worth	The ratio determine how much of a company's financing involves debt.
	3.1	Total Liabilities
	3.2	Net Worth
	INCOME STATEMENT RATIOS: Profitability (Earning Power)	
4	Gross Margin	gross margin is the profitability of a company after subtracting the cost of goods sold from the revenue that denotes the amount of money the company retains for every incremental unit of the currency earned.
	4.1	Gross Profit
	4.2	Sales
5	Net profit Margin	The net profit margin ratio represents the percentage of sales revenue a company keeps after covering all of its costs including interest and taxes.
	5.1	Net Profit Before Tax
	5.2	Sales
	ASSET MANAGEMENT RATIOS: Overall Efficiency Ratios	
6	Sales-to-Assets	An asset-to-sales ratio determines the efficiency of a company in managing its assets to generate enough sales for the company to make the assets worthwhile.
	6.1	Sales
	6.2	Total Assets
7	Return on Assets	Return on assets (ROA), determines how efficiently a company is able to generate profit with the assets it has available.
	7.1	Net Profit Before Tax
	7.2	Total Assets
8	Return on Investment	Return on investment (ROI) is an approximate measure of an investment's profitability.
	8.1	Net Profit Before Tax
	8.2	Net Worth
	ASSET MANAGEMENT RATIOS: Working Capital Cycle Ratios	
9	Inventory Turnover	The inventory turnover ratio determines how many times inventory is sold or used in a given time period.
	9.1	Cost of Goods Sold
	9.2	Inventory
10	Inventory Turn-Days	Days Inventory Outstanding (DIO) determines the number of days it takes on average before a company needs to replace its inventory.
	10.1	Inventory Turnover
11	Accounts Receivable Turnover	The Accounts Receivables Turnover Ratio determines the number of times a company collects its average accounts receivable balance, which denotes the quantification of a company's effectiveness in collecting outstanding balances from clients and managing its line of the credit process.
	11.1	Sales
	11.2	Accounts Receivable
12	Accounts Receivable Turn-Days	The accounts receivable turnover ratio determines the number of times a company collects its average accounts receivable balance in a specific time period.
	12.1	Accts. Rec. Turnover
13	Accounts Payable Turnover	Accounts payable turnover shows how many times a company pays off its accounts payable during a period. The accounts payable turnover ratio denotes how efficient a company is at paying its suppliers and short-term debts.
	13.1	Cost of Goods Sold
	13.2	Accounts Payable
14	Average Payment Period	The Average Payment Period (APP) determines the average time period taken by a company to pay off its dues against the purchases made on a credit basis from the supplier.
	14.1	Accts. Pay. Turnover

$$\text{Current Assets turnover rate} = \frac{\text{net sale}}{\text{current assets}}$$

$$\text{Total assets turnover rate} = \frac{\text{net sale}}{\text{Total assets}}$$

$$\text{Accounts payable turnover rate} = \frac{\text{deferred payments}}{\text{average paid accounts durig the year}}.$$

Profitability ratios: Profitability is the potential of a company to create income more than expenses. The former good performance of a company partially ensures the investors that the company shall also be successful in earing profit from new resources [19].

$$\text{Net profit margin rate} = \frac{\text{profit after tax}}{\text{sale}}$$

$$\text{Return on investment rate} = \frac{\text{profit before tax}}{\text{shareholder's equity}}.$$

Growth ratios: Growth is always an index which is interested by capital market and shareholders [20]. The growth ratios show the company's position is the corresponding industry [9]. Sale growth, operational profit growth, shareholder's equity growth and asset growth are of ratios which are used:

$$\text{Sale growth} = \frac{\text{current year sale} - \text{previous year sale}}{\text{previous year sale}} \times 100$$

$$\text{Operational profit growth} = \frac{\text{current year operational profit} - \text{previous year operational profit}}{\text{previous year operational profit}} \times 100$$

$$\text{Shareholder's equity growth} = \frac{\text{current year shareholder's equity} - \text{previous year shareholder's equity}}{\text{previous year shareholder's equity}} \times 100$$

$$\text{Asset growth} = \frac{\text{current year assets} - \text{previous year assets}}{\text{previous year assets}} \times 100$$

4 Methodology

4.1 Identify the factors affecting enterprise performance

To determine factors affecting enterprise performance, the literature on financial management was reviewed. 18 articles were checked out and four main dimensions consisting of 25 indicators in 14 components were identified.

4.2 Fuzzy DEMATEL

In order to determine the interrelationship of the factors affecting the performance of the enterprise, a pair- wise questionnaire was prepared and distributed among 27 experts.

Dematel approach is based on matrix linear algebra and graph theory. By pairwise method which is an important tool for multiple-criteria decision-making evaluates the causal relations among the factors and exposes the degree of relation or the strength of influence analytically [22, 27].

