



# Voluntary Risk disclosure Assessment in The Corporate Board Structure under uncertainty: A Case Study of Saudi Arabian Companies

Abdulaziz Ali Murayr<sup>1</sup>, Khalid Hameed Alharbi<sup>2</sup>, Hanin Mubarak Aloufi<sup>3</sup>

<sup>1,2</sup>Victoria University, Business school, Melbourne, Australia

<sup>1</sup>Email: murayr.a@outlook.com ; <sup>2</sup>Email: alharbi.khalid.h@gmail.com; <sup>3</sup>Email: hanin.m.aloufi@gmail.com

\*Correspondence: murayr.a@outlook.com

**Abstract:** The global crisis of financial and corporate scandals of governance have run to calls for well voluntary risk disclosure. Firms limit this disclosure of voluntary by the proprietary cost theory to evade the risk of opposing actions. So, this paper investigates and assessment voluntary risk disclosure in the corporate board structure. These voluntary risk disclosures contain the conflict and multiple criteria. So the concept of multi-criteria decision-making (MCDM) is used to overcome this problem. The neutrosophic sets are used to deal with uncertain information. This paper used the Analytic Network Process (ANP) and Decision-making trial and evaluation laboratory (DEMATEL) methods to assess voluntary risk disclosure. The ANP is used to calculate the weights of criteria. DEMATEL method is used to assess and show the impact of voluntary risk disclosure. This research uses Saudi Arabian companies as a case study.

**Keywords:** ANP; DEMATEL; SVNSs; Neutrosophic Sets; voluntary risk disclosure.

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## 1. Introduction

Mandatory disclosure is known as the corporates are needed to disclosure minimum level of information according to standards of accepted account. Mandatory disclosure includes related information about the company's performance and results of financial reporting[1]. To make an economic and financial decision, attaining the appropriate information is very important for many

stakeholders[2, 3]. Annually in companies, the financial reporting is published as a source of information for internal and external stakeholders. Financial reporting is considered as a tool of communication for moving information of non-financial and financial to attention stakeholders[3].

Corporates have become more attention to possible risks that can affect the performance of systems and sustainability in the last years due to the global crisis of finance [4]. By the review of the literature, the stakeholders obtain a little information about risks that might affect corporates. So, the investors, shareholders, and stakeholders are pressure corporates to obtain and disclose risks to help them to lessen the uncertainty in decisions and to do better management in potential risks[5]. This needs more and more information than the standards generally accepted. This is known as voluntary disclosure, which means reporting information of financial and non-financial related operations of corporates, this gives more information and explanations beyond the framework set by regulations. Eng and Mak state that “voluntary disclosure is measured by the amount and detail of non-mandatory information that is contained in the management discussion and analysis in the annual report”[6]. While mandatory disclosure regulations ensure access to basic information, voluntary disclosures should be augmented by companies[7]. The level of voluntary disclosure depends on the attitude of board members towards voluntary disclosure and the benefits and costs involved[8]. So, the voluntary disclosure information helps the users and producers for the development of the accounting standards and policies[2]. Mandatory voluntary risk disclosure includes risk information disclosed by companies as specified in the International Financial Reporting Standards (IFRS) and Saudi GAAP. Voluntary disclosure of risk is any other risk information that appears in the narrative sections of the annual corporate reports. Both of these risk types are measured by the number of risk information sentences used in the accounting literature.

Reporting of risks is important in corporate disclosure practices due to offers information and details that related to corporate investment options [9]. The previous studies found deficiencies in the disclosure of risk and vague in corporate annual reports[10]. The voluntary risk disclosure is known as “the inclusion of information about managers’ estimates, judgments, reliance on market-based accounting policies such as impairment, derivative hedging, financial instruments, and fair value as well as the disclosure of concentrated operations, non-financial information about

corporations' plans, recruiting strategy, and other operational, economic, political and financial risks"[11]. So, voluntary risk disclosure is important for helping corporates to overcome uncertainties.

The capital market of Saudi Arabian is still in the stage of development with efforts to enhance its performance compared to the global capital market[12]. Moreover, though it is one of the major global oil sources, the Saudi government is investing heavily to diversify the economy by incorporating other industries including the tourism and entertainment sectors[13]. This will attract investors in local and global companies. So, the Saudi Government needs to include that corporates disclose enough information about their performance, risk vague and uncertainty. Hence, voluntary risk disclosure becomes more significant for the stability and profitability of Saudi corporates.

There are several theories that have been employed by researchers to examine how corporate board structure might influence the performance of companies. The current research employs agency theory to study the correlation between corporate board structure and level of voluntary risk disclosure in the Saudi context. Agency theory has been used by many studies to link corporate governance and voluntary risk disclosure. This theory posits that a corporate comprises of the agent and the principal. Agency theory can reduce agency loss. Agency theory advocates for the frequency of board meetings to characterize an active board of directors. Boards of directors that meet frequently are likely to result in risk reporting. Agency theory suggests that autonomous directors have no management role in the corporate, hence information concealment is minimized. Agency theory provides that presence of autonomous directors yields quality financial reports that are factual hence credible. Agency theory suggests that the characterization of corporate boards in terms of age, size, autonomy, and diversity does impact on the practice of voluntary risk disclosure

The voluntary risk disclosure more uncertain and vague information. So, this study proposed the neutrosophic sets to overcome this problem. The neutrosophic sets are generalized from fuzzy sets. Fuzzy sets cannot deal perfectly with uncertainty because not take into consideration the indeterminacy value[14]. This study proposed the single-valued neutrosophic sets (SVNSs). It is a subset of neutrosophic sets. It includes the Truth, Indeterminacy, False values (T,I,F)[15].

This kind of information includes multiple conflict criteria. So, proposed the concept of MCDM for overcoming it[16]. The MCDM method is used for assessing voluntary risk disclosure. The ANP method is used to obtaining the weights of criteria[17]. The DEMETAL is used to show impact and assessment the voluntary risk disclosure[18].

