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Strategic planning and performance measurement using Fuzzy DEMATEL: A case study of Iran Kaolin and Barite company

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This paper presents an empirical investigation to measure the performance of a mining firm in province of Semnan, Iran based on fuzzy fuzzy Decision Making Trial and Evaluation Laboratory (DEMATEL) technique. The proposed study of this paper uses strength, weakness, opportunity and threat (SWOT) technique to analyze the firm and using DEMATEL rank various items based on their relative importance. Based on the results of our survey, cost reduction and increase investment in mining sector are the most important components of this survey. The study also compares the results with similar study, which has recently been accomplished and we believe the proposed model is capable of detecting possible threats and helping us provide possible actions.

1. Introduction

Many managerial decisions are involved with a set of different criteria where we often see some sorts of conflict among them leading us to use multi-criteria decision making (MCDM) techniques. Existing methods of equity investment, such as fundamental analysis, technical analysis, and institutional investor analysis, explore essential factors of stock price behaviors. Lee et al. (2011) provided the first analysis on the interactive relationships among the factors in incorporating the techniques of Decision Making Trial and Evaluation Laboratory (DEMATEL) (Fontela & Gabus, 1974) and Analytic Network Process (ANP) (Saaty, 1994, 2004). They reported that factors from the existing analytical methodologies had significant interactive and self-feedback dynamics. Among the key factors, profitability has been the most important one influencing investment decision, followed by growth and trading volume. In addition, due to the complexity of the ANP, this study proposed a new method to simplify the process, and empirical evidences indicated that the approach was effective and efficient.

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According to Lin and Wu (2008) Causal analysis largely impacts the effectiveness of decision-making and the productivity of actions. The complicated relationship between cause and effect as well as the fuzzy nature of human judgment often make the casual analysis more difficult. Lin and Wu (2008) developed a fuzzy DEMATEL method for group decision-making to gather group ideas and analyzed the cause–effect relationship of complex problems in fuzzy environments. They used the fuzzy DEMATEL procedures and separated the involved criteria of a system into the cause and effect groups to help decision-makers concentrate on those criteria, which provide important impact. They presented an empirical study based on their proposed fuzzy DEMATEL method to the R&D project selection of a Taiwanese firm. They reported that, within the cause group, the criterion of "probability of technical success" was the most important items for R&D project selection, whereas the "strategic fit" and "potential size of market" have the best impact on the other criteria.

Tzeng et al. (2007) proposed a new hybrid MCDM model to address the independent relationship of evaluation criteria with the help of factor analysis and the dependent relationship of evaluation criteria with the aid of DEMATEL. They used analytical hierarchy process (AHP) (Saaty & Vargas, 1994) and the fuzzy integral techniques (Li, 1999) for synthetic utility in accordance with subjective perception environment. Empirical results indicated that the proposed model was capable of producing effective evaluation of e-learning programs with adequate criteria that fit with respondent's perception patterns, especially when the evaluation criteria were numerous and intertwined. Zhou et al. (2011) discussed on how to enhance emergency management by segmenting complex impacting factors into groups to improve them in a stepwise way. To address this concern involving the vagueness of human judgments, they used an efficient technique that mixes fuzzy logic and DEMATEL. Considering the interdependence among factors, this fuzzy DEMATEL technique formed a structural model and then visualizes the causal relationships among factors through a cause-effect relationship diagram. Then based on the results of their proposed method, critical success factor (CSF) of emergency management was detected. They identified five factors out of 20 ones where all factors could be achieved in a stepwise way for better promoting the effectiveness and efficiency of emergency management.

Yang et al. (2008) proposed a novel hybrid MCDM model combined with DEMATEL and ANP to handle the dependence and feedback problems to suit the real-world applications. They also gave an instance to show the proposed method with applications thereof. Their results demonstrated the proposed method is more suitable for real-world applications than the traditional ones. Opricovic and Tzeng (2003) proposed fuzzy MCDM (FMCDM), which consists of two phases. In the first phase, the CFCS phase, the method converts the Fuzzy data into Crisp Scores, and the MCDM phase, MCDM. The model seems to be applicable for defuzzification within the MCDM model with a mixed set of crisp and fuzzy criteria. The CFCS method is based on the procedure of determining the left and right scores by fuzzy min and fuzzy max, respectively, and the total score is computed a weighted average based on the membership functions.