Step 1: After determining, a questionnaire with a square matrix (a square matrix of order 14) shall be prepared to compare these criteria.

Step 2: The experts used four linguistic variables to express the degree of causality between the criteria [7, 26]. Linguistic variables and their Corresponding triangular fuzzy numbers to defining the degree of influence of criteria are shown in Table 2.

Table 2: Linguistic variables for degree of influence of criterion.

Linguistic variables	Crisp Scales	fuzzy scales
No influence (N)	0	(0,0,0)
Low influence (L)	1	(0,0,0.25)
Medium influence (M)	2	(0,025,0.5)
High influence (H)	3	(0.25,0.5,0.75)
Very high influence (VL)	4	(0.5,0.75,1)

After converting linguistic variables to triangular fuzzy numbers based on table 2, the Initial direct-relation matrix for the kth expert was made as $\check{X}^k = \left[\check{x}_{ij}^k\right]_{n \times n}$ $k = 1, 2, ..., 27$ and, n is the number of criteria where $i, j = 1, 2, ..., n$. Each element in matrix $\check{X}^k$ i.e. $\check{x}_{ij}^k = (l_{ij}^k, m_{ij}^k, u_{ij}^k)$ is a triangular fuzzy number that denotes the degree of the ith criteria affects the jth criteria when $i \neq j$ and, is equal to (0,0,0) when $i = j$.

Step 3: using the combination rule of fuzzy triangular numbers, i.e., equation (4.1) aggregated direct-relation matrix $\tilde{A} = [\tilde{a}_{ij}]_{n \times n}(i, j = 1, 2, ..., n)$ was achieved.

$$\tilde{a}_{ij} = \frac{1}{m}[x_{ij}^1(+)x_{ij}^2(+)...(+)x_{ij}^m] \tag{4.1}$$

where $(+)$ denotes the Chen's [7] fuzzy addition operation of triangular fuzzy numbers.

Step 4: Let $\tilde{G} = [\tilde{g}_{ij}]_{n \times n}(i, j = 1, 2, ..., n)$ be the normalized direct-relation matrix that was calculated by applying equations (4.2) to (4.4).

Assumes that each element in aggregated direct-relation matrix $\tilde{A}$ is $\tilde{a}_{ij} = (l'_{ij}, m'_{ij}, u'_{ij})$ $(i, j = 1, 2, ..., n)$.

$$[\tilde{c}_i]_{n \times 1} = \left(\sum_{j=1}^{n} l'_{ij}, \sum_{j=1}^{n} m'_{ij}, \sum_{j=1}^{n} u'_{ij} \right) \quad i = 1, 2, ..., n \tag{4.2}$$

$$c = \max_{1 \le i \le n} \left(\sum_{j=1}^{n} u'_{ij} \right) \tag{4.3}$$

$$\tilde{G} = [\tilde{g}_{ij}]_{n \times n} = \left(\frac{\sum_{j=1}^{n} l'_{ij}}{c}, \frac{\sum_{j=1}^{n} m'_{ij}}{c}, \frac{\sum_{j=1}^{n} u'_{ij}}{c} \right) \tag{4.4}$$

Step 5: The total direct-relation matrix $\tilde{S} = [\tilde{s}_{ij}]_{n \times n}(i, j = 1, 2, ..., n)$ where $[\tilde{s}_{ij}] = (l''_{ij}, m''_{ij}, u''_{ij})$ was calculated as follows.

By dividing $\tilde{G}$ and $\tilde{S}$ fuzzy triangular matrices into three crisp matrices of their left, center and, right elements of fuzzy triangular number, $\tilde{S}$ can be obtain by using equations (4.5) to (4.7).

$$[l''_{ij}]_{n \times n} = [l'_{ij}]_{n \times n} \times ([I]_{n \times n} - [l'_{ij}]_{n \times n})^{-1} \tag{4.5}$$

$$[m''_{ij}]_{n \times n} = [m'_{ij}]_{n \times n} \times ([I]_{n \times n} - [m'_{ij}]_{n \times n})^{-1} \tag{4.6}$$

$$[u''_{ij}]_{n \times n} = [u'_{ij}]_{n \times n} \times ([I]_{n \times n} - [u'_{ij}]_{n \times n})^{-1} \tag{4.7}$$

where I is the unit matrix of order n.

Step 6: The sum of each row and column of the total direct-relation matrix, were stamped as two vectors $\tilde{D} = [\tilde{d}_i]_{n \times n}, (i = 1, 2, ..., n)$ and, $\tilde{R} = [\tilde{r}_j]_{1 \times n}(j = 1, 2, ..., n)$ respectively [2]. which indicated effectiveness rate of that criteria on others, which shows the rate of mentioned criterion affected by others have been calculated [2].

