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# Evaluating the Effectiveness of Internal Control System under Using Blockchain Technology: Evidence from Dubai Government

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**Abstract**
Dubai has witnessed a great development in its economic sector and a massive volume in its financial services, so simple operations become more complex. Therefore, Blockchain Technology (BCT) has been implemented in the department of Finance (DOF) in Dubai government. Based on this, the objective of this research is to evaluate the internal control system (ICS) under the use of BCT. In order to achieve this objective, the data in this research was collected by using qualitative approach thorough conducting the interviews with focus group consists of heads of departments, accountants, and auditors. The collected data was analyzed by using the Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) (Hamdan, 2013). The following are the most important findings of this research. First, designing an effective and strong model to evaluate the effectiveness of ICS. Second, the Blockchain implementing strategies has a significant role on evaluating the effectiveness of ICS. Third, obtaining a standard percentage of the effectiveness of ICS under the use of BCT which is 72% to be used in the future research.
**Keywords:** Internal Control System, Blockchain Technology, COSO, Analytical Hierarchy Process, Analytical Network Process, Dubai Government.

## Introduction

The failure that occurred in some large corporations like Enron at the beginning of 21st century due to lack of effective internal control system (ICS) Dibra (2016); Hamdan (2017) leads to growth in the interest in effectiveness of ICS, not only for stakeholders and management, but also for governments. Every government seeks to implement an effective ICS to ensure that their objectives are well-achieved. Also, it evaluates its ICS continuously in order to develop it and address any weaknesses in it.

Due to emergence of massive digital transformation that is currently used in the business around the world, using advanced technology has become increasingly vital to make accounting process smart, as well as more secure and efficient. BCT, one such cutting-edge technology, is a shred, permissioned, and immutable ledger that will make promising future in the various accounting fields especially in internal control. As long as is highly advanced technology in used, there will be an effective ICS.

The governments have realized the importance of using information technology as well as developing and adopting telecommunication and technology systems that undoubtedly lead to improvement at the various level in the public sector (Momeni & Nakhaee, 2018). The ICS is one of the most important department that governments have concern with its effectiveness (Cao et al., 2017). The Government of Dubai, one of the seven emirates in the United Arab Emirates (UAE), has long traditional of leading digital innovation for the region. It launched Dubai BCT at its DOF. With the rapid development of the Dubai Government in several economic sectors and the enormous volume of financial transactions in its DOF, the traditional operations must be continuously updated to assure efficiency and effectiveness, otherwise the simple operations become more complicated. Consequently, the Dubai Government needs more effective internal control on its activities such as permissions, transactions verifications, and processes tracking. It finds the possibility of BCT to give a solution (Bisher, 2018). BCT has been recently executed by Dubai Government in Smart Financial Services (SFS) to automate all financial transactions, settlements and reconciliations, payments, invoices, contracts, and documentation with significant implications for accountants, finance professionals, and regulators. This will help to ensure continued financial efficiency in the public sector by fostering smart and electronic transformation and applying the best international accounting, financial standers and improving transparency and reliability. Consequently, the internal control at DOF in Dubai Government will be strongly affected. One of the important points presented by this research is the service of multicultural societies, as they always seek rapid progress, both technologically and economically. The implementation of such model that proposed in this research helps in integrating BCT with economic systems in multicultural societies to create more effective and efficient systems and facilitate business transactions. This research will pave the way for authors to develop their future researches regarding how BCT contribute to accounting. It is finding will be important reference for upcoming scientific research. Besides, it was prepared according to innovative methodology.

This research aims to evaluate the effectiveness of ICS under using BCT at DOF in Dubai Government. It will contribute in adding value to the scientific research as it provides an integrated model to evaluate the effectiveness of ICS based on Committee of Sponsoring Organizations (COSO) framework. In addition, it will serve the professionals in establishing effective ICS using advanced technology.

## Literature Review

### Evaluating the of Internal Control System

Turedi & Celayir (2018) pointed out that strong ICS is necessary for the organizations that are permanently seeking to implement their budgeted plans in order to achieve their objectives including safeguard assets, maintain records, eliminate fraud, and decrease errors. According to COSO, ICS is defined as a process effected by an entity's board of directors, management and other personnel. It is designed to provide reasonable assurance regarding the achievement of objectives relating to operations, reporting, and compliance (COSO, 2013); (Hamdan et al., 2021). The ICS has five main components that interrelated with each other to form an integrated framework. The approach of accomplishing those components vary

depending on the business volume in the organization and its requirements (Kumuthinidevi, 2016). The components of ICS as stated by COSO are: control environment, risk assessment, control activities, information and communication, and monitoring (COSO, 2013). In order to support the concept of ICS, COSO's framework presented 17 principles related to five components of ICS. They are important to evaluate the internal control components in terms of both, presence and function probably in design and implementation of ICS (Provasi & Riva, 2015).
The 17 principles with associated components are summed up in the table below:

Table (1)
*Five components and 17 principles of COSO's internal control framework (COSO, 2013):*

| Five Components | 17 Principles |
|---|---|
| Control environment | 1- Commitment to integrity and ethical values.<br>2- Exercises oversight responsibility<br>3- Establishes structure, authority, and responsibility.<br>4- Demonstrates commitment to competence<br>5- Enforces accountability |
| Risk Assessment | 6- Specifies suitable objectives<br>7- Identifies and analyzes risk<br>8- Assesses fraud risk<br>9- Identifies and analyzes significant change. |
| Control activities | 10- Selects and develops control activities<br>11- Selects and develops general controls over technology<br>12- Deploys through policies and procedures |
| Information and Communication | 13- Uses relevant information<br>14- Communicates internally<br>15- Communicates externally |
| Monitoring | 16- Conducts ongoing and/or separate evaluations.<br>17 Evaluates and communicates deficiencies |

They are many studies that has used the COSO framework in order to evaluate the effectiveness of ICS. The study of Saputra et al (2017) aimed to evaluate the effectiveness of ICS by using its five components and their 17 principles. It has been concluded that the absence of one or more of these five components will adversely affect the effectiveness of ICS (Saputra et al., 2017);. Another study aimed to evaluate the quality of ICS using COSO framework as it is excellent in evaluating, implementing, and assessing the effectiveness of ICS (Thabit et al., 2017).
The study of Zhang and Wang (2018) created a suitable indicators evaluation system to assess the ICS at administrative institutions in China by using the AHP and the related content of fuzzy mathematics. Evaluating the ICS in the administrative institutions throws the light on the status of its ICS, increases the structure of ICS, and progresses the working efficiency of it. To improve the evaluation of ICS, the researchers have to examine the Inclusiveness of ICS and the indicators of evaluation. Besides, they should focus on the advantages and disadvantages of ICS in administrative institutions which are more objective to the community.

**The Effectiveness of Internal Control System**

COSO's Internal control- integrated framework stated that effectiveness of ICS requires that the processes of designing and implementing internal control should comprise the five components and its relevant principles of each one. Besides the continued presence of components or its principles in operating and managing of the ICS (COSO, 2013). Low & Keving (2018), finished that there is an important and positive relationship between internal control components and effectiveness of ICS. Each component contributes through its principles to achieve control objectives.

The five components of internal control which are: control environment, risk assessment, control activities, information and communication, and monitoring support and improve the effectiveness of internal control system moderately. On the other hand, there are others factors that affect the effectiveness of ICS for instance: time framework, the minimum time possessed to correct the errors or frauds, and effectiveness of using resources as well as reduce its damage (Kumuthinidevi, 2016; Hamdan & Al-Hajri, 2021).

Briefly, ICS will be effective if the operations objectives have been achieved, reliable financial reports have been prepared, and applicable rules and regulations have been complied with. Consequently, the effectiveness of ICS is determined by evaluating the effectiveness of its five components and their relevant principles.

**Blockchain Technology and the Effectiveness of Internal Control System**

BCT was first introduced by Satoshi Nakamoto in 2008 to exchange the encrypted digital currency like Bitcoin (Sammali, et al., 2017). As Pradhan (2018) described, Blockchain is a digital distributed ledger which records the transactions cryptographically in form of blocks. This is done after the transactions have been authorized among the participants who are called nodes. Each block that includes the authorized transaction add to the last block in the existing Blockchain. Then it becomes dissemination to each node in the network who can view the transactions and cannot delete or alter it (Hamdan, 2017). BCT is an enormous database of transaction. As it is cryptographically protected, it prevents manipulation and keeps the database constant (Beck, 2018).

The concept of BCT is easier than its implementation. Simply, it's a series of transactions assembled into blocks which are progressed by a network of digitally connected computers.

The rapid expansion of Blockchain project led by e-government around the world is spectacular. There are more than 100 Blockchain projects are created to convert government systems in more than 30 countries. Estonia has utilized Blockchain technology to release e-ID for verification the identity. Besides, many counties along with Estonia like Ukrania and Australia had built electronic voting system based on Blockchain. Honduras and Gerogia tried to conduct lands registration by using BCT. United State employed Blockchain to record and share medical information, and as china announced a plan to build a city of Blockchain. The direct related of Blockchain to social organization is the reason behind the rapidly lunch of BCT in the e-governments (Jun, 2018).