The main contributions in this work, assessment and show the impact of voluntary risk disclosure by using the neutrosophic sets to overcome uncertainty information, which not used in previous research, the ANP and DEMATAL are used as an MCDM method for assessing the voluntary risk disclosure not used in previous research and proposed a case study in Saudi Arabian companies.

The rest in this paper is organized as follow: section 2 present the review of the literature. Section 3 introduces the methodology. The case study is presented in section 4. The analysis of VRD is presented in section 5. Finally, section 5 introduces the conclusions of this work.

## **2. Review of Literature**

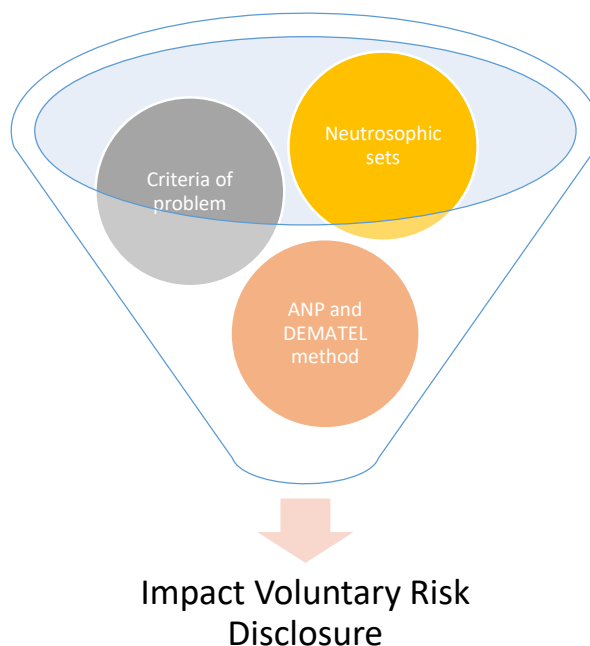
Voluntary risk disclosure is an important process for corporates due to the decrease issue of inconsistent information. The benefits of voluntary risk disclosure that help in relieve issues between director's boards and stakeholders. Can decrease problems by enough information disclosing risks and uncertainties, hence the investors can acquire more and more confidence in corporate due to symmetry and consistent information[19].

Elshandidy & Neri study the impact of corporate governance on voluntary risk disclosure practices in the UK and Italy and also study the influence of those practices on market fluidity[20]. The results have many influences on organizers and investors in both the UK and Italy. Al-Maghzom et al. scout corporate governance and the demographic feature of top management teams as the determinants of voluntary risk disclosure practices in listed banks [10]. They make a case study in all Saudi Arabian banks from 2009 to 2013. The results of their study show that outer ownership, gender, audit committee meetings, profitability, the board size, and volume are primary determinants of voluntary risk disclosure practices in Saudi listed banks. Al-Janadi et al. measure and contrast the standard of voluntary disclosure practices in Saudi Arabia and the UAE by using a modified

voluntary disclosure index[21]. Their results found that the level of voluntary disclosure is low and decreases for most of the items of social and ecological information. Al-Maghzom & Abdullah address the current hole in the disclosure literature by investigating voluntary risk disclosure in a developing economy (Saudi Arabia)[22]. Habbash et al. determine the voluntary disclosure level in Saudi Arabia and identify the main drivers of voluntary disclosure in Saudi Arabia[23].

The neutrosophic sets are used to overcome the uncertainty in voluntary risk disclosure. Karabašević et al. used the neutrosophic sets to select the e-commerce development strategies[24]. Dung et al. use the interval neutrosophic sets for personnel selection[25]. Broumi et al. SVNSSs to shortest path problem[26]. Akram et al used the SVNSSs for the physician selection problem[27]. The MCDM is used in this paper to deal with conflict criteria. ANP and DEMATEL are MCDM methods. Yang et al. used the ANP method for calculating the weights of criteria for a novel cluster weighted[17]. Abdel-Baset et al. used the ANP method for achieving sustainable supplier selection[28]. The DEMATEL method is used to determine the degrees of impact of these criteria. Han & Deng are used the fuzzy DEMATEL method to identify the critical success factors[29]. Abdel-Baset et al. used the neutrosophic with DEMATEL method for developing supplier selection criteria[30]. Mao et al. used the DEMATEL method handling dependent evidence [31].

The review of the literature found that no study used the ANP and DEMATEL method for voluntary risk disclosure and no study used the neutrosophic sets with this kind of problem. So, this study proposed the hybrid ANP and DEMATEL method for impact and assessment of the risk closure in companies for Saudi Arabian.



**Fig 1.** Research Methodology for this paper

### 3. Methodology

This methodology integrates the ANP and DEMATEL MCDM method under a neutrosophic environment for voluntary risk disclosure. This methodology has two-stage. In the first stage proposed the SVNNS and ANP method. ANP is used to calculate the weights of criteria. The second stage is used to show the impact and assessment of the voluntary risk disclosure. Fig 1. Show the research methodology.

#### 3.1 First Stage ANP Method

ANP is a common MCDM method. It is modified on the AHP method. The main benefits of ANP consider dependency between elements of the problem. ANP is used to calculate the weights of criteria.

Words are described semantic better than numbers. This paper used the SVNNS as a linguistic variable. Table 1. present the single-valued neutrosophic numbers (SVNNs) and linguistic variables[15]. The steps of the ANP method are organized as follows [28]: Fig 2. Show the steps of the ANP method.

Step 1: Select a group of decision-makers and experts

Step 2: Collect the criteria from the review of the literature.

Step 3: Build the structure of the problem.

Step 4: Build the pairwise comparison matrix between criteria by using Eq. (1)

$$P^T = \begin{bmatrix} P_{11}^T & \dots & P_{1b}^T \\ \vdots & \ddots & \vdots \\ P_{a1}^T & \dots & P_{ab}^T \end{bmatrix} \tag{1}$$

Where T presents the decision-makers.