2. The proposed model

The proposed model of this paper uses fuzzy DEMATEL for ranking various strategies extracted SWOT matrix (Lee & Walsh, 2011). In this section, we present details of the implementation of our proposed method.

Step 1. Setup goals and objectives,

Step 2. Determine fuzzy goals and scales based on the following triangular linguistic verbal terms,

Very high (VH)	High	Low	Very Low	No effect (NO)
(0.75,1,1)	(0.5, 0.75, 1)	(0.25, 0.5, 0.75)	(0.0, 0.25, 0.50)	(0.0, 0.0, 0.25)

Step 3. Setup decision matrix as follows,

$$\tilde{Z}^{\langle k\rangle} = \begin{bmatrix} 0 & \tilde{Z}_{12}^{\langle k\rangle} & \cdots & \tilde{Z}_{1n}^{\langle k\rangle} \\ \tilde{Z}_{21}^{\langle k\rangle} & 0 & \cdots & \tilde{Z}_{2n}^{\langle k\rangle} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{Z}_{n1}^{\langle k\rangle} & \tilde{Z}_{n2}^{\langle k\rangle} & \cdots & 0 \end{bmatrix} \quad k = 1,2,...,p \tag{1}$$

where $\tilde{z}_{ij}^{\langle k\rangle} = \left(\lambda_{ij}^{\langle k\rangle}, m_{ij}^{\langle k\rangle}, u_{ij}^{\langle k\rangle}\right)$ is associated with k^{th} decision maker, which is called Initial direct-relation fuzzy matrix.

Step 4. Normalize decision making matrix as follows,

$$\tilde{a}_i^{\langle k\rangle} = \sum_{j=1}^{n} \tilde{Z}_{ij}^{\langle k\rangle} = \left(\sum_{j=1}^{n} \lambda_{ij}^{\langle k\rangle}, \sum_{j=1}^{n} m_{ij}^{\langle k\rangle}, \sum_{j=1}^{n} u_{ij}^{\langle k\rangle}\right), \tag{2}$$

$$r^{\langle k\rangle} = \max_{1\le i\le n}\left(\sum_{j=1}^{n} u_{ij}^{\langle k\rangle}\right). \tag{3}$$

Now, in order to convert scale criteria into measurable scales we use linearization technique. Let $\tilde{X}^{\langle k\rangle}$ be relationship matrix associated with k^{th} decision maker, which is defined as follows,

$$\tilde{X}^{\langle k\rangle} = \begin{bmatrix} \tilde{X}_{11}^{\langle k\rangle} & \tilde{X}_{12}^{\langle k\rangle} & \cdots & \tilde{X}_{1n}^{\langle k\rangle} \\ \tilde{X}_{21}^{\langle k\rangle} & \tilde{X}_{22}^{\langle k\rangle} & \cdots & \tilde{X}_{2n}^{\langle k\rangle} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{X}_{n1}^{\langle k\rangle} & \tilde{X}_{n2}^{\langle k\rangle} & \cdots & \tilde{X}_{nn}^{\langle k\rangle} \end{bmatrix} \quad k = 1,2,...,p \tag{4}$$

where

$$\tilde{X}_{ij}^{\langle k\rangle} = \frac{\tilde{Z}_{ij}^{\langle k\rangle}}{r^{\langle k\rangle}} = \left(\frac{\lambda_{ij}^{\langle k\rangle}}{r^{\langle k\rangle}}, \frac{m_{ij}^{\langle k\rangle}}{r^{\langle k\rangle}}, \frac{u_{ij}^{\langle k\rangle}}{r^{\langle k\rangle}}\right) \tag{5}$$

Like standard DEMATEL we assume there is at least one i where $\sum_{j=1}^{n} u_{ij}^{\langle k\rangle} < r^{\langle k\rangle}$.

