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Identification and prioritization of effective elements in usefulness of information and efficiency of stock price using multicriteria decision making (DANP)

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Abstract

Nowadays, it is necessary to enhance the usefulness of information and investigate effective indices in making decisions. The research aims to make decisions and identify the effective elements in making decisions by the users of accounting information. In the current study, the effective elements have been selected from 8 classes and 26 sub-elements using a matrix questionnaire according to the views of the experts. Then, the Fuzzy Dematel DANP method was used to determine the connections, intensity of effectiveness and impactability and to weigh and prioritize the elements, a network analysis process was used. The results of the fuzzy Dematel method (DANP) indicated that the elements including the items of financial statements (0.1347), the structure of the quality board of directors (0.1305), and the structure of quantitative ownership (0.128) are the most effective elements in making decisions and efficiency of stock price, respectively. Out of basic elements, the items of financial statements with the weight of 0.1347 have priority and the sub-elements involving operational cash flow (0.3450), capital cash flow (0.3367), and financing cash flow (0.3183) are the first to third priorities, respectively. Also, the return on total assets (1.816), current ratio (1.791) and inventory turnover ratio (1.751) have been the most impactable elements according to the computed weights.

Keywords: usefulness of information, efficiency of stock price, DANP technique
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1 Introduction

The increased stock transactions have been seen in Iran due to the advances of information technology which contributed to the transaction processing in capital markets so that the capital markets have been quickly growing. The capital market is regarded as a tool to invest funds by the investors while the funds keep growing in the market. As well, the capital market acts as a facility to facilitate investment. Because of information technology, investors achieve the desired information quicker and more complete. The information of financial statements issued by the stock exchange and the quality of financial statements are used as a basis for the investors to make effective investment

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decisions in a way that the investments are more likely to be more efficient. The investigations provide information on the activities in capital markets for the investors and people. The information will be effective for the investors if the documents and evidence concerning the effects on stock price are available and the information requirements are met [5]. To meet the information requirements, accounting has been created. Given that accounting has varied based on the political, economic and social conditions in every era, the accounting goals and methods were changed according to the variations in environmental conditions. The accounting goals have been developed so that accounting plays a fundamental role in the economy and making exact and accurate decisions is essential for the government, people and so on to allocate financial resources effectively. For these decisions, related and reliable information should be provided for the decision-making. In fact, the accounting aims to help the decision-makers make better decisions. Given that there is sufficient information in the market, which affects the stock price quickly and timely, a direct connection is observed between information and market efficiency. In such markets, the information reflected in the market affects the prices quickly and approaches the price of securities to the future value. If the accounting information is useful for the decision-makers, the conditions to predict some events regarded as inputs in the decision model should be provided. Also, the decision-making models can be identified through the existing theories in terms of investors' reactions to accounting information [7]. Accounting information usefulness has been one of the main concerns of accountants; thus, the goal of financial reporting is to prepare financial information on the reporters for the creditors, investors and other users to make useful decisions about the preparation of resources concerning the business unit. If it is supposed to have useful financial information, the information must be related and honestly indicate the reality [4].

Aqhaei et al. [2] in research that used the views of three main spectrums involving users, auditors and accounting information providers by AHP method have ranked the relative importance of financial reports and qualitative features of accounting information. Research results indicated that except for the relative importance, the qualitative features of information have varied from the viewpoints of users, providers and auditors. The providers, auditors and users care for the relevance, reliability and understandability, respectively. Accounting information will be an efficient information resource for making decisions and predicting future financial events. Certainly, some express that the financial statements have no prediction power because of the following reasons:

1. Accounting information is based on historical events.
2. The distance between historical figures in books and their real value.
3. Under the effect of accounting figures with accounting trends.

Therefore, it can be stated that non-financial information will gain importance and remove the shortcomings if the usefulness of information included in financial statements is assessed in different fields with different interdisciplinary models. Because one of the accounting information advantages is to quantify risk in accounting, the experts have relied on such methods as the pricing of capital assets, index model and market model to test the risk. Since the reliance on market prices is the pivot of the mentioned models, the firms which are not in the stock exchange are ignored. It seems that market risk and accounting information are effective in stock prices concerning the several studies conducted on the content role of information [6]. Accounting information plays a valuation role in affecting capital expenses and stock prices. Information asymmetry is reduced by high-quality information and costs of external financing are more likely to decrease. The valuation role of accounting information can be understood while considering the effectiveness in stock price and a specific firm's stock price is indicative of specific information on the share. High quality and information transparency lead to reflect the investment opportunities and growth aspects in the stock price and attract more investors. It is believed that the high-quality disclosure of accounting information is likely to be useful and effective in controlling and observing the managers, encouraging the managers to make efficient decisions, improving the efficiency of capital allocation and achieving more returns. High-quality accounting information makes the investors aware of other firms' investment orientations and tendencies timely. Thus, the reporting system and accounting information are important resources to determine the exact estimate of stock price [1]. Accordingly, it is necessary to answer the following questions:

What does effective information in the efficiency of stock price involve?