Step 5: Obtaining the crisp value.

After building the pairwise comparison matrix need to convert the three values (T,I,F) with one value by applying the score function by using Eq. (2)

$$S(P_{kl}^T) = \frac{2 + T_{kl}^T - I_{kl}^T - F_{kl}^T}{3} \tag{2}$$

Where,  $T_{kl}^T - I_{kl}^T - F_{kl}^T$  presents truth, indeterminacy, and falsity of the SVNSSs.

Step 6: Combine the pairwise comparison matrix

After obtaining the crisp value (one value) need to combine the opinions of decision-makers into one value by using Eq. (3).

$$P_{kl} = \frac{\sum_{T=1}^T P_{kl}}{T} \tag{3}$$

Step 7: Build the combined pairwise comparison matrix.

After combined the opinions of decision-makers build the combined matrix by using Eq. (4)

$$P = \begin{bmatrix} P_{11} & \dots & P_{1l} \\ \vdots & \ddots & \vdots \\ P_{k1} & \dots & P_{kl} \end{bmatrix} \tag{4}$$

Step 8: Calculate the weights of criteria

The weights of criteria are computed by computing the eigenvector which will be used in the building of the supermatrix of interdependences.

Step 9: Compute the weights of sub-criteria.

The weights of sub-criteria are computed by multiplying the weights of the interdependences matrix by the weights of local weight which was obtained by comparison matrix of opinions decision-makers.

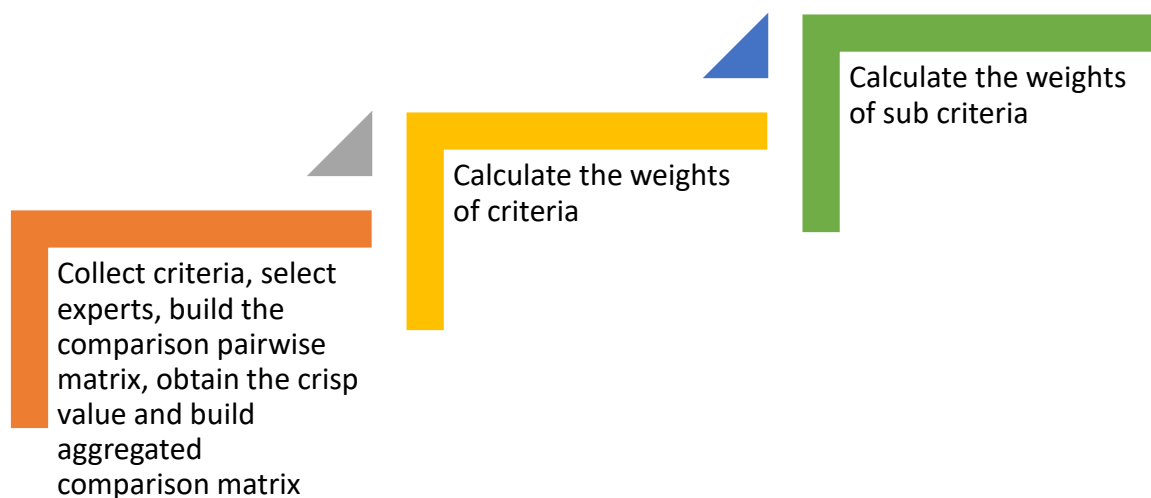


Fig 2. The steps of the ANP method

### 3.2. The Second Stage DEMATEL Method

The DEMATEL method is used for assessing voluntary risk disclosure and shows the impact of criteria. DEMATEL is an MCDM method. It is used to solve complex problems. The following steps of the DEMATEL method as follows [30]:

Step 10: Build the direct relation matrix.

By using the combined pairwise matrix in step 7 the direct relation matrix is built.

Step 11: Normalize the direct relation matrix.

The normalized direct relation matrix is computed by using Eqs. (5,6)

$$N = \frac{1}{\max_{1 \leq a \leq b} \sum_{k=1}^n P_{kl}} \tag{5}$$

$$M = N \times P \tag{6}$$

Step 12: Calculate the total relation matrix.

The total relation matrix is computed by using software Matlab to attain the identity matrix by using Eq. (7).

$$R = M(I - M)^{-1} \tag{7}$$

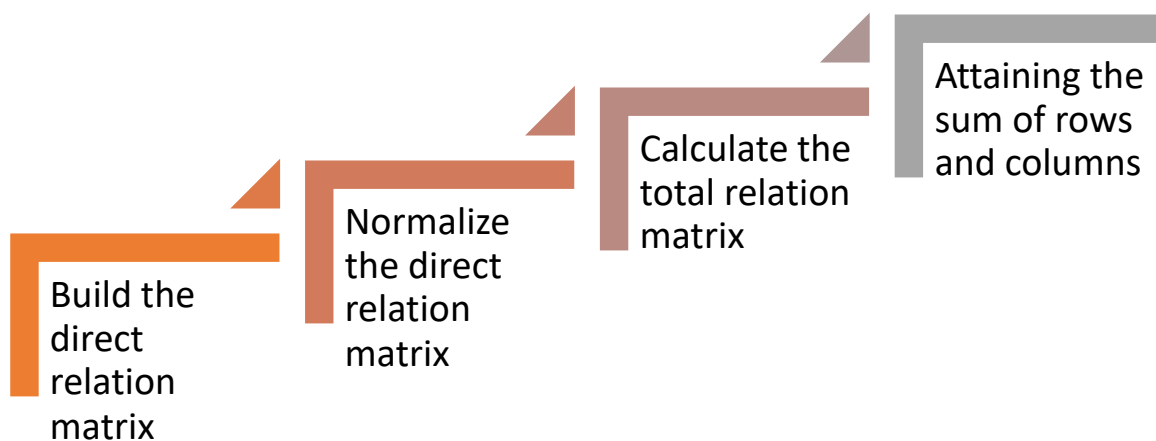


Step 13: Attaining the sum of rows and columns.