Step 5. In order to compute total relation fuzzy matrix we first need to make sure that $\lim_{w\to\infty} \tilde{X}^{w} = 0$. Consider $\tilde{X}_{ij} = \left(\lambda_{ij}, m_{ij}, u_{ij}\right)$ and consider the following three matrices,

$$X_u = \begin{bmatrix} 0 & u_{12} & \cdots & u_{1n} \\ u_{21} & 0 & \cdots & u_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ u_{n1} & u_{n2} & \cdots & 0 \end{bmatrix} \quad X_m = \begin{bmatrix} 0 & m_{12} & \cdots & m_{1n} \\ u_{21} & 0 & \cdots & m_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ m_{n1} & m_{n2} & \cdots & 0 \end{bmatrix} \quad X_\lambda = \begin{bmatrix} 0 & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & 0 & \cdots & \lambda_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & 0 \end{bmatrix}$$

Like deterministic DEMATEL we define the following,

$$\tilde{T} = \lim_{w \to \infty} \left(\tilde{X} + \tilde{X}^2 + \ldots + \tilde{X}^w \right) = X \times \left(I - X \right)^{-1} \tag{7}$$

Lemma 1. Let $\tilde{T} = \begin{bmatrix} \tilde{t}_{11} & \tilde{t}_{12} & \cdots & \tilde{t}_{1n} \\ \tilde{t}_{21} & \tilde{t}_{22} & \cdots & \tilde{t}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{t}_{n1} & \tilde{t}_{n2} & \cdots & \tilde{t}_{nn} \end{bmatrix}$ where $\tilde{t}_{ij} = \left(\lambda''_{ij}, m''_{ij}, u''_{ij} \right)$ then

$\text{Matrix}\left[\lambda''_{ij} \right] = X_\lambda \times \left(I - X_\lambda \right)^{-1}$ $\quad$ $\text{Matrix}\left[m''_{ij} \right] = X_m \times \left(I - X_m \right)^{-1}$ $\quad$ $\text{Matrix}\left[u''_{ij} \right] = X_u \times \left(I - X_u \right)^{-1}$ ■

Let $\tilde{n}_k = \left(\lambda_k, m_k, u_k \right); k = 1, 2, \ldots, n$, where $\tilde{n}_k^{def}$ is a crisp value, $L = \min\left(\lambda_k \right)$ and $R = \max\left(u_k \right)$; $k = 1, 2, \ldots, n$ and $\Delta = R - L$ then we have,

$$\tilde{n}_k^{def} = L + \Delta \times \frac{(m - L)(\Delta + u - m)^2 (R - \lambda) + (u - L)^2 (\Delta + m - \lambda)^2}{(\Delta + m - \lambda)(\Delta + u - m)^2 (R - \lambda) + (u - L)(\Delta + u - m)} \tag{8}$$

3. Case study

The proposed study of this paper is implemented for one of Iranian firm called Iran Kaolin and Barite company located in province of Semnan, Iran. Iran Kaolin and Barite company was established in 1992 and it produces and provides mineral products needed by industries such as oil and gas drilling, chemical and ceramic. The company is one of major producers of industrial mineral powders such as Barite, Bentonite and Hematite according to API, OCMA & ASTM standards, micronized calcium carbonate, Kaolin, Talc, Feldespar, Silicaflour and other mineral powders. The firm is also active in exporting its products to the countries in the Persian Gulf region and CIS countries. Table 1 demonstrates the summary of SWOT for our study.