The information technology (IT) is rapidly developing. The widespread and deep use of IT lead to change day to day activities and processes of business organization. These changes guided organizations to adopt new technologies to cope with them and maintain their growth (Clohessy et al., 2019); (Mohammad & Mohammad, (2016). The integration of ICS with a strong infrastructure with high technological capabilities will support the control components, reinforce control of organization's activities, and build more effective internal control system. What's more, using new technology applications may strengthen some

internal control functions (COSO, 2013). Cao, et al. (2017), concluded that IT investment plays an important and positive role in improving the effectiveness of ICS, fundamentally by increasing the efficiency of monitoring.
The consolidation of cutting edge technology like Blockchain with organization's control processes, will alter the interaction of data within its ERP system. Consequently, they have to ensure meeting of all components of internal control framework as well as being constantly evaluated. Kuhn (2018), outlined the possible changes of five control components under the use of BCT. With BCT the business process will be modified, so the management should establish new control environment, with taking its principles into consideration, and integrate it with current one in order to join with external parties on Blockchain network. Blockchain likes any technology does not guarantee 100% attack risk free, it will create new IT risks (Hamdan & Hosban, 2015). Nonetheless, it will open a field of management to reduce the risk of an accessibility to an ERP data by unauthorized parties. Based on Blockchain, all elements of verification and reconciliation will be automated and all control activities are built into Blockchain. Into its network, when the transaction is entered, approved, and verified, it will be copied to all parties' ledgers who are involved in the transaction. This indicates that information and communication have changed drastically due to using BCT. Regarding monitoring activities, it will exceed the internal rang of monitoring. All external and internal authorized parties are qualified to monitor all transactions and accurate data, so all of them will be attentive to any conflicts or differences in the data and suggest ways to correct any deficiencies. Blockchain- based automated monitoring makes it possible to transmit data according to the regulations of participating parties.
This study aims to evaluate the effectiveness of ICS, one of the most important field in accounting, under using BCT, the latest cutting edge technology, at DOF in Dubai Government. The study combines the COSO framework with BCT to build an integrated model by using AHP and ANP to evaluate the effectiveness of ICS.

## Research Methods and Results

In this study researcher adopted the qualitative approach which cares about experiences, views, feeling and senses of individuals as it provides objective data not subjective. In qualitative approach the objective is achieved through a comprehensive perspective of the problem. The problem of the study will be handled as a case study, one of the qualitative design choices. The reason why this design is chosen is because of its deep analyzing of the case in its natural state, especially, if it is based on evaluating process. The data was collected by conducted interviews with participants in focus group which consists of five individuals including heads of departments, auditors, and accountants. Theses interviews include unstructured and generally open-ended questions to extract participants' perspectives and opinions. For creating a unique and worthy method to evaluate the effectiveness of ICS under using BCT, besides the complexity of this evaluating process, this study adopted an AHP and ANP to analyze gathering data.

## Analytical Hierarchy Process (AHP)

AHP is a generic measurement theory instituted by Thomas L.Saaty in 1670, Pioneer of mathematic and operation research (Mahmud, et al., 2016). AHP is a mathematical Multi-Criteria Decision Making (MCDM) method form in hierarchy. It aims to find the solutions of complicated problems by breaking it down into small parts. AHP is designed to deal with both rationality and axiomatic selection of the best form various alternatives that has been evaluated in the relation to several criteria (Saaty & Vargas, 2012). AHP considers qualitative and quantitative aspects to generate multiple decision pattern. It analyzes the problem from overall goal to more controllable sub-objectives or criteria, and finally to alternatives. These sub-sets contain standards, objectives, and activities. AHP is capable of extracting the ratios from separate and continuous comparisons which can be carried out from real scales or fundamental one that reflects the proportional power of feelings. The applications of AHP are widely found in planning, making decision, solving conflicts, and allocating resources. The most important feature of the AHP that it measures tangible and intangible things (Saaty, 2008).

**Analytical Network Process (ANP)**

Occasionally, the problem of the study becomes more complex. This occurs when the high level elements "criteria" interact with the low level elements "sub-criteria or alternatives", and this interaction should be taken into consideration. Such complex problem cannot be organized by using AHP and this is considered as a limitation of this analysing method. ANP was developed by Saaty in order to solve that limitation (Saaty, 2008). ANP is more advanced and generalized than AHP. It is able to integrate all of objectives, criteria, and alternatives into a consolidates framework that allow ANP to evaluate wide range of elements that affects the results (Janes, et al., 2018).

ANP consists of two parts. The first is the one that control interaction among elements both objectives and criteria in a hierarchy and network model. The second is a number of sub-networks of effects among the problem's elements and clusters, as well as each control criteria have one sub-networks. ANP has been used in various decisions such as: marketing, medical, social, and forecasting (Jayant, 2016).