The sum of rows and columns is obtained as  $X$  and  $Y$  respectively. Then calculate  $X+Y$  and  $X-Y$

Step 14: Drawing the cause and effect diagram.

The cause diagram presents in Horizontal the value of  $X+Y$  and Vertically  $X-Y$ .



**Fig 3.** Show the steps of the DEMATEL method



**Fig 4.** The criteria of this study

#### **4. Case Study**

This study is made on companies of Saudi Arabian. The hybrid model was applied to voluntary risk disclosure. The target population of the study was all companies listed on the Saudi Stock Exchange, called Tadawul. Given the aim of this research, the sample included financial and non-financial companies. Financial institutions included banks, whereas non-financial institutions included all other listed companies. Since there are only 11 listed banks, all of them were selected and included 30 in the study. Also, out of 160 listed non-financial companies, 14 non-financial companies were randomly selected.

This study used the three decision-makers and experts to assess the criteria by their opinions. The criteria are determined from the review of the literature. The seven criteria are used in this research. Fig 4. Show the main criteria of this work. The five factors are proposed to show impact of board composition in the (voluntary risk disclosure) VRD. The five factor include: Gender  $F_1$ , Independent directors  $F_2$ , Board qualification  $F_3$ , Audit Committee meetings  $F_4$ , Board size  $F_5$ .

First by using the linguistic term in Table 1. the pairwise comparison matrix is built by opinions of experts by using Eq. (1). Then replace the linguistic term with SVNNs. Then convert the SVNNs into crisp value by score function by using Eq. (2). Then aggregate the crisp value to obtain one value instead of three values of three matrices by using Eq. (3). Then build the combined pairwise comparison matrix by using Eq. (4) to obtain one matrix. Table 2. Show the combined pairwise comparison matrix from main criteria. Tables 3 to 9 show the interdependency matrix for the main criteria. Table 10 shows the comparative for impact criteria. Fig 5. Show the weights of criteria. The weights of the criteria show that  $C_7$  Operational Risk is the highest risk by the ANP method and  $C_1$  Reputation Risk is the lowest risk. The rank risks in Table 11.

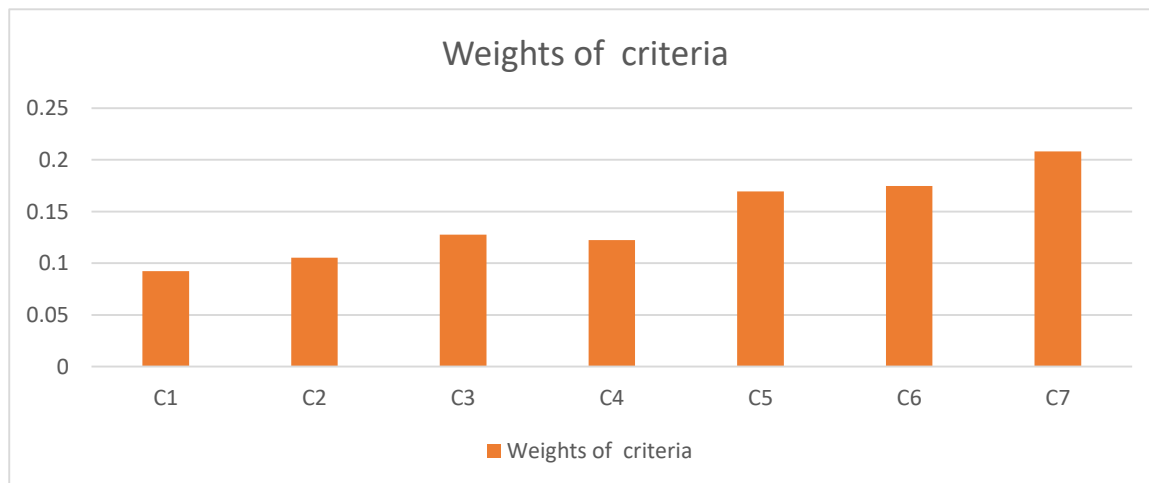


Fig 5. The weights of the criteria

Table 1. SVNSs scale.

Linguistic Term	SVNNs
Very Immoral	$\langle 0.25, 0.7, 0.7 \rangle$
Immoral	$\langle 0.35, 0.6, 0.6 \rangle$
Medium	$\langle 0.45, 0.5, 0.45 \rangle$

Honest	<0.75,0.35,0.25>
Very Honest	<0.85,0.2,0.2>

**Table 2.** The combined pairwise comparison of criteria and local weight.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.783367	0.527767	0.672233	0.750033	0.494433	0.494433	0.087967
C <sub>2</sub>	1.281388	0.5	0.6389	0.7167	0.494433	0.672233	0.750033	0.103278
C <sub>3</sub>	2.147428	1.742882	0.5	0.8167	0.494433	0.750033	0.3833	0.12385
C <sub>4</sub>	1.281388	1.22444	1.22444	0.5	0.750033	0.527767	0.750033	0.121667
C <sub>5</sub>	2.608923	2.204376	2.204376	1.338336	0.5	0.672233	0.783367	0.184447
C <sub>6</sub>	1.281388	1.338336	1.338336	2.147428	1.685934	0.5	0.783367	0.179213
C <sub>7</sub>	2.204376	1.338336	2.608923	1.338336	1.281388	1.281388	0.5	0.199578

**Table 3.** Interdependency matrix of the criteria related to C<sub>1</sub> Reputation Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.8167	0.605567	0.6389	0.750033	0.605567	0.3833	0.085857
C <sub>2</sub>	1.22444	0.5	0.672233	0.605567	0.750033	0.494433	0.7167	0.100001
C <sub>3</sub>	1.79983	1.685934	0.5	0.783367	0.6389	0.750033	0.672233	0.127074
C <sub>4</sub>	2.147428	1.395284	1.281388	0.5	0.672233	0.6389	0.8167	0.139085
C <sub>5</sub>	1.338336	1.742882	1.742882	1.685934	0.5	0.672233	0.7167	0.159205
C <sub>6</sub>	1.395284	2.204376	1.338336	1.742882	1.685934	0.5	0.3833	0.171669
C <sub>7</sub>	2.608923	1.395284	1.685934	1.22444	1.395284	2.608923	0.5	0.217109