How are the usefulness and ranking of effective information in the efficiency of stock price?

The current research collects the financial and non-financial information affecting the efficiency of stock price based on the questionnaires designed by the DANP method in a matrix way and the interviews with 15 experts and financial analysts. After evaluating the effective elements in the efficiency of the stock price as compared to the ranking of elements, non-parametric fuzzy DANP which is a new method mixed of two methods of ANP and DEMATEL has been applied to answer the research questions. So far, concerning the usefulness of accounting information, lots of studies have been conducted but the innovation of current research is that the evaluation of usefulness is done according to the views of experts using the fuzzy Delphi method. Here, to rank the quantitative financial and non-financial elements

affecting the desired efficiency, DANP, which is a combination of DEMATEL techniques and network analysis process, has been used for the first time and the fundamental advantage is high power in analyzing the rankings of decisions.

2 Research methodologies

The current research is an exploratory-applied one using a mathematical modelling approach in which the questionnaires and interviews of experts have been applied to answer the questions. To do this, 15 managers, brokers and financial experts with Master's degrees were selected from investment firms and brokerage agents and then, interviewed. The current research reflects the importance of accounting information using financial reporting information and questionnaires as well as DANP, a combination of fuzzy DEMATEL and ANP models. Ranking the accounting information and determining the effective elements are to be addressed in this regard. The accounting information has been classified into two groups of Rial and non-Rial factors. Rial factors have two parts financial information involving financial ratios and items of financial statements and non-financial information such as stock exchange index and stock price changes. Non-Rial information has been divided into two qualitative and quantitative groups; quantitative factors include board of directors and ownership structure and qualitative factors include ownership structure, board of directors structure, independent auditors and auditing committee; Every basic factor has smaller elements.

2.1 DANP technique

In the the ANP method, it is supposed that branches are of similar weights although the impact of each branch may be different on other branches. Therefore, in the traditional ANP method, the hypothesis of similar weights is not rational to create the balanced supermatrix, but the effective weights of DANP can remove this defect. Results will be given through a complete correlation matrix of T_C and T_D Which is computed by DEMATEL based on the fundamental ANP concept. Thus, the DEMATEL technique is used to create a network structure model and improve the normalization trend of traditional ANP [3]. The technique has been suitable as compared to the traditional methods, especially in real-world problems and also, considers the dependence between criteria; finally, DEMATEL is combined with ANP to create DANP and to determine the effective weights of each criterion and dimension. Using the DEMATEL technique, the stages of creating the structure of network connections and determining the effective weights of DANP are explained by the complete connection matrix.

2.2 DEMATEL Technique to develop a map of network connections

2.2.1 First step: Computing matrix of direct connection

At first, according to the views of research experts, the connections between criteria (impact of one criterion on another one) are evaluated by the spectrum of ranks 0-4; 0 means no effect, 1, 2, 3 and 4 refer to little, medium, high and very high impact, respectively. The experts are asked to determine the impact of one criterion on another one; if the criterion I affects the criterion j, it should be presented as d_c^{ij}. Thus, the matrix $D = [d_c^{ij}]$ will have a direct connection.

$$D = \begin{bmatrix} d_c^{11} & \cdots & d_c^{1j} & \cdots & d_c^{1n} \\ \vdots & & \vdots & & \vdots \\ d_c^{i1} & \cdots & d_c^{ij} & \cdots & d_c^{in} \\ \vdots & & \vdots & & \vdots \\ d_c^{n1} & \cdots & d_c^{nj} & \cdots & d_c^{nn} \end{bmatrix} \tag{2.1}$$

2.2.2 Second step: Normalizing direct connections matrix

The direct connections matrix D is normalized using the following equation and the matrix N is given.

$$N = VD; \quad V = \min \left\{ 1/\sum_{j=1}^{n} d_{ij}, 1/\sum_{i=1}^{n} d_{ij} \right\}, \quad i, j \in \{1, 2, ..., n\} \tag{2.2}$$

2.2.3 Third step: Computing direct connections matrix

When the matrix D is normalized and the matrix N is given, the matrix of complete connections will be obtained. In the equation, I is the unit matrix.

$$T = N + N^2 + ... + N^h = N(1-N)^{-1}, \quad \text{when } h \to \infty \tag{2.3}$$

The matrix of complete connections can be counted by the criteria, shown by T_C.