Table 1
The summary of SWOT

	Strength (S)	Weakness (W)
Opportunities (O)	Using S-O strategies	Using W-O strategies
	Using competitive strategies (O_2, O_3, S_2)	Increase investment in production (W_1, O_3)
	Increase customer satisfaction (O_5, S_3)	Increase investment in mining (W_2, O_2)
		Use competitors' capability to increase production (W_1, O_4)
Threats (T)	Using S-T strategies	Using W-T strategies
	Use present good reputation (S_2, T_1)	Concentration on export methods (W_1, T_4)
	Increase global opportunities (T_1, S_3, S_4, S_6)	
	Increase export (T_4, S_2)	
	Reduce production cost (T_5, S_4, S_6)	

In order to accomplish the SWOT strategies, we need to ask decision makers to express their opinions in terms of verbal language. Table 2 to Table 5 demonstrate details of our findings as follows,

Table 2
S-O strategies

	Description	O2	O3	O4	O5
S2	Existence of sales' records for domestic and international firms	H	VH	NO	NO
S3	Existence of necessary test equipment and access to ISO 9001:2000	NO	NO	NO	VH
S4	Existence of mines, which are located only 1.5 km away from firm	H	H	H	NO
S6	Existence of export opportunities towards north part of Iran	NO	H	NO	NO
O2	Unique product characteristics and lack of replacement product	___	___	___	___
O3	Existence of common resources in the region	___	___	___	___
O4	Quitting one of the biggest competitors from the region	___	___	___	___
O5	Existence of international standards to control the quality	___	___	___	___

Table 3
S-T strategies

	Description	T1	T4	T5
S2	Existence of sales' records to well-known firms	H	NO	H
S3	Existence of necessary test equipment and access to ISO 9001:2000	H	NO	VH
S4	Existence of mines, which are located only 1.5 km away from firm	L	NO	L
S6	Existence of export opportunities towards north part of Iran	M	H	NO
T1	Tension in south region	___	___	___
T4	Economic crises and shortage in liquidity	___	___	___
T5	Unfair completion through newly established firms in other countries	___	___	___

Table 4
W-O strategies

	Description	W1	W2
O2	Lack of replacement products	NO	L
O3	Existence of common natural resources in the region and competition	L	NO
O4	Quitting one of the biggest competitors from the region	H	NO
O5	Existence of necessary test equipment and access to ISO 9001:2000	NO	NO
W1	Production limit in quantity	___	___
W2	Insufficient investment in mineral resources	___	___

Table 5
W-T strategies

	Description	W1	W2
T1	Tension in south region	NO	NO
T4	Economic crises and shortage in liquidity	M	NO
T5	Unfair completion through newly established firms in other countries	NO	NO
W1	Production limit in quantity	___	___
W2	Insufficient investment in mineral resources	___	___

Table 6 summarizes the results of relationships between different actions.

Table 6
The summary of relationship between various components

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	–	–	–	–	H	VH	NO	NO	H	NO	H	NO	NO
S3	–	–	–	–	NO	NO	NO	VH	H	NO	VH	NO	NO
S4	–	–	–	–	H	H	H	NO	L	NO	L	NO	NO
S6	–	–	–	–	NO	H	NO	NO	M	H	NO	NO	NO
O2	NO	NO	NO	NO	–	–	–	–	NO	NO	NO	NO	L
O3	NO	NO	NO	NO	–	–	–	–	NO	NO	NO	L	NO
O4	NO	NO	NO	NO	–	–	–	–	NO	NO	NO	H	NO
O5	NO	NO	NO	NO	–	–	–	–	NO	NO	NO	NO	NO
T1	NO	NO	NO	NO	NO	NO	NO	NO	–	–	–	NO	NO
T4	NO	NO	NO	NO	NO	NO	NO	NO	–	–	–	M	NO
T5	NO	NO	NO	NO	NO	NO	NO	NO	–	–	–	NO	NO
W1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	–	–
W2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	–	–

Now we are able to compute X_{λ} for different constructive components of various strategies.