**Integration the COSO Framework with AHP and ANP to Evaluate the Effectiveness of Control Internal**

The use of COSO framework has become one of the traditional-known approaches that has proved its efficiency in evaluating the effectiveness of ICS. However, introducing advanced technological applications like BCT will lead to modify the interaction of data within the organization's ERP system, alter business process, create new IT risk, change the way of recording transactions, and increase the range of monitoring. Therefore, we have to be sure that the five components of internal control and their relevant principles are being met in order to achieve an effective ICS. As Saaty & Vargas confirmed, the traditional evaluating approaches may not be sufficient to evaluate the strategic choices on the vision and multiple objectives in a complex business environment. Consequently, the researcher integrated the COSO framework with AHP and ANP to create an effective methodology approach that allows the researcher to greatly fulfil the objective of the study in evaluating the effectiveness of ICS (Saaty & Vargas, 2012).

**The Phases for Applying COSO Hierarchy Model to Analyze the Data and Evaluate the Internal Control System**

The AHP and ANP approaches are used for analysing the qualitative data to evaluate the effectiveness of ICS under using BCT at the DOF in Dubai Government.

The following phases will be followed for analysing the qualitative data:

***Phase 1: Building COSO Hierarchal Model***

The COSO hierarchal model consists of four levels. The first level is the goal, the second is the strategies, the third level is the components, and the fourth is the principles. The Figure (1) shows the structure of COSO hierarchal model that is designed in this study. It includes the elements of COSO internal control framework which all of them intended to achieve the effectiveness of ICS. The researcher depends on previous studies (Frahan and Hamdan, 2017), interviews with DOF staff in Dubai Government, internal control experts, and researcher's personal analysis to identify the COSO elements and design its hierarchal model based on four levels.

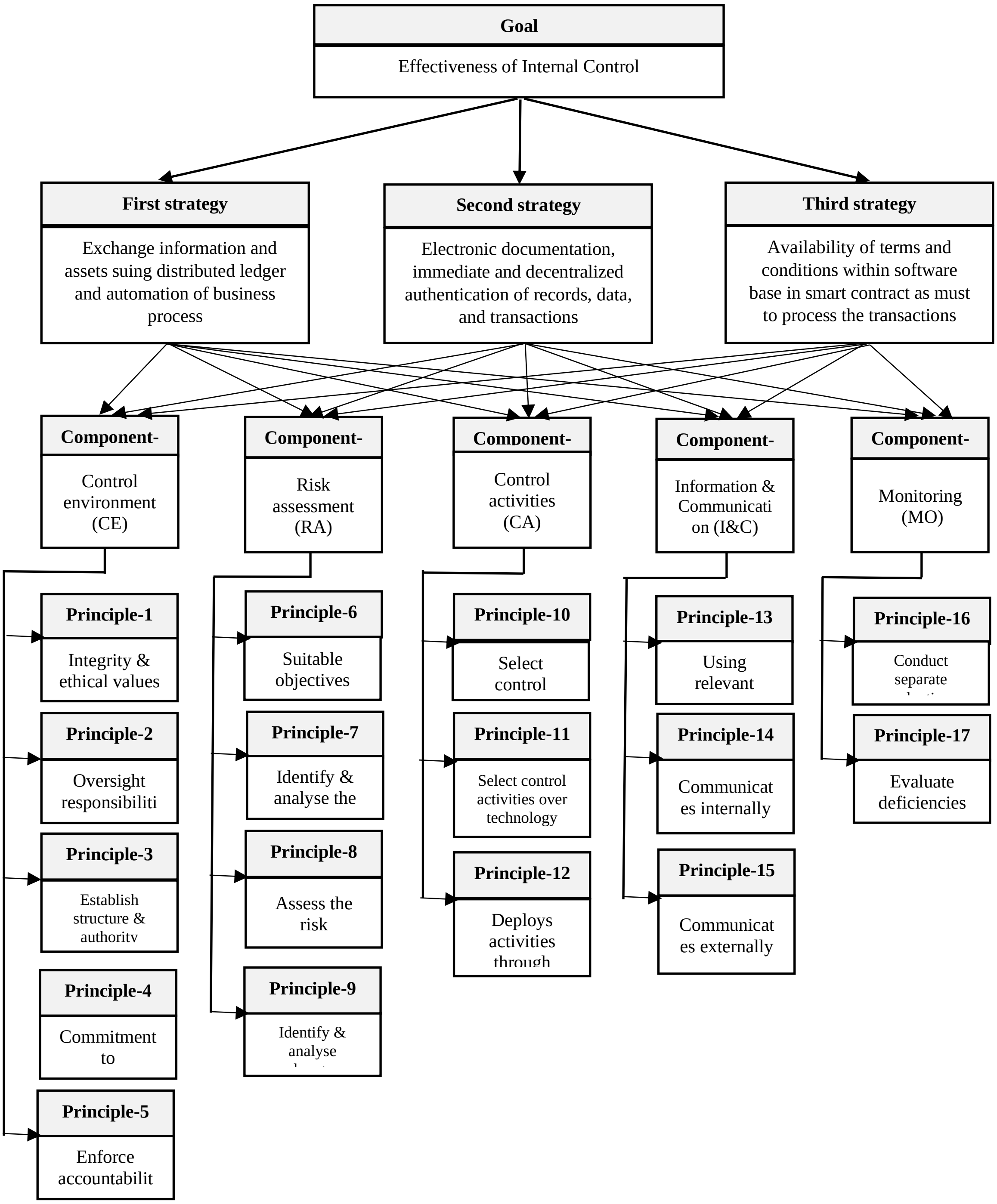

Figure (1): The COSO hierarchal model (Yuksel & Dagdeviren, 2010)