Step 7: The sum $(D + R)$ and difference $(D - R)$ were calculated. $(D + R)$ indicates effective and affected sum of the considered criteria in the system. The most $(D + R)$ value, the most interaction with other criteria. Final value of each criterion's effectiveness on others is also achieved from $(D - R)$, so that:

If $D > R \to D - R > 0$, then considered factor is a net cause;

If $D < R \to D - R < 0$, then considered factor is a net effect.

Step 8: Final ranked diagraph formation

A Cartesian coordinate system was formed which its X and Y axes are graded in terms of $(D + R)$ and $(D - R)$, respectively and the position of each available factor was assigned by a point with coordinate of "$A : (D + R, D - R)$ in this system. Drawn diagraph is a simple exponent of the final structure resulted from the system [2].

5 Result

By reviewed literature identified factors affecting on enterprise performance. 18 articles were surveyed and four main dimensions containing 14 components were extracted. The factors affecting enterprise performance are shown in Figure 2.

After extracting the factors affecting enterprise performance, the interrelationship of them has been measured. Therefore, by gathering expert opinion using the pairwise comparisons matrix for the criteria. the linguistic variables
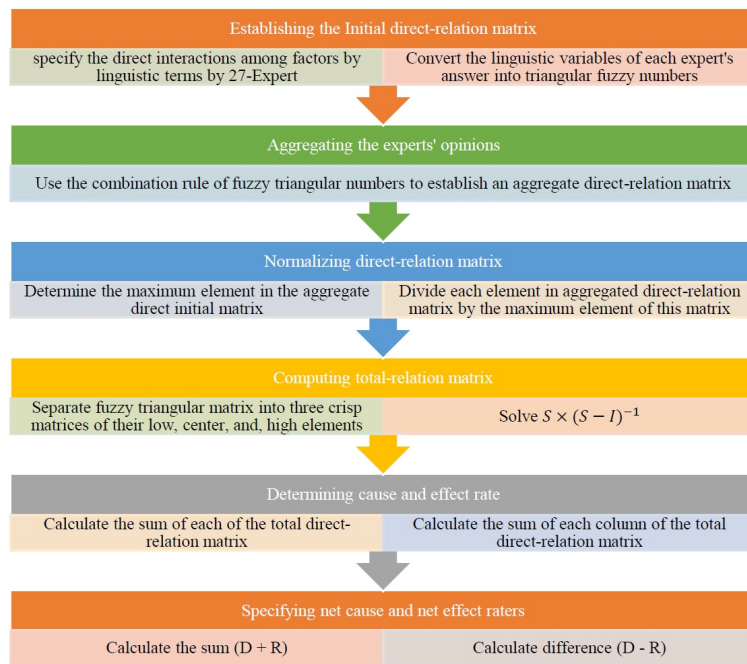
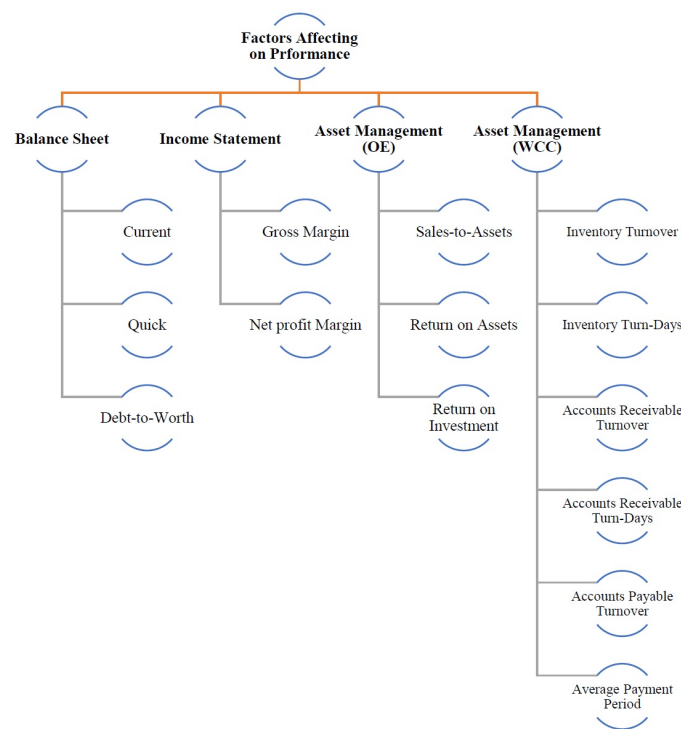Figure 1: Stages of the proposed fuzzy-DEMATEL approach

Figure 2: The factors affecting enterprise performance

were converted to triangular fuzzy numbers and, by using Equation (4.1); the expert's opinions were combined. The crisp and, fuzzy total direct-relation matrix were illustrated in tables 3, 4 respectively.