**Table 4.** Interdependency matrix of the criteria related to C<sub>2</sub> Compliance Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.6389	0.6389	0.6389	0.6389	0.8167	0.8167	0.097589
C <sub>2</sub>	1.742882	0.5	0.6389	0.6389	0.6389	0.750033	0.7167	0.107704
C <sub>3</sub>	1.742882	1.742882	0.5	0.8167	0.6389	0.3833	0.527767	0.112032

C <sub>4</sub>	1.281388	1.22444	1.22444	0.5	0.3833	0.750033	0.527767	0.10576
C <sub>5</sub>	1.79983	1.742882	1.742882	2.608923	0.5	0.672233	0.7167	0.170402
C <sub>6</sub>	2.147428	2.608923	2.608923	1.338336	1.685934	0.5	0.3833	0.193487
C <sub>7</sub>	1.22444	1.395284	2.147428	2.147428	1.395284	2.608923	0.5	0.213027

**Table 5.** Interdependency matrix of the criteria related to C<sub>3</sub> Commodity.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.7167	0.527767	0.6389	0.527767	0.605567	0.527767	0.084499
C <sub>2</sub>	1.395284	0.5	0.750033	0.527767	0.750033	0.783367	0.7167	0.1109
C <sub>3</sub>	2.147428	1.338336	0.5	0.8167	0.6389	0.527767	0.527767	0.118158
C <sub>4</sub>	1.685934	1.22444	1.22444	0.5	0.494433	0.494433	0.672233	0.11665
C <sub>5</sub>	1.79983	1.742882	1.742882	2.204376	0.5	0.8167	0.7167	0.173688
C <sub>6</sub>	1.685934	2.147428	2.147428	2.204376	1.22444	0.5	0.8167	0.197791
C <sub>7</sub>	2.147428	1.395284	2.147428	1.685934	1.395284	1.22444	0.5	0.198313

**Table 6.** Interdependency matrix of the criteria related to C<sub>4</sub> Sustainability Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.750033	0.672233	0.750033	0.672233	0.605567	0.527767	0.093228
C <sub>2</sub>	1.338336	0.5	0.750033	0.6389	0.6389	0.783367	0.7167	0.109671
C <sub>3</sub>	1.685934	1.338336	0.5	0.783367	0.6389	0.605567	0.783367	0.122658
C <sub>4</sub>	1.685934	1.281388	1.281388	0.5	0.494433	0.494433	0.672233	0.120819
C <sub>5</sub>	2.204376	1.742882	1.742882	2.204376	0.5	0.783367	0.7167	0.180828
C <sub>6</sub>	1.338336	1.79983	1.79983	2.204376	1.281388	0.5	0.8167	0.18619
C <sub>7</sub>	2.147428	1.395284	1.281388	1.685934	1.395284	1.22444	0.5	0.186606

**Table 7.** Interdependency matrix of the main criteria related to C<sub>5</sub> Technological Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.750033	0.6389	0.6389	0.783367	0.527767	0.527767	0.0899

C <sub>2</sub>	1.338336	0.5	0.527767	0.6389	0.6389	0.783367	0.7167	0.104511
C <sub>3</sub>	1.742882	2.147428	0.5	0.783367	0.6389	0.6389	0.6389	0.130527
C <sub>4</sub>	1.685934	1.281388	1.281388	0.5	0.3833	0.605567	0.6389	0.118516
C <sub>5</sub>	1.685934	1.742882	1.742882	2.608923	0.5	0.783367	0.7167	0.177868
C <sub>6</sub>	1.281388	1.742882	1.742882	1.79983	1.281388	0.5	0.527767	0.165805
C <sub>7</sub>	2.147428	1.395284	1.742882	1.742882	1.395284	2.147428	0.5	0.212873

**Table 8.** Interdependency matrix of the main criteria related to C<sub>6</sub> Strategic Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.8167	0.605567	0.6389	0.750033	0.605567	0.672233	0.097709
C <sub>2</sub>	1.22444	0.5	0.672233	0.6389	0.750033	0.494433	0.7167	0.103149
C <sub>3</sub>	1.79983	1.685934	0.5	0.783367	0.6389	0.750033	0.783367	0.136629
C <sub>4</sub>	1.685934	1.281388	1.281388	0.5	0.672233	0.6389	0.527767	0.12808
C <sub>5</sub>	1.338336	1.742882	1.742882	1.685934	0.5	0.783367	0.605567	0.162535
C <sub>6</sub>	1.338336	1.338336	1.338336	1.742882	1.281388	0.5	0.672233	0.161323
C <sub>7</sub>	1.685934	1.395284	1.281388	2.147428	1.79983	1.685934	0.5	0.210576

**Table 9.** Interdependency matrix of the main criteria related to C<sub>7</sub> Operational Risk.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	Local Weight
C <sub>1</sub>	0.5	0.8167	0.605567	0.6389	0.750033	0.605567	0.527767	0.094102
C <sub>2</sub>	1.22444	0.5	0.672233	0.6389	0.750033	0.494433	0.7167	0.103519
C <sub>3</sub>	1.79983	1.685934	0.5	0.783367	0.6389	0.750033	0.672233	0.133783
C <sub>4</sub>	1.685934	1.281388	1.281388	0.5	0.672233	0.6389	0.494433	0.126593
C <sub>5</sub>	1.338336	1.742882	1.742882	1.685934	0.5	0.783367	0.605567	0.162214
C <sub>6</sub>	1.338336	1.338336	1.338336	1.742882	1.281388	0.5	0.8167	0.165547
C <sub>7</sub>	2.147428	1.395284	1.685934	2.204376	1.79983	1.22444	0.5	0.214242