The following are the four levels that are shown in Figure (1):
Level 1**:** Determine the goal that desirable to achieve by DOF in Dubai Government with regard to internal control. The goal is "achieving the effectiveness of ICS".
Level 2**:** Determine the strategies or objective related to the implementing of BCT at DOF in Dubai Government that assist to achieve the effectiveness of ICS.

**These Strategies are**
First strategy: Exchange information as well as assets using distributed ledger and automation of business process.
Second strategy: Electronic documentation, immediate and decentralized authentication of records, data, and transactions.
Third Strategy: Availability of terms and conditions within software base in smart contract as must to process the transactions.
Level 3: Determine the five components of COSO framework that are implemented at DOF in Dubai Government in order to assure the achievement of the three strategies. The five components are: control environment (CE), risk assessment (RA), control activities (CA), information and communication (I&C), and Monitoring (MO).
Level 4: Determine the COSO-17 principles and classify them according to relevant COSO-component to evaluate the five components and assure their existence. Under the COSO-components, each principle has a relative importance that differs from other principles.

***Phase 2: Conducting the pairwise comparisons (unweighted supermatrix)***
After building the hierarchy model, the next step is conducting the pairwise comparisons to measure the relative importance of the elements. During the pairwise comparisons each top-level element is used to compare the elements in the direct level below with regard to it by using fuzzy scales (Saaty, 2008). It is able to analyse complicated relationships among elements by taking it as pairwise and connecting them together through attributes properties in order to make pairwise comparison. The pairwise comparison matrix matrix $\widetilde{D}$= [$\tilde{a}_{ij}$] is structured as (Yuksel & Dagdeviren, 2010):

$$\widetilde{D}=\begin{pmatrix} (1,1,1) & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & (1,1,1) & \cdots & \tilde{a}_{2n} \\ \vdots & \cdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & (1,1,1) \end{pmatrix}$$

Where $\tilde{a}_{ij} \times \tilde{a}_{ji} \approx \upsilon e = \omega_i/\omega_j$, *i, j*= 1,2,…, *n* and all $\tilde{a}_{ij}$ = ( $l_{ij}, m_{ij}, u_{ij}$)
As shown in Figure (1), there are three strategies contribute in achieving the goal with different contribution percentage of each one, as there are not equally contribute to achieve the goal. By conducting the pairwise comparison as table (2) we can define the fuzzy relationship among strategies and calculate its local weight to determine the contribution percentage of each strategy in achieving the goal.

Table (2)
*Pairwise comparisons matrix of strategies that achieved the goal*

| **Goal** | Strategy-1 | Strategy-2 | Strategy-3 | Weight |
|---|---|---|---|---|
| Strategy-1 | 1,1,1 | ½, 1, 3/2 | 1, 3/2, 2 | **0.38** |
| Strategy-2 | 2/3, 1, 2 | 1,1,1 | 1, 3/2, 2 | **0.38** |
| Strategy-3 | ½, 2/3, 1 | ½, 2/3, 1 | 1,1,1 | **0.24** |

In order to fill this matrix, we have to compare the strategy-1 in the first row with strategy-1 in the second column. This process is reiterated with strategy-2 and so on. Each cell in the matrix reflects the answer of the question "How much strategy-1 has of strategy- 2 that is important to achieve the goal? " that means, regarding to the goal how important is strategy-1 when it is compared with strategy-2?
in the matrix, the fuzzy scales are used to express the relative importance that result from pairwise comparisons in the form of numbers. Table (3) and Figure (2) shown linguistic fuzzy scale of pairwise comparisons that reflects the relative importance of elements from "*Equally Important*" to "*Absolutely More Important*". (Yuksel & Dagdeviren, 2010).