Table 7

The summary for X_{λ}

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	0	0	0	0	0.5	0.75	0	0	0.5	0	0.5	0	0
S3	0	0	0	0	0	0	0	0.75	0.5	0	0.75	0	0
S4	0	0	0	0	0.5	0.5	0.5	0	0.25	0	0.25	0	0
S6	0	0	0	0	0	0.5	0	0	0.25	0.5	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0.25
O3	0	0	0	0	0	0	0	0	0	0	0	0.25	0
O4	0	0	0	0	0	0	0	0	0	0	0	0.5	0
O5	0	0	0	0	0	0	0	0	0	0	0	0	0
T1	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	0	0	0	0.25	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0
W1	0	0	0	0	0	0	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8

The summary for X_{m}

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	0	0	0.75	1	0	0	0.75	0	0.75	0	0	0	0
S3	0	0	0	0	0	1	0.75	0	1	0	0	0	0
S4	0	0	0.75	0.75	0.75	0	0.5	0	0.5	0	0	0	0
S6	0	0	0	0.75	0	0	0.5	0.75	0	0	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0.5	0	0
O3	0	0	0	0	0	0	0	0	0	0.5	0	0	0
O4	0	0	0	0	0	0	0	0	0	0.75	0	0	0
O5	0	0	0	0	0	0	0	0	0	0	0	0	0
T1	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	0	0.5	0	0	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0
W1	0	0	0	0	0	0	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9

The summary for X_{u}

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	0	0.25	0.25	0.25	1	1	0.25	0.25	1	0.25	1	0.25	0.25
S3	0.25	0	0.25	0.25	0.25	0.25	0.25	1	1	0.25	1	0.25	0.25
S4	0.25	0.25	0	0.25	1	1	1	0.25	0.75	0.25	0.75	0.25	0.25
S6	0.25	0.25	0.25	0	0.25	1	0.25	0.25	0.75	1	0.25	0.25	0.25
O2	0.25	0.25	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.75
O3	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25	0.75	0.25
O4	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.25	0.25	1	0.25
O5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.25	0.25	0.25
T1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.25	0.25
T4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.75	0.25
T5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25
W1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25
W2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0

Table 10

The summary of $Matrix\left[\lambda''_{ij}\right]=X_{\lambda}\times\left(I-X_{\lambda}\right)^{-1}$

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	0	0	0	0	0.5	0.75	0	0	0.5	0	0.5	0.188	0.125
S3	0	0	0	0	0	0	0	0.75	0.5	0	0.75	0	0
S4	0	0	0	0	0.5	0.5	0.5	0	0.25	0	0.25	0.375	0.125
S6	0	0	0	0	0	0.5	0	0	0.25	0.5	0	0.25	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0.25
O3	0	0	0	0	0	0	0	0	0	0	0	0.25	0
O4	0	0	0	0	0	0	0	0	0	0	0	0.5	0
O5	0	0	0	0	0	0	0	0	0	0	0	0	0
T1	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	0	0	0	0.25	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0
W1	0	0	0	0	0	0	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11
The summary of $Matrix\left[m''_{ij}\right]=X_m\times\left(I-X_m\right)^{-1}$

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	0	0	0	0	0.75	1	0	0	0.75	0	0.75	0.5	0.375
S3	0	0	0	0	0	0	0	1	0.75	0	1	0	0
S4	0	0	0	0	0.75	0.75	0.75	0	0.5	0	0.5	0.938	0.375
S6	0	0	0	0	0	0.75	0	0	0.5	0.75	0	0.75	0
O2	0	0	0	0	0	0	0	0	0	0	0	0	0.5
O3	0	0	0	0	0	0	0	0	0	0	0	0.5	0
O4	0	0	0	0	0	0	0	0	0	0	0	0.75	0
O5	0	0	0	0	0	0	0	0	0	0	0	0	0
T1	0	0	0	0	0	0	0	0	0	0	0	0	0
T4	0	0	0	0	0	0	0	0	0	0	0	0.5	0
T5	0	0	0	0	0	0	0	0	0	0	0	0	0
W1	0	0	0	0	0	0	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 12
The summary of $Matrix\left[u''_{ij}\right]=X_u\times\left(I-X_u\right)^{-1}$