**Table 10.** The comparative impact of seven criteria and rank of risks.

Criteria	Weights of criteria	Rank
C <sub>1</sub>	0.092312	7
C <sub>2</sub>	0.105421	6
C <sub>3</sub>	0.127567	4
C <sub>4</sub>	0.122383	5
C <sub>5</sub>	0.169425	3
C <sub>6</sub>	0.174767	2
C <sub>7</sub>	0.208124	1

The results of the DEMATEL method discuss as follow. First, build the direct relation matrix in step 7. Then applying Eqs. (5,6) for normalizing the direct relation matrix. Table 11. Present the normalized matrix for the criteria. Then use the Matlab code for obtaining the total relation matrix in Table 12. Then the sum of rows and columns in Table 13. The results of the cause diagram show that C<sub>3</sub> Commodity risk had the greatest impact and Operational risk C<sub>7</sub> had a lesser impact. Fig 6. Show the cause diagram.

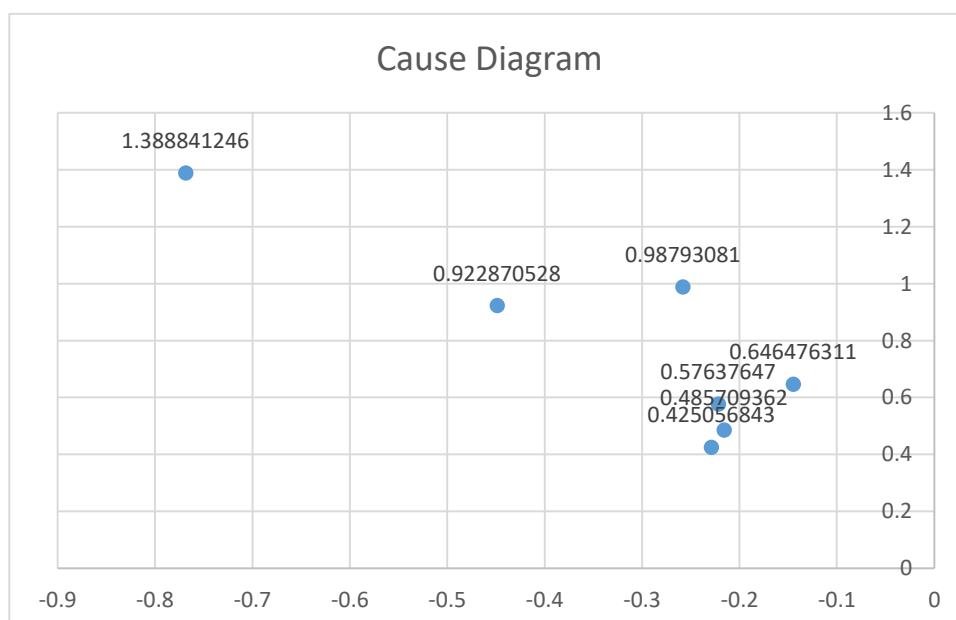


Fig 6. The cause diagram by DEMATEL method.

**Table 11.** The normalized decision matrix for main criteria.

Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>
C <sub>1</sub>	0.052476	0.082215	0.05539	0.070552	0.078717	0.051891	0.051891
C <sub>2</sub>	0.134483	0.052476	0.067053	0.075218	0.051891	0.070552	0.078717
C <sub>3</sub>	0.225375	0.182917	0.052476	0.085714	0.051891	0.078717	0.040228
C <sub>4</sub>	0.134483	0.128506	0.128506	0.052476	0.078717	0.05539	0.078717
C <sub>5</sub>	0.273809	0.231352	0.231352	0.14046	0.052476	0.070552	0.082215
C <sub>6</sub>	0.134483	0.14046	0.14046	0.225375	0.176941	0.052476	0.082215
C <sub>7</sub>	0.231352	0.14046	0.273809	0.14046	0.134483	0.134483	0.052476

**Table 12.** The total relation matrix.

Main Criteria	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>
C <sub>1</sub>	-0.02384	0.0216	-0.00471	0.022175	0.041601	0.019845	0.021454
C <sub>2</sub>	0.053234	-0.01624	-0.00057	0.017843	0.003389	0.032477	0.044792
C <sub>3</sub>	0.131494	0.105464	-0.02012	0.016379	-0.00687	0.032037	-0.00757
C <sub>4</sub>	0.026911	0.043409	0.051409	-0.01504	0.026146	0.007276	0.037166
C <sub>5</sub>	0.114421	0.102734	0.125921	0.04172	-0.03044	-0.00443	0.015003
C <sub>6</sub>	-0.02795	0.007524	0.016442	0.133228	0.10441	-0.01425	0.017613
C <sub>7</sub>	0.052674	-0.01144	0.154788	0.026163	0.045809	0.059633	-0.01752

**Table 13.** The sum of rows and columns.

Main Criteria	X	Y	X-Y	X+Y
C <sub>1</sub>	0.098121	0.326936	-0.22882	0.425057
C <sub>2</sub>	0.13493	0.350779	-0.21585	0.485709
C <sub>3</sub>	0.25081	0.395666	-0.14486	0.646476
C <sub>4</sub>	0.177274	0.399102	-0.22183	0.576376
C <sub>5</sub>	0.36493	0.623001	-0.25807	0.987931
C <sub>6</sub>	0.237016	0.685854	-0.44884	0.922871



$C_7$	0.310103	1.078739	-0.76864	1.388841
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The results of board composition show the weights of six factors. The Board size  $F_5$  is the highest weights in the five factors with value 0.245594, then the Audit Committee meetings  $F_4$  with value 0.210658, then Independent directors  $F_3 = 0.21379$ , then Board qualification  $F_2 = 0.17068$ , then the lowest factor is Gender  $F_1 = 0.15277$ . Table 14. Show the decision matrix between criteria and others. Table 15 show the weights and rank of six factors.