Table (3)
*The fuzzy scales of pairwise comparison (Yuksel & Dagdeviren, 2010)*

| **Linguistic fuzzy scale for importance** | **Triangular fuzzy scale** | **Triangular fuzzy reciprocal scale** |
|---|---|---|
| Just equal | 1, 1, 1 | 1, 1, 1 |
| Equally important (EI) | ½, 1, 3/2 | 2/3, 1, 2 |
| Weakly more important (WMI) | 1, 3/2, 2 | ½, 2/3, 1 |
| Strongly more important (SMI) | 3/2, 2, 5/2 | 2/5, ½, 2/3 |
| Very strongly more important (VSMI) | 2, 5/2, 3 | 1/3, 2/5, ½ |
| Absolutely more important (AMI) | 5/2, 3, 7/2 | 2/7, 1/3, 2/5 |

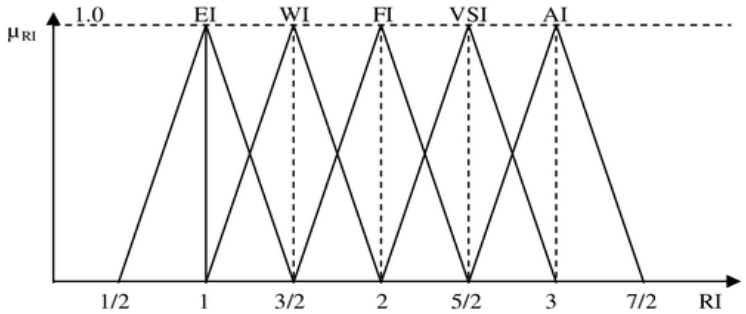

Figure (2): Linguistic scale for relative importance (Deng, 2016)

***Phase 3: Calculating the local weight of the elements Using Chang's Extent Analysis Method. (weighted supermatrix)***

After conducting the pairwise comparisons, the next step is calculating the local weight of elements for these comparisons in order to determine the priority weight of each element. This procedure is done by conducting a particular mathematical formulae using the resulting scale of pairwise comparisons (Saaty & Vargas, 2012).
Triangle Fuzzy Number (TFN) is the most widely used membership functions of fuzzy number as well as it is the best type of decision makers to make a decision easily. TFN is the best choice to express the linguistic fuzzy scales that is used in the study (Noor et al., 2017). The researcher adopted to use Chang's extent analysis method that uses TFN to obtain a priority weight. This method is the easiest to use and calculate of fuzzy AHP methods, besides it is perfect in formulating the problems of decision (Deng, 2017)
According to Chang, the researcher used his method by comparing two TFNs as each triangle express one strategy that contributes with others strategies to achieve the goal (Chang, 1996).

Suppose, $X = \{x_1, x_2, \cdots, x_n\}$ to be as a set of objects, and $U = \{u_1, u_2, \cdots, u_n\}$ to be as a set of o strategies. Based on Chang's method, each object is obtained and extent analysis is performed for each object, respectively. Accordingly, with using the following notation we can obtain the extent analysis value for each object:
$M^1_{\text{strategy } i}, M^2_{\text{strategy } i}, \cdots, M^m_{\text{strategy } i}$ *i* = 1, 2, ….., *n*
As $M^1_{\text{strategy } i}$ ( *j* = 1, 2, …., *m*) are TFNs which is simply read as (*l, m, u*). the variable *l* indicates the lower possible value, while the *m* indicates the moderate possible value, and *u* indicates the upper possible value.
The following are Chang's extent analysis steps to be performed (Chang, 1996):
Step 1: Perform the fuzzy addition operation of *m* extent analysis value as table (4), such that:

$$\sum_{j=1}^{m} M^j_{\text{strategy } i} = \left( \sum_{j=1}^{m} l, \sum_{j=1}^{m} m, \sum_{j=1}^{m} u \right)$$

And

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{\text{strategy } i} = \left( \sum_{j=1}^{n} l, \sum_{j=1}^{n} m, \sum_{j=1}^{n} u \right)$$

Table (4)
*Strategic addition matrix*

| Goal | Strategy-1 | Strategy-2 | Strategy-3 | $\sum_{i=1}^{3} l_j$ | $\sum_{i=1}^{3} m_j$ | $\sum_{i=1}^{3} u_j$ |
|---|---|---|---|---|---|---|
| Strategy-1 | 1,1,1 | ½, 1, 3/2 | 1, 3/2, 2 | 2.50 | 3.50 | 4.50 |
| Strategy-2 | 2/3, 1, 2 | 1,1,1 | 1, 3/2, 2 | 2.67 | 3.50 | 5.00 |
| Strategy-3 | ½, 2/3, 1 | ½, 2/3, 1 | 1,1,1 | 2.00 | 2.33 | 3.00 |
| **Totals** | | | | **7.17** | **9.33** | **12.50** |

Step 2: Calculating the inverse of the total dimensional vector in step (1) and rotating the total dimension value *l* with the total dimension *u*, and leaving the total dimension value *m* the same as follow:

$\sum_{i=1}^{3} \sum_{j=1}^{3} M^j_{strategy\ i} =$ (1.17, 9.33, 12.5)

So the $\left(\sum_{i=1}^{n} \sum_{j=1}^{m} M^j_{strategy\ i}\right)^{-1} = \left(\frac{1}{\sum_{j=1}^{n} u}, \frac{1}{\sum_{j=1}^{n} m}, \frac{1}{\sum_{j=1}^{n} i}\right) =$ (0.08, 0.11, 0.14)