$$T_c = \begin{array}{c} \\ D_1 \\ \vdots \\ D_i \\ \vdots \\ D_n \end{array} \begin{array}{c} \begin{array}{cccccc} D_1 & & D_j & & D_n \\ c_{11} \cdots c_{1m_1} & \cdots & c_{j1} \cdots c_{jm_j} & \cdots & c_{n1} \cdots c_{nm_n} \end{array} \\ \begin{bmatrix} T_c^{11} & \cdots & T_c^{1j} & \cdots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \cdots & T_c^{ij} & \cdots & T_c^{in} \\ \vdots & & \vdots & & \vdots \\ T_c^{n1} & \cdots & T_c^{nj} & \cdots & T_c^{nn} \end{bmatrix} \end{array} \tag{2.4}$$

2.2.4 Fourth step: Analysis of results

In this step, the sum of matrix rows and columns is computed as follows:

$$\begin{aligned} T &= [t_{ij}], \quad i,j \in \{1,2,...,n\} \\ r &= [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} \\ c &= [c_j]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} \end{aligned} \tag{2.5}$$

The index r_i indicates the sum of row ith and c_j indicates the sum of column jth. The index $r_i + c_j$ is given by the addition of the row i and the column j, where $(i = j)$. The index shows the importance of criterion i. Similarly, the index $r_i - c_j$ is given by the subtraction of the row i and column j demonstrating the effectiveness or impactability of the criterion i. Generally, if $r_i - c_j$ is positive $(i = j)$, the criterion i will be put in the category of cause. If $r_i - c_j$ is negative $(i = j)$, the criterion i will be in the category of impactable ones. The graph of cause can be drawn in terms of two mentioned indices, which is known as the map of network connections. This map helps to make decisions on how to improve the dimensions and criteria.

2.3 DANP technique to find the effective weights in each criterion

2.3.1 Fifth step: Normalizing matrix of complete connections of dimensions (T_D^{∞})

The matrix T_D is given by the average of T_C^{ij}. The matrix will be normalized by the following equation; the sum of each row is computed and each element is divided by the sum of elements in the row. The matrix of normalized complete connections T_D is demonstrated as T_D^{∞}.

$$T_D = \begin{bmatrix} t_{11}^{D_{11}} & \text{L} & t_{1j}^{D_{1j}} & \text{L} & t_{1m}^{D_{1m}} \\ \text{M} & \text{M} & \text{M} & \text{M} & \text{M} \\ t_{i1}^{D_{i1}} & \text{L} & t_{ij}^{D_{ij}} & \text{L} & t_{im}^{D_{im}} \\ \text{M} & \text{M} & & \text{M} & \text{M} \\ t_{m1}^{D_{m1}} & \text{L} & t_{mj}^{D_{mj}} & \text{L} & t_{mm}^{D_{mm}} \end{bmatrix} \begin{array}{l} \longrightarrow d_1 = \sum_{j=1}^{m} t_{1j}^{D_{1j}} \\ \\ \longrightarrow d_i = \sum_{j=1}^{m} t_{ij}^{D_{ij}} \\ \\ \longrightarrow d_m = \sum_{j=1}^{m} t_{mj}^{D_{mj}} \end{array} \quad , d_i = \sum_{j=1}^{m} t_{ij}^{D_{ij}}, i = 1,...,m \tag{2.6}$$

2.3.2 Sixth step: Normalizing matrix of complete connections of criteria ($T_C^{\propto}$)

Normalizing T_C is done by the sum of effectiveness and impact ability degrees of criteria and dimensions to obtain $T_C^{\propto}$ as follows:

$$d_{ci}^{11} = \sum_{j=1}^{m_1} t_{cij}^{11}, \quad i = 1, 2, ..., m_1 \tag{2.7}$$

$$T_C^{\propto 11} = \begin{bmatrix} \frac{t_{c11}^{11}}{d_{c1}^{11}} & \cdots & \frac{t_{c1j}^{11}}{d_{c1}^{11}} & \cdots & \frac{t_{c1m1}^{11}}{d_{c1}^{11}} \\ \vdots & & \vdots & & \vdots \\ \frac{t_{ci1}^{11}}{d_{ci}^{11}} & \cdots & \frac{t_{cij}^{11}}{d_{ci}^{11}} & \cdots & \frac{t_{cim1}^{11}}{d_{ci}^{11}} \\ \vdots & & \vdots & & \vdots \\ \frac{t_{cm11}^{11}}{d_{cm1}^{11}} & \cdots & \frac{t_{cm1j}^{11}}{d_{cm1}^{11}} & \cdots & \frac{t_{cm1m1}^{11}}{d_{cm1}^{11}} \end{bmatrix} = \begin{bmatrix} t_{c11}^{\propto 11} & \cdots & t_{c1j}^{\propto 11} & \cdots & t_{c1m1}^{\propto 11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{\propto 11} & \cdots & t_{cij}^{\propto 11} & \cdots & t_{cim1}^{\propto 11} \\ \vdots & & \vdots & & \vdots \\ t_{cm11}^{\propto 11} & \cdots & t_{cm1j}^{\propto 11} & \cdots & t_{cm1m1}^{\propto 11} \end{bmatrix} \tag{2.8}$$