With the DEMATEL method show that the  $F_5$  board size has high impact on VRD and the  $F_1$  Gender has lowest impact on VRD. Table 16. Show the sum or rows and columns and rank of impact on VRD. Fig 7. Show the cause diagram of board composition.

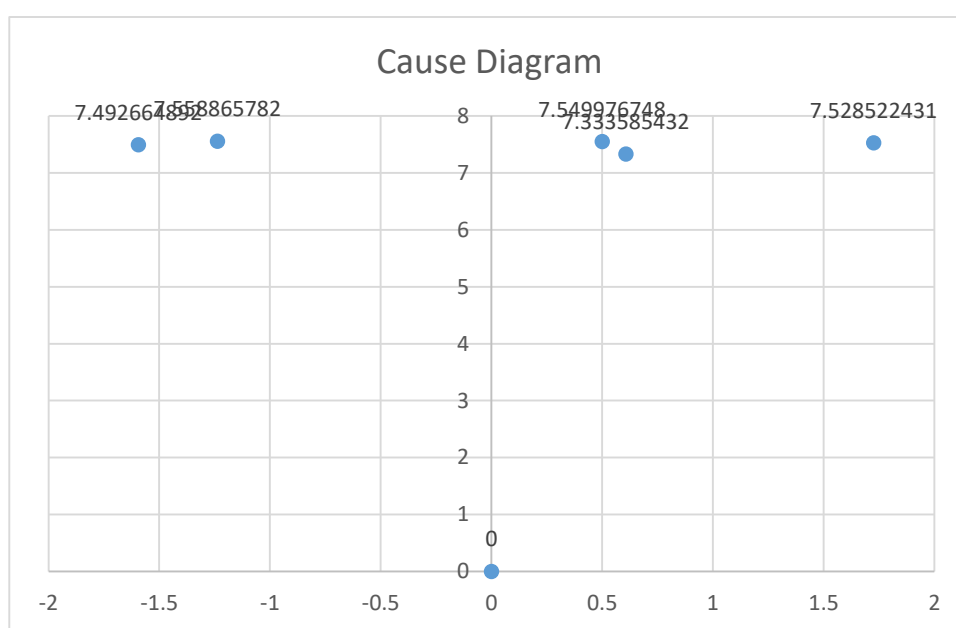


Fig 7. Cause Diagram of Six Factors of board composition.

Table 14. The combined pairwise comparison of six factors.

Criteria	$F_1$	$F_2$	$F_3$	$F_4$	$F_5$
$F_1$	0.5	0.783367	0.750033	0.8167	0.7167
$F_2$	1.281388	0.5	0.6389	0.7167	0.783367
$F_3$	1.338336	1.742882	0.5	0.8167	0.750033
$F_4$	1.281388	1.22444	1.22444	0.5	0.750033
$F_5$	1.281388	1.338336	1.338336	1.338336	0.5

**Table 15.** The weights and rank of six factor of board composition on VRD.

Six Factors	Weights of Six Factors	Rank
F <sub>1</sub>	0.159277	5
F <sub>2</sub>	0.17068	4
F <sub>3</sub>	0.21379	2
F <sub>4</sub>	0.210658	3
F <sub>5</sub>	0.245594	1

**Table 16.** The sum of rows and columns of board composition for six factor.

Six Factors	X	Y	X-Y	X+Y
F <sub>1</sub>	2.949194	4.543471	-1.59428	7.492665
F <sub>2</sub>	3.160792	4.398073	-1.23728	7.558866
F <sub>3</sub>	4.024743	3.525234	0.499509	7.549977
F <sub>4</sub>	3.97023	3.363355	0.606875	7.333585
F <sub>5</sub>	4.626848	2.901674	1.725174	7.528522

### 5. Analysis of VRD

The dependent variable for the study was voluntary risk disclosure. A disclosure index, which is coded as VRD, was developed based on a seven criteria. The regression equation that was used to test the hypothesis was of the form:

$$VRD = \beta_0 + \beta_1 BSIZE + \beta_2 BQUAL + \beta_3 INDEP + \beta_4 ACMEET + \beta_5 GENDER + \beta_6 IFRS + e$$

Where

VRD: Voluntary risk disclosure,

BSIZE: Board size,

BQUAL: Board qualification

INDEP: Independent directors

ACMEET: Audit committee meetings

GENDER: Number of females on the board

IFRS: International Financial Reporting Standards

The outputs of the multiple regression analysis indicate the regression model was statistically significant: F (5, 74) 3.542 and  $p < 0.05$ . The R<sup>2</sup> was 0.193, which means that 19.3% of the variance in

the level of voluntary risk disclosure was explained by the five independent variables. Independent variables has an impact on the voluntary risk disclosure practices by the Saudi listed corporates.

## 6. Conclusions

This paper study the voluntary risk disclosure in companies of Saudi Arabian. This paper proposes seven criteria. The neutrosophic sets are used to deal with uncertainty. The MCDM method is used in this paper like ANP and DEMATEL methods. ANP is used to calculate the weights of main and sub-criteria. DEMATEL method is used to assess and show the impact of voluntary risk disclosure. The main results show that the Operational risks are the highest impact and reputation risk is the lowest impact. Future work can use other MCDM methods like TOPSIS and VIKOR.