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2
S2	-0.355	-0.155	-0.155	-0.155	-0.139	-0.045	-0.248	-0.248	-0.014	-0.248	-0.076	-0.385	-0.1
S3	-0.112	-0.312	-0.112	-0.112	-0.246	-0.314	-0.179	-0.301	-0.144	-0.179	-0.189	-0.417	-0.211
S4	-0.178	-0.178	-0.378	-0.178	-0.089	-0.017	-0.196	-0.284	-0.213	-0.284	-0.142	-0.181	-0.142
S6	-0.123	-0.123	-0.123	-0.323	-0.271	-0.135	-0.197	-0.197	-0.05	-0.283	-0.32	-0.074	-0.232
O2	-0.056	-0.056	-0.056	-0.056	-0.323	-0.157	-0.09	-0.09	-0.168	-0.09	-0.146	-0.208	-0.215
O3	-0.056	-0.056	-0.056	-0.056	-0.123	-0.357	-0.09	-0.09	-0.168	-0.09	-0.146	-0.112	-0.105
O4	-0.064	-0.064	-0.064	-0.064	-0.141	-0.179	-0.302	-0.102	-0.192	-0.102	-0.166	-0.242	-0.12
O5	-0.04	-0.04	-0.04	-0.04	-0.088	-0.112	-0.064	-0.264	-0.12	-0.064	-0.104	-0.149	-0.075
T1	-0.04	-0.04	-0.04	-0.04	-0.088	-0.112	-0.064	-0.064	-0.32	-0.064	-0.104	-0.149	-0.075
T4	-0.056	-0.056	-0.056	-0.056	-0.123	-0.157	-0.09	-0.09	-0.168	-0.29	-0.146	-0.112	-0.105
T5	-0.04	-0.04	-0.04	-0.04	-0.088	-0.112	-0.064	-0.064	-0.12	-0.064	-0.304	-0.149	-0.075
W1	-0.04	-0.04	-0.04	-0.04	-0.088	-0.112	-0.064	-0.064	-0.12	-0.064	-0.104	-0.349	-0.075
W2	-0.04	-0.04	-0.04	-0.04	-0.088	-0.112	-0.064	-0.064	-0.12	-0.064	-0.104	-0.149	-0.275

Next, we build triangular numbers based on instruction gave in Step 5 of the proposed method.

Table 13
The summary of triangular numbers

Component	S2	S3	S4	S6	O2	O3	O4	O5	T1	T4	T5	W1	W2	R
S2	-0.032	-0.014	-0.014	-0.014	-0.184	-0.635	-0.022	-0.022	-0.483	-0.022	3.915	-0.026	-0.008	3.157
S3	-0.01	-0.028	-0.01	-0.01	-0.022	-0.028	-0.016	-0.275	-0.161	-0.016	15.316	-0.038	-0.019	14.682
S4	-0.016	-0.016	-0.034	-0.016	1.029	-0.353	-0.041	-0.026	-0.016	-0.026	-0.027	-0.17	-0.014	-0.652
S6	-0.011	-0.011	-0.011	-0.029	-0.025	-0.201	-0.018	-0.018	-0.059	-0.028	-0.029	-0.126	-0.021	-0.161
O2	-0.005	-0.005	-0.005	-0.005	-0.029	-0.014	-0.008	-0.008	-0.015	-0.008	-0.013	-0.019	-0.036	-0.1
O3	-0.005	-0.005	-0.005	-0.005	-0.011	-0.032	-0.008	-0.008	-0.015	-0.008	-0.013	-0.014	-0.01	-0.112
O4	-0.006	-0.006	-0.006	-0.006	-0.013	-0.016	-0.027	-0.009	-0.017	-0.009	-0.015	-0.004	-0.011	-0.137
O5	-0.004	-0.004	-0.004	-0.004	-0.008	-0.01	-0.006	-0.024	-0.011	-0.006	-0.009	-0.013	-0.007	-0.109
T1	-0.004	-0.004	-0.004	-0.004	-0.008	-0.01	-0.006	-0.006	-0.029	-0.006	-0.009	-0.013	-0.007	-0.109
T4	-0.005	-0.005	-0.005	-0.005	-0.011	-0.014	-0.008	-0.008	-0.015	-0.026	-0.013	-0.014	-0.01	-0.112
T5	-0.004	-0.004	-0.004	-0.004	-0.008	-0.01	-0.006	-0.006	-0.011	-0.006	-0.028	-0.013	-0.007	-0.109
W1	-0.004	-0.004	-0.004	-0.004	-0.008	-0.01	-0.006	-0.006	-0.011	-0.006	-0.009	-0.032	-0.007	-0.109
W2	-0.004	-0.004	-0.004	-0.004	-0.008	-0.01	-0.006	-0.006	-0.011	-0.006	-0.009	-0.013	-0.025	-0.109
J	-0.109	-0.109	-0.109	-0.109	1.363	-0.632	-0.179	-0.422	-0.262	-0.117	11.279	-0.16	-0.109	—