Step 3: Multiplying each dimension value of each strategy by the resulting dimension value in step (2) as table (5):

Table (5)
*Total TFN of the strategies*

| Goal | *l* | *m* | *u* |
|---|---|---|---|
| Strategy-1 | 0.20 | 0.38 | 0.63 |
| Strategy-2 | 0.21 | 0.38 | 0.70 |
| Strategy-3 | 0.16 | 0.25 | 0.42 |

Step 4: Conducting a comparison of one strategy with each of the other strategies in order to determine the degree of possibility.
Step 5: Identify the degree of possibility of $\widetilde{M}_1 = (l_1, m_1, u_1)$ and $\widetilde{M}_2 = (l_2, m_2, u_2)$ as shown in Figure (3) is defined as: $V(\widetilde{M}_2 \geq \widetilde{M}_1)$

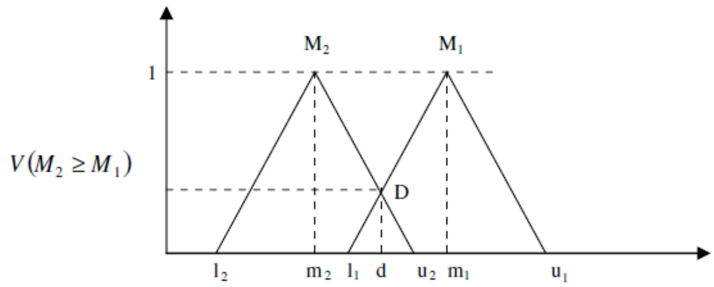


Figure (3): The intersection of TFNs (Chang, 1996)

and can be equivalently expressed as follows:

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_2 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases}$$

where d is the ordinate of the highest intersection point between $\widetilde{M}_2$ and $\widetilde{M}_1$
The step (4) and (5) are shown as tables (6), (7), and (8).

Table (6)
*Comparison Strategy-1 with Strategy-2 and Strategy-3*

| **Comparison** | $l_2$ | $m_2$ | $u_2$ | Vs | $l_1$ | $m_1$ | $u_1$ | **Result** |
|---|---|---|---|---|---|---|---|---|
| S-1 and S-2 | 0.20 | 0.38 | 0.63 | Vs | 0.21 | 0.38 | 0.70 | **1** |
| S-1 and S-3 | 0.20 | 0.38 | 0.63 | Vs | 0.16 | 0.25 | 0.42 | **1** |

Table (7)
*Comparison Strategy-2 with Strategy-1 and Strategy-3*

| **Comparison** | $l_2$ | $m_2$ | $u_2$ | Vs | $l_1$ | $m_1$ | $u_1$ | **Result** |
|---|---|---|---|---|---|---|---|---|
| S-2 and S-1 | 0.21 | 0.38 | 0.70 | Vs | 0.20 | 0.38 | 0.63 | **1** |
| S-2 and S-3 | 0.21 | 0.38 | 0.70 | Vs | 0.16 | 0.25 | 0.42 | **1** |

Table (8)
*Comparison Strategy-2 with Strategy-1 and Strategy-3*

| **Comparison** | $l_2$ | $m_2$ | $u_2$ | Vs | $l_1$ | $m_1$ | $u_1$ | **Result** |
|---|---|---|---|---|---|---|---|---|
| S-3 and S-1 | 0.16 | 0.25 | 0.42 | Vs | 0.20 | 0.38 | 0.63 | **0.64** |
| S-3 and S-2 | 0.16 | 0.25 | 0.42 | Vs | 0.21 | 0.38 | 0.70 | **0.62** |

Step 6: The degree of possibility for a convex fuzzy number to be greater than $k$ convex fuzzy numbers $M_i$ ($i$ = 1, 2, ...., $k$) can be defined as:
$V(M \geq M_1, M_2, ..., M_k) = \min V(M \geq M_i) \quad i = 1, 2, ..., k$
Step 7: Calculate the weight vector and normalize the nonfuzzy weight vector by:
$W = (\min V(M_1 \geq M_k), \min V(M_2 \geq M_k), \min V(M_n \geq M_k))^T \quad k = 1, 2, ...$
Assume that:

$d' = A_i = V(M_i \geq M_k)$, $i,k = 1,2,......, n$ $k \neq i$
Then, the weight vector is calculated by:
$W' = (d'(A_1), d'(A_2),...., d'(A_n))^T$
And the normalize nonfuzzy weight vector is calculated by:
$W = (d(A_1), d(A_2),...., d(A_n))^T$
The step (6), and (7) are shown in tables (9).