## References

- [1] Bhasin, M.L., R. Makarov, and N. Orazalin, *Determinants of voluntary disclosure in the banking sector: An empirical study*. International Journal of Contemporary Business Studies, 2012. **3**(3).
- [2] Alhazaimeh, A., R. Palaniappan, and M. Almsafir, *The impact of corporate governance and ownership structure on voluntary disclosure in annual reports among listed Jordanian companies*. Procedia-Social and Behavioral Sciences, 2014. **129**: p. 341-348.
- [3] Beattie, V., B. McInnes, and S. Fearnley. *A methodology for analysing and evaluating narratives in annual reports: a comprehensive descriptive profile and metrics for disclosure quality attributes*. in *Accounting forum*. 2004. Elsevier.
- [4] Brown, P., W. Beekes, and P. Verhoeven, *Corporate governance, accounting and finance: A review*. Accounting & finance, 2011. **51**(1): p. 96-172.
- [5] Neifar, S. and A. Jarboui, *Corporate governance and operational risk voluntary disclosure: Evidence from Islamic banks*. Research in International Business and Finance, 2018. **46**: p. 43-54.
- [6] Eng, L.L. and Y.T. Mak, *Corporate governance and voluntary disclosure*. Journal of accounting and public policy, 2003. **22**(4): p. 325-345.
- [7] Ho, S.S. and K.S. Wong, *A study of the relationship between corporate governance structures and the extent of voluntary disclosure*. Journal of International Accounting, Auditing and Taxation, 2001. **10**(2): p. 139-156.
- [8] Chau, G. and S.J. Gray, *Family ownership, board independence and voluntary disclosure: Evidence from Hong Kong*. Journal of International Accounting, Auditing and Taxation, 2010. **19**(2): p. 93-109.
- [9] Abraham, S. and P. Cox, *Analysing the determinants of narrative risk information in UK FTSE 100 annual reports*. The British Accounting Review, 2007. **39**(3): p. 227-248.
- [10] Al-Maghzom, A., K. Hussainey, and D.A. Aly, *Corporate governance and risk disclosure: Evidence from Saudi Arabia*. Corporate Ownership and Control Journal, 2016. **13**(2).
- [11] Hassan, M.K., *UAE corporations-specific characteristics and level of risk disclosure*. Managerial Auditing Journal, 2009.

- [12] Moshashai, D., A.M. Leber, and J.D. Savage, *Saudi Arabia plans for its economic future: Vision 2030, the National Transformation Plan and Saudi fiscal reform*. British Journal of Middle Eastern Studies, 2020. **47**(3): p. 381-401.
- [13] Nurunnabi, M., *Transformation from an oil-based economy to a knowledge-based economy in Saudi Arabia: the direction of Saudi vision 2030*. Journal of the Knowledge Economy, 2017. **8**(2): p. 536-564.
- [14] Chinnadurai, V. and M. Sindhu, *A Novel Approach for Pairwise Separation Axioms on Bi-Soft Topology Using Neutrosophic Sets and An Output Validation in Real Life Application*. Neutrosophic Sets and Systems, 2020. **35**: p. 435-463.
- [15] Wang, H., et al., *Single valued neutrosophic sets*. 2010: Infinite study.
- [16] Tsaur, S.-H., T.-Y. Chang, and C.-H. Yen, *The evaluation of airline service quality by fuzzy MCDM*. Tourism management, 2002. **23**(2): p. 107-115.
- [17] Yang, J.L. and G.-H. Tzeng, *An integrated MCDM technique combined with DEMATEL for a novel cluster-weighted with ANP method*. Expert Systems with Applications, 2011. **38**(3): p. 1417-1424.
- [18] Tzeng, G.-H., C.-H. Chiang, and C.-W. Li, *Evaluating intertwined effects in e-learning programs: A novel hybrid MCDM model based on factor analysis and DEMATEL*. Expert systems with Applications, 2007. **32**(4): p. 1028-1044.
- [19] Elshandidy, T., et al., *Risk reporting: A review of the literature and implications for future research*. Journal of Accounting Literature, 2018. **40**: p. 54-82.
- [20] Elshandidy, T. and L. Neri, *Corporate governance, risk disclosure practices, and market liquidity: Comparative evidence from the UK and Italy*. Corporate Governance: An International Review, 2015. **23**(4): p. 331-356.
- [21] Al-Janadi, Y., R.A. Rahman, and N.H. Omar, *The level of voluntary disclosure practices among public listed companies in Saudi Arabia and the UAE: Using a modified voluntary disclosure index*. International Journal of disclosure and Governance, 2012. **9**(2): p. 181-201.
- [22] Al-Maghzom, A., *The determinants and consequences of risk disclosure in Saudi banks*. 2016, University of Gloucestershire.
- [23] Habbash, M., K. Hussainey, and A.E. Awad, *The determinants of voluntary disclosure in Saudi Arabia: an empirical study*. International Journal of Accounting, Auditing and Performance Evaluation, 2016. **12**(3): p. 213-236.
- [24] Karabašević, D., et al., *A Novel Extension of the TOPSIS Method Adapted for the Use of Single-Valued Neutrosophic Sets and Hamming Distance for E-Commerce Development Strategies Selection*. Symmetry, 2020. **12**(8): p. 1263.
- [25] Dung, V., et al., *TOPSIS approach using interval neutrosophic sets for personnel selection*. 2018: Infinite Study.
- [26] Broumi, S., et al. *Shortest path problem on single valued neutrosophic graphs*. in 2017 international symposium on networks, computers and communications (ISNCC). 2017. IEEE.
- [27] Sun, R., J. Hu, and X. Chen, *Novel single-valued neutrosophic decision-making approaches based on prospect theory and their applications in physician selection*. Soft Computing, 2019. **23**(1): p. 211-225.
- [28] Abdel-Baset, M., et al., *An integrated neutrosophic ANP and VIKOR method for achieving sustainable supplier selection: A case study in importing field*. Computers in Industry, 2019. **106**: p. 94-110.
- [29] Han, Y. and Y. Deng, *An enhanced fuzzy evidential DEMATEL method with its application to identify critical success factors*. Soft computing, 2018. **22**(15): p. 5073-5090.

- [30] Abdel-Basset, M., et al., *A hybrid approach of neutrosophic sets and DEMATEL method for developing supplier selection criteria*. *Design Automation for Embedded Systems*, 2018. **22**(3): p. 257-278.
- [31] Mao, S., et al., *A hybrid DEMATEL-FRACTAL method of handling dependent evidences*. *Engineering Applications of Artificial Intelligence*, 2020. **91**: p. 103543.

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