Then, the normalized direct-relation matrix, fuzzy and crisp total direct-relation matrix was calculated. The fuzzy and, crisp total direct-relation matrix were illustrated in tables 5, 6 respectively.

The $\vec{D}, \vec{R}, \vec{D} + \vec{R}$ and, $\vec{D} - \vec{R}$ vectors for showing the "Prominence" and "Relation" values for main factors and sub-factors base on gray DEMATEL were calculated, where can be seen in Table 7.

Table 3: The crisp direct-relation matrix

	Balance Sheet	Income Statement	Asset Management (OE)	Asset Management (WCC)
Balance Sheet	0	0.25	0.25	0.5
Income Statement	0.25	0	0.5	0.75
Asset Management (OE)	0.5	0.25	0	0.25
Asset Management (WCC)	0.25	0.25	0.5	0

Table 4: The fuzzy direct-relation matrix

	Balance Sheet	Income Statement	Asset Management (OE)	Asset Management (WCC)
Balance Sheet	(0,0,0)	(0,0.25,0.5)	(0,0.25,0.5)	(0.25,0.5,0.75)
Income Statement	(0,0.25,0.5)	(0,0,0)	(0.25,0.5,0.75)	(0.5,0.75,1)
Asset Management (OE)	(0.25,0.5,0.75)	(0,0.25,0.5)	(0,0,0)	(0,0.25,0.5)
Asset Management (WCC)	(0,0.25,0.5)	(0,0.25,0.5)	(0.25,0.5,0.75)	(0,0,0)

Table 5: The fuzzy total direct-relation matrix ($\tilde{S}$)

	Balance Sheet	Income Statement	Asset Management (OE)	Asset Management (WCC)
Balance Sheet	(0.04,0.46,0.93)	(0,0.5,1)	(0.12,0.69,1.21)	(0.35,0.85,1.36)
Income Statement	(0.19,0.79,1.32)	(0,0.5,1)	(0.58,1.03,1.52)	(0.73,1.18,1.67)
Asset Management (OE)	(0.35,0.72,1.18)	(0,0.5,1)	(0.04,0.54,1.03)	(0.12,0.75,1.29)
Asset Management (WCC)	(0.12,0.61,1.12)	(0,0.5,1)	(0.35,0.8,1.28)	(0.04,0.59,1.1)

Table 6: The crisp total direct-relation matrix (S)

	Balance Sheet	Income Statement	Asset Management (OE)	Asset Management (WCC)
Balance Sheet	0.47	0.5	0.67	0.85
Income Statement	0.77	0.5	1.04	1.19
Asset Management (OE)	0.75	0.5	0.53	0.72
Asset Management (WCC)	0.62	0.5	0.81	0.58

Table 7: The "Prominence" and "Relation" values

Factors	D	R	D+R	D-R
Balance Sheet	2.500	2.607	5.107	−0.107
Income Statement	3.500	2.000	5.500	1.500
Asset Management (OE)	2.500	3.056	5.556	−0.556
Asset Management (WCC)	2.500	3.338	5.838	−0.838

Asset Management (WCC) has the most Prominence and interaction with at other criteria and since $(D_i - R_i)$ is negative for this factor, so this criterion is a net effect. Asset Management (OE) after Asset Management (WCC) has the most interaction with other criteria and since $(D_i - R_i)$ is negative for this factor, so this criterion is a net effect. Income Statement is net cause for $(D_i - R_i)$ is positive for this factor.

6 Discussion and conclusion

The performance of the enterprise in order to ensure the optimal allocation of the limited resources that the shareholders and creditors provide to the company. Measurement functions are considered management control systems because economic planning and control decisions are the unit of evaluation of performance evaluation. Making rational decisions is directly related to evaluating the performance of the economic enterprise. The most important evaluation of enterprises' performance is the financial evaluation of companies and it is often based on financial statements. The process of applying performance appraisal can be suitable for companies and related departments. Financial ratios extracted from the income statement and balance sheet are considered as the main measurement tools for determining the performance and financial evaluation of companies. For many years, a large number of studies in the financial literature have demonstrated the benefits of financial ratios. These ratios allow the user to summarize and analyze relevant data to provide meaningful information for decision making. Also, this significance of financial ratios shows the strengths and weaknesses of companies in terms of liquidity, growth and profitability.

Figure 3: The Causal Diagram for The Factors

The use of evaluation criteria such as company earnings, profit per share, cash flow and the like in the capital market has been common for consecutive years until value-based criteria were proposed to evaluate the performance of companies. In traditional performance evaluation, only the accounting profit is considered, which is not considered a desirable method due to not taking into account the costs of providing the capital resources of the companies. One of the newest value-based criteria is the economic added value criterion. According to this criterion, the value of the company depends on the return and cost of capital employed by the company.

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