2.3.3 Seventh step: Forming unbalanced supermatrix W

In this step, the matrix of complete connections is normalized and computed as $T_C^{\propto}$ and the matrix W is given. If a matrix like W^{11} is null or zero, the matrix will be independent.

$$\boldsymbol{W} = (\boldsymbol{T}_c^{\alpha})' = \begin{array}{c} \\ D_1 \\ \\ \mathrm{M} \\ D_j \\ \mathrm{M} \\ D_n \\ \end{array} \begin{array}{c} \begin{array}{cccccc} D_1 & & D_i & & D_n \\ c_{11}\ c_{1m_1} & \cdots & c_{i1}\ c_{im_i} & \mathrm{L} & c_{n1}\ c_{nm_n} \end{array} \\ \begin{bmatrix} \boldsymbol{W}^{11} & \mathrm{L} & \boldsymbol{W}^{i1} & \mathrm{L} & \boldsymbol{W}^{n1} \\ \mathrm{M} & & \mathrm{M} & & \mathrm{M} \\ \boldsymbol{W}^{1j} & \mathrm{L} & \boldsymbol{W}^{ij} & \mathrm{L} & \boldsymbol{W}^{nj} \\ \mathrm{M} & & \mathrm{M} & & \mathrm{M} \\ \boldsymbol{W}^{1n} & \mathrm{L} & \boldsymbol{W}^{in} & \mathrm{L} & \boldsymbol{W}^{nn} \end{bmatrix} \end{array} \tag{2.9}$$

2.3.4 Eighth step: Forming an unbalanced supermatrix

To form an unbalanced supermatrix, the matrix of complete connections $T_D^{\propto}$ is transposed and is multiplied by the unbalanced supermatrix.

$$W^{\propto} = T_D^{\propto} W = \begin{bmatrix} t_D^{\propto 11} \times W^{11} & \cdots & t_D^{\propto i1} \times W^{i1} & \cdots & t_D^{\propto n1} \times W^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\propto 1j} \times W^{1j} & \cdots & t_D^{\propto ij} \times W^{ij} & \cdots & t_D^{\propto nj} \times W^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\propto 1n} \times W^{1n} & \cdots & t_D^{\propto in} \times W^{in} & \cdots & t_D^{\propto nn} \times W^{nn} \end{bmatrix} \tag{2.10}$$

2.3.5 Ninth step: Limiting an unbalanced supermatrix

The unbalanced supermatrix is limited through the exponentiation of one large number Z until the supermatrix gets converged and constant. The output is the effective DANP.

$$W^Z. \tag{2.11}$$

3 Research elements

In this paper, it aims to investigate the effect of information usefulness on the efficiency of stock prices. Using the research literature and resources, 27 indices were extracted from 8 main dimensions, which are presented in Table 1.

Table 1: Introducing the research elements

Dimension	Index	Code
Structure of quantitative ownership	Ownership concentration percent	A1
	Institutional ownership percent	A2
	Managerial ownership percent	A3
	Governmental ownership percent	A4
	Free and floating shares percent	A5
Structure of qualitative ownership	Existence of institutional ownership	B1
	Existence of governmental ownership	B2
Structure of quantitative board of directors	Ratio of independent members	C1
	Dual duties of CEO	C2
Structure of qualitative board of directors	Expertise of members	D1
Auditing, internal control and committee	Auditors type	E1
	Reports type	E2
	Suitable internal control	E3
	Auditing committee	E4
	Independence of auditing committee	E5
Items of financial statements	Operational cash flows	F1
	Investment cash flows	F2
	Financing cash flows	F3
Financial ratios	Current ratio	G1
	Inventory turnover ratio	G2
	Ratio of debt to total assets	G3
	Return on assets (ROA)	G4
	Return on equity (ROE)	G5
	Earnings per share (EPS)	G6
	P/E	G7
Indices	Currency price index	H1
	Stock exchange index	H2

4 Results of DANP method

First, the matrix of direct connections in terms of research elements has been applied to assess the connections between elements (impact of one element on another one) according to the comments of experts based on 0-4 (0= no effect, 1= Very low effect, 2= low effect, 3= high effect and 4= very high effect). To form the matrix of direct connections, the comments of 15 experts have been used; afterwards, the matrix is normalized by equations 3 and 4 (Table 2).

4.1 Forming a causal diagram

In this section, according to equation 5 and the matrix of total connections, the amounts of D and R are computed by the addition of row and column of the matrix (Table 3). Then, each index is specified on the axes based on the amounts of D+R and D-R as the axis x and the axis Y, respectively (Fig. 1). Accordingly, the indices at the top of axis X have a positive D-R regarded as the cause and the indices at the bottom of the axis X have the negative D-R considered as the effect.