Table 14
The summary of DEMATEL computations

Strategies	(R)	(J)	(R-J)	(R+J)
S2	0.241	-0.109	0.349	0.132
S3	0.191	-0.109	0.3	0.083
S4	0.163	-0.109	0.272	0.055
S6	0.166	-0.109	0.275	0.058
O2	0.19	-1.363	1.553	-1.173
O3	0.213	0.632	-0.418	0.845
O4	0.158	-0.179	0.337	-0.021
O5	0.22	-0.422	0.642	-0.202
T1	0.231	0.262	0.031-	0.492
T4	0.225	-0.117	0.342	0.108
T5	0.214	11.279	-11.065	11.493
W1	0.31	0.16	0.15	0.47
W2	0.177	-0.109	0.287	0.068

Finally, we may present details of suitable strategies for the proposed case study of this paper in Table 15 as follows,

Table 15
The summary of appropriate strategies

Strategies	(R)	(J)	(R-J)	(R+J)
Use strong competitive skills	0.644	-0.84	1.484	-0.196
Increase customers' trust in products and services	0.411	-0.531	0.942	-0.12
Take advantage of good reputations among existing customers	0.472	0.153	0.319	0.625
Increase in competition capabilities in international market	0.751	-0.065	0.816	0.686
Increase transaction with foreign customers	0.466	-0.226	0.692	0.24
Cost reduction endeavors	**0.543**	**11.061**	**-10.518**	**11.604**
Increase investment in production units	0.523	0.792	-0.269	1.315
Increase investment in mining industries	**0.367**	**-1.472**	**1.839**	**-1.105**
Take advantage of competitors' capabilities to increase production	0.468	-0.019	0.487	0.449
Allocate production for export purposes	0.535	0.043	0.492	0.578

As we can observe from the results of Table 15, cost reduction and increase investment in mining sector are the most important components of this survey.

4. Discussion and conclusion

In this paper, we have presented an empirical investigation to determine weakness, strength, opportunities and possible threats (SWOT) for a case study of an Iranian firm named Kaolin and Barite company, which was doing business on providing mineral products needed by industries such as oil and gas drilling, chemical and ceramic. They discussed different issues influencing the market activities using SWOT analysis and then ranked important components based on fuzzy DEMATEL. Based on the results of our survey, cost reduction and increase investment in mining sector are the most important components of this survey. The implementation of DEMATEL for ranking different alternatives has recently become popular among researchers (Shepherd & Günter, 2006; Amiri et al., 2011).

Najmi and Makui (2010), for instance, provided hierarchical approach for measuring supply chain performance using AHP and DEMATEL methodologies. Sofiyabadi et al. (2012) presented an integrated balanced score card combined with DEMATEL technique to prioritize different alternatives for supply chain implementation.

Danaei and Omidifard (2013) performed strategic planning and performance measurement using balanced scorecard (BSC) (Kaplan & Norton, 1992, 1996, 2004) for the same case study. The results of their survey indicated that the firm was able to make a 30% improvement on its performance after one-year implementation of BSC. In other words, the firm was able to make 59% improvement on learning and growth, 33% growth on internal process, 32% growth on customer and 21% improvement on financial figures.

We hope the results of this survey along with other investigations accomplished recently could help this industry grow faster and build better business activities.

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