Table 2: Matrix of total connections

	A1	A2	A3	A4	A5	B1	B2	C1	C2	D1	E1	E2	E3	E4	E5	F1	F2	F3	G1	G2	G3	G4	G5	G6	G7	H1	H2
A1	0.176	0.229	0.226	0.217	0.211	0.208	0.213	0.186	0.199	0.221	0.189	0.234	0.234	0.182	0.178	0.222	0.217	0.210	0.216	0.206	0.207	0.215	0.213	0.217	0.211	0.199	0.192
A2	0.220	0.198	0.237	0.212	0.212	0.218	0.228	0.194	0.212	0.237	0.193	0.237	0.233	0.189	0.197	0.235	0.236	0.219	0.205	0.226	0.202	0.209	0.215	0.216	0.212	0.189	0.185
A3	0.238	0.276	0.224	0.226	0.231	0.259	0.241	0.215	0.242	0.257	0.215	0.265	0.283	0.214	0.224	0.277	0.259	0.247	0.245	0.245	0.233	0.261	0.251	0.235	0.254	0.240	0.238
A4	0.193	0.204	0.206	0.156	0.197	0.190	0.202	0.169	0.178	0.202	0.177	0.232	0.215	0.170	0.166	0.213	0.192	0.194	0.186	0.188	0.187	0.191	0.197	0.194	0.188	0.179	0.177
A5	0.205	0.235	0.234	0.205	0.192	0.219	0.211	0.188	0.216	0.238	0.199	0.247	0.255	0.192	0.200	0.250	0.239	0.225	0.229	0.217	0.215	0.229	0.227	0.231	0.233	0.211	0.205
B1	0.217	0.244	0.239	0.227	0.221	0.186	0.218	0.185	0.217	0.233	0.192	0.250	0.245	0.190	0.198	0.245	0.236	0.219	0.220	0.215	0.218	0.233	0.218	0.215	0.226	0.201	0.195
B2	0.210	0.227	0.227	0.209	0.208	0.215	0.172	0.189	0.198	0.218	0.191	0.238	0.231	0.188	0.186	0.229	0.214	0.206	0.204	0.206	0.204	0.208	0.206	0.211	0.199	0.193	0.189
C1	0.239	0.275	0.272	0.242	0.253	0.258	0.238	0.194	0.247	0.268	0.233	0.273	0.286	0.229	0.246	0.287	0.284	0.274	0.260	0.257	0.245	0.261	0.269	0.252	0.266	0.251	0.238
C2	0.183	0.205	0.209	0.186	0.194	0.196	0.183	0.160	0.159	0.196	0.176	0.211	0.209	0.172	0.175	0.203	0.208	0.192	0.192	0.192	0.198	0.198	0.192	0.193	0.188	0.184	0.166
D1	0.242	0.253	0.256	0.224	0.248	0.238	0.228	0.216	0.224	0.217	0.219	0.266	0.265	0.213	0.207	0.265	0.259	0.241	0.240	0.236	0.232	0.257	0.239	0.253	0.235	0.243	0.221
E1	0.195	0.215	0.218	0.186	0.193	0.197	0.192	0.180	0.196	0.211	0.156	0.217	0.224	0.195	0.200	0.228	0.210	0.198	0.204	0.196	0.194	0.205	0.199	0.192	0.198	0.198	0.187
E2	0.197	0.212	0.210	0.196	0.209	0.202	0.199	0.182	0.195	0.212	0.188	0.198	0.226	0.182	0.189	0.233	0.219	0.209	0.203	0.207	0.211	0.212	0.213	0.216	0.219	0.187	0.190

E3	0.261	0.265	0.253	0.236	0.264	0.234	0.235	0.232	0.254	0.256	0.244	0.272	0.245	0.216	0.235	0.269	0.290	0.268	0.247	0.246	0.247	0.256	0.265	0.276	0.268	0.234	0.228
E4	0.193	0.209	0.203	0.177	0.192	0.192	0.187	0.182	0.191	0.199	0.196	0.214	0.220	0.148	0.192	0.215	0.207	0.195	0.190	0.184	0.191	0.201	0.190	0.192	0.190	0.185	0.190
E5	0.174	0.183	0.190	0.184	0.178	0.176	0.177	0.167	0.172	0.189	0.178	0.207	0.191	0.173	0.138	0.193	0.189	0.180	0.181	0.175	0.172	0.173	0.176	0.175	0.175	0.162	0.159
F1	0.240	0.250	0.250	0.214	0.246	0.226	0.222	0.211	0.228	0.250	0.214	0.259	0.265	0.203	0.204	0.226	0.257	0.252	0.249	0.239	0.242	0.246	0.237	0.239	0.241	0.223	0.213
F2	0.248	0.265	0.258	0.220	0.254	0.240	0.219	0.210	0.248	0.253	0.223	0.274	0.277	0.212	0.211	0.273	0.230	0.257	0.264	0.250	0.252	0.264	0.254	0.255	0.253	0.230	0.215
F3	0.263	0.274	0.268	0.234	0.262	0.252	0.232	0.232	0.252	0.260	0.238	0.288	0.290	0.216	0.234	0.287	0.272	0.227	0.257	0.256	0.253	0.268	0.274	0.270	0.275	0.238	0.226
G1	0.244	0.265	0.265	0.223	0.253	0.241	0.237	0.224	0.245	0.268	0.228	0.275	0.289	0.218	0.219	0.270	0.277	0.255	0.218	0.249	0.250	0.264	0.253	0.250	0.253	0.242	0.229
G2	0.241	0.288	0.283	0.241	0.258	0.261	0.247	0.221	0.244	0.286	0.227	0.286	0.300	0.233	0.212	0.292	0.273	0.264	0.265	0.222	0.259	0.279	0.256	0.256	0.251	0.248	0.239
G3	0.205	0.241	0.235	0.201	0.211	0.217	0.210	0.187	0.210	0.233	0.191	0.255	0.253	0.196	0.184	0.263	0.240	0.225	0.230	0.225	0.187	0.235	0.220	0.219	0.218	0.197	0.191
G4	0.230	0.260	0.248	0.230	0.242	0.232	0.218	0.213	0.234	0.253	0.211	0.277	0.278	0.209	0.213	0.266	0.273	0.259	0.248	0.248	0.244	0.216	0.254	0.251	0.259	0.217	0.216
G5	0.260	0.289	0.282	0.250	0.274	0.265	0.251	0.226	0.247	0.277	0.230	0.302	0.311	0.229	0.231	0.296	0.283	0.277	0.284	0.262	0.275	0.279	0.233	0.269	0.268	0.253	0.243
G6	0.251	0.284	0.287	0.239	0.263	0.256	0.256	0.223	0.252	0.287	0.226	0.299	0.300	0.231	0.227	0.309	0.288	0.278	0.280	0.275	0.276	0.273	0.263	0.232	0.267	0.244	0.237
G7	0.258	0.278	0.286	0.240	0.267	0.250	0.255	0.230	0.248	0.285	0.230	0.290	0.294	0.226	0.229	0.294	0.287	0.272	0.266	0.272	0.256	0.269	0.260	0.269	0.228	0.242	0.228
H1	0.201	0.229	0.226	0.217	0.218	0.210	0.205	0.185	0.209	0.225	0.189	0.248	0.248	0.195	0.195	0.237	0.242	0.220	0.215	0.214	0.210	0.221	0.225	0.222	0.223	0.174	0.206
H2	0.210	0.221	0.222	0.222	0.225	0.207	0.204	0.195	0.216	0.233	0.193	0.255	0.239	0.189	0.202	0.244	0.245	0.226	0.222	0.219	0.220	0.226	0.228	0.226	0.226	0.197	0.171

Table 3: Amounts of D and R

	D	**R**	**D+R**	**D-R**
A1	1.059	1.032	2.091	0.028
A2	1.079	1.143	2.221	-0.064
A3	1.195	1.127	2.322	0.067
A4	0.957	1.016	1.973	-0.059
A5	1.071	1.043	2.114	0.028
B1	0.404	0.401	0.805	0.003
B2	0.387	0.389	0.776	-0.003
C1	0.442	0.355	0.797	0.087
C2	0.319	0.406	0.725	-0.087
D1	0.217	0.217	0.435	0
E1	0.993	0.962	1.955	0.031
E2	0.983	1.109	2.092	-0.126
E3	1.213	1.106	2.318	0.107
E4	0.969	0.914	1.883	0.056
E5	0.888	0.955	1.843	-0.067
F1	0.736	0.786	1.522	-0.050
F2	0.760	0.759	1.519	0.001
F3	0.786	0.737	1.523	0.049
G1	1.737	1.791	3.528	-0.054
G2	1.788	1.751	3.539	0.037
G3	1.534	1.749	3.282	-0.215
G4	1.721	1.816	3.536	-0.095
G5	1.870	1.739	3.609	0.132
G6	1.866	1.746	3.613	0.120
G7	1.820	1.745	3.565	0.076
H1	0.380	0.372	0.752	0.009
H2	0.368	0.377	0.745	-0.009

4.2 Forming and normalizing matrix of complete connections of dimensions (T_D^{∞})

In this step, using the equation (2.6), the matrix of complete connections is developed and then, is normalized by the equation (2.7). To normalize the matrix, each element is divided by the sum of each row and then transposed. Results are presented in Table 4.

4.3 Forming supermatrices and computing final weights

In this Section, three supermatrices involving initial, balanced and limit are created, and the limit matrix reflects the final weights of elements, which have been converted at the exponent of 3. The final weights have been presented in Table 5.

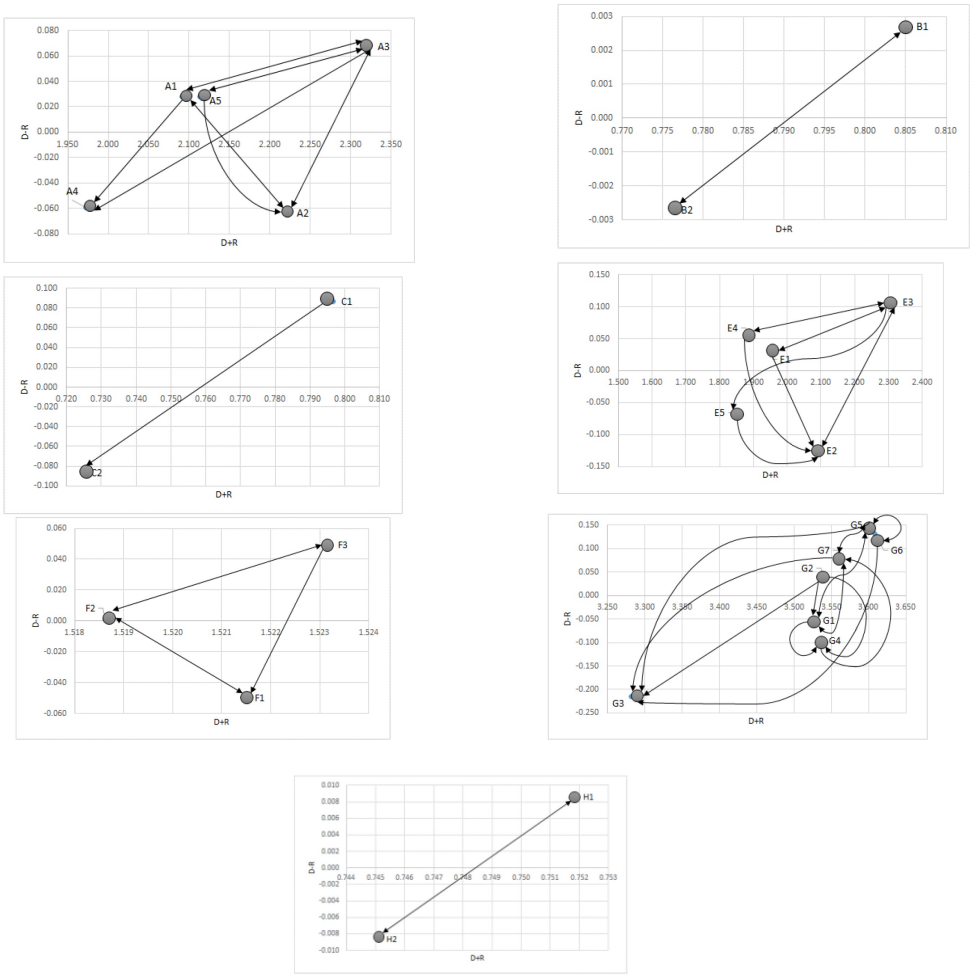

Figure 1: Causal diagram of elements

Table 4: Transpose of normal matrix of complete connections of dimensions T_D^{∞}

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
A	0.124	0.132	0.128	0.130	0.127	0.129	0.127	0.128
B	0.127	0.117	0.124	0.124	0.122	0.120	0.121	0.120
C	0.116	0.117	0.108	0.117	0.119	0.119	0.115	0.117
D	0.134	0.134	0.131	0.116	0.130	0.131	0.135	0.134
E	0.123	0.125	0.125	0.125	0.123	0.124	0.123	0.126
F	0.133	0.133	0.137	0.136	0.135	0.131	0.137	0.137
G	0.126	0.126	0.128	0.129	0.126	0.131	0.126	0.129
H	0.117	0.115	0.119	0.123	0.117	0.116	0.115	0.109

5 Conclusion and further suggestions

The extracted elements by the use of the DANP method have been prioritized. The items of financial statements (0.1374), qualitative structure of the board of directors (0.1305) and quantitative structure of ownership (0.1282) were put in the first, second and third places, respectively. Considering the results, the items of financial statements have achieved the first rank because the use of information included in the financial statements provided useful data to make decisions in terms of stock price and efficiency and played a fundamental role in making decisions. The information included in the financial statements is of high value. If valid and correct information exists in the financial statements, more useful economic decisions will be made. Thus, if the information disclosed in the statements has no desirability, undesirable decisions are made and consequently, waste of economic resources and disruption in the capital markets are caused. Financial statements and information disclosed by the business units are the most important resources to show the financial status and performance of managers. Therefore, important decisions are made based on the

Table 5: Final weights

Criteria	**Relative weight**	**Final weight**	**Rank**
Structure of quantitative ownership (A)	0.1282		3
Ownership concentration percent	0.1931	0.0247	4
institutional ownership percent	0.2104	0.027	1
managerial ownership percent	0.2092	0.0268	2
governmental ownership percent	0.1882	0.0241	5
free and floating share percent	0.1991	0.0255	3
structure of qualitative ownership (B)	0.1219		6
existence of institutional ownership	0.5084	0.062	1
existence of governmental ownership	0.4916	0.0599	2
structure of qualitative board of directors (C)	0.116		8
ratio of independent members	0.4776	0.0554	2
dual duties of CEO	0.5224	0.0606	1
structure of qualitative board of directors (D)	0.1305		2
expertise of members	1	0.1305	–
auditing, internal control and committee (E)	0.1243		5
auditors' type	0.1841	0.0229	3
reporting type	0.2272	0.0282	1
suitable internal control	0.2271	0.0282	2
auditing committee	0.1794	0.0223	5
independence of auditing committee	0.1822	0.0226	4
items of financial statements (F)	0.1347		1
operational cash flows	0.345	0.0465	1
investment cash flows	0.3367	0.0454	2
financing cash flows	0.3183	0.0429	3
financial ratios (G)	0.1278		4
current ratio	0.1427	0.0182	5
inventory turnover ratio	0.1407	0.018	6
ratio of debt to total assets	0.1397	0.0178	7
return on assets (ROA)	0.1465	0.0187	1
return on equity (ROE)	0.1435	0.0183	3
earnings per share (EPS)	0.144	0.0184	2
P/E	0.143	0.0183	4
indices (H)	0.1166		7
currency price index	0.5099	0.0594	1
stock exchange index	0.4901	0.0571	2

information resources. If the financial statements are more desirable, they will be considered as an important basis for making decisions. The information can be regarded as the basis for making decisions in terms of future activities if the information is prepared correctly.

The structure of the board of directors (qualitative) has been put it in second place since the board of directors with accounting and financial information to supervise more efficiently plays a significant role in the management of firms and increases the value of firms. Managers who are more familiar with accounting and financial affairs can make more effective connections between managers and auditors committees concerning the estimates and judgments and improve their understanding of the financial reporting and disclosure requirements. Managers who have more accounting skills and expertise may confirm information for the users outside the organization leading to decreased information unbalance. A board of directors with more accounting and financial skills will have less unbalanced information concerning financial markets and less capital costs. In this research, the board of directors has been assessed according to the educational degrees and those with accounting and financial degrees have been considered.

The structure of ownership (quantitative) has been put in third place due to the high impact of affairs and structure of ownership on the decisions. Institutional ownership runs the operations effectively and desirably due to the high ability and resources required for correct supervision and management decisions as well as investment expertise. Institutional ownership can enhance the informational environment and cause more transparency of information. If the shareholders mostly depend on the government, it may be more effective in the stock price. Concerning the support rules and transparency in capital markets, the concentration of ownership can lead to increased returns. The structure of ownership is a significant tool in running the firms and making decisions to decrease the problems. Thus, users of financial statements must be aware of stockholders while using the statements disclosed by the firms. Generally, the performance of firms with higher percentages of institutional ownership will be higher. Considering the results and applying the DANP method, this research provides a new field for future research and suggests that other qualitative factors such as the sexuality of members, number of meetings, risk management committee, etc. are investigated and

compared concerning the different methods of making decisions.

References

[1] A.M. Alimohammadi, A. Tavangar, and M.J. Sharifi, *The role of quality accounting information management system in investment selection*, J. Account. Knowledge Manag. Audit. **7** (2018), no. 28.

[2] M.A. Aqhaei, A. Anvari Rostami, V. Ahmadian, and G. Montazeri, *Ranking qualitative features of accounting information based on views of providers, auditors and users of financial statements: Application of AHP*, J. Exper. Account. Stud. **10** (2012), no. 38, 1–27.

[3] W.Y. Chiu, G.H. Tzeng, and H.L. Li, *A new hybrid MCDM model combining DANP with VIKOR to improve e-store business*, Knowledge-Based Syst. **37** (2013), 48–61.

[4] FASB, *The FASB's Conceptual Framework: Relevance and Reliability*, Financial Accounting Standards Advisory Council, Stamford, CT, 2004.

[5] Q. He and C. Fang, *Regulatory sanctions and stock pricing efficiency: Evidence from the Chinese stock market*, Pacific-Basin Finance J. **58** (2019), 101241.

[6] M. Namazi and B. Zare, *The theoretical application of information in determining systematic risk*, Account. Audit. Stud. **10** (2003), no. 35, 79–100.

[7] O. Poorheidari and S. Yazdi, *Investigating the ability to prediction and content of information elements such as profit and loss*, Account. Knowledge **2** (2011), no. 7, 121–142.