Table (9)
*The results of comparison and the local weights of each Strategy*

| Comparison | Min ( degree of possibility) | Min/ ∑min | Weights |
|---|---|---|---|
| S-1 with (S-2 and S-3) | 1 | 1/2.62 | **0.38** |
| S-2 with (S-1 and S-3) | 1 | 1/2.62 | **0.38** |
| S-3 with (S-1 and S-2) | 0.62 | 0.62/2.62 | **0.24** |
| **Totals** | **2.62** | | 1 |

The local weights are presented the contribution amount of each strategy in achieving the goal among the compared strategies. Strategy-1 and strategy-2 obtained 38% while strategy-3 obtained 24%. These percentages reflect the relative importance of strategies in achieving the goal. As strategy-1 and strategy-2 are relatively equal in achieving the goal, and strategy-3 is the relatively weaker in achieving the goal.
In the same way, Conducting the pairwise comparisons and calculating local weights will be processed for all COSO elements in hierarchy model in our study as tables (10), and (11).

Table (10)
*Pairwise comparisons matrix and local weights of components that achieved the strategies*

| **Strat** | CE | RA | CA | I&C | MO | Wei |
|---|---|---|---|---|---|---|
| CE | 1,1,1 | 2,5/2 | 1,3/2 | 1,3/ | 3/2,2,5/2 | **0.3** |
| RA | 1/3,2 | 1,1,1 | 1,3/2 | 2,5/ | 1,3/2,2 | **0.2** |
| CA | ½, | ½,2/3 | 1,1,1 | 5/2, | 1/2,1,3/2 | **0.2** |
| I&C | ½,2/3 | 1/3,2 | 2/7,1 | 1,1, | 1,3/2,2 | **0.0** |
| MO | 2/5, | ½,2/3 | 2/3,1 | ½,2/ | 1,1,1 | **0.1** |
| **Strat** | CE | RA | CA | I&C | MO Ocomparisons matrix and local weights | Wei |
| CE | 1,1,1 | 5/2,3 | 1,3/2 | 1,3/ | 1,3/2,2 | **0.3** |
| RA | 2/7,1 | 1,1,1 | 3/2,2 | 5/2, | 1,3/2,2 | **0.3** |
| CA | ½,2/3 | 2/5, | 1,1,1 | 2,5/ | ½,1,3/2 | **0.2** |
| I&C | ½,2/3 | 2/7,1 | 1/3,2 | 1,1, | 1,3/2,2 | **0.0** |
| MO | ½,2/3 | ½,2/3 | 2/3,1 | ½,2/ | 1,1,1 | **0.1** |
| **Strat** | CE | RA | CA | I&C | MO | Wei |
| CE | 1,1,1 | 1,3/2 | 1,3/2 | 1,3/ | 1,3/2,2 | **0.2** |

| | | | | | | |
|---|---|---|---|---|---|---|
| RA | ½,2/3,1 | 1,1,1 | 2,5/2,3 | 5/2,3,7/ | ½,1,3/2 | **0.32** |
| CA | ½,2/3,1 | 1/3,2/5, ½ | 1,1,1 | 1,3/2,2 | 1,3/2,2 | **0.17** |
| I&C | ½,2/3,1 | 2/7,1/3,2/ | ½,2/3,1 | 1,1,1 | 1,3/2,2 | **0.11** |
| MO | ½,2/3,1 | 2/3,1,2 | ½,2/3,1 | ½,2/3,1 | 1,1,1 | **0.13** |

Table (10) represents the relative importance of each component in achieving each strategy. The control environment (CE) obtained the highest percentage which is 33% in achieving the strategy-1 as well as the strategy-2, while the risk assessment obtained the highest percentage which is 32% in achieving the strategy-3.

Table (11)

*Pairwise comparisons matrix and local weights of principles based on COSO- components*

| **CE** | CE P-1 | CE P-2 | CE P-3 | CE P-4 | CE P-5 | Weight |
|---|---|---|---|---|---|---|
| CE P-1 | 1,1,1 | 2,5/2, 3 | 2,5/2,3 | ½,1,3/2 | 3/2,2,5/2 | **0.37** |
| CE P-2 | 1/3,2/5, ½ | 1,1,1 | 1,3/2,2 | 1,3/2,2 | 3/2,2,5/2 | **0.24** |
| CE P-3 | 1/3,2/5, ½ | ½,2/3,1 | 1,1,1 | 1,3/2,2 | ½,1,3/2 | **0.13** |
| CE P-4 | 2/3,1,2 | ½,2/3,1 | ½,2/3,1 | 1,1,1 | 3/2,2,5/2 | **0.20** |
| CE P-5 | 2/5, ½,2/3 | 2/5, ½,2/3 | 2/3,1,2 | 2/5, ½,2/3 | 1,1,1 | **0.06** |
| **RA** | RA P-6 | RA P-7 | RA P-8 | RA P-9 | Weight | |
| RA P-6 | 1,1,1 | 2,5/2,3 | 3/2,2,5/2 | ½,1,3/2 | **0.40** | |
| RA P-7 | 1/3,2/5,1/3 | 1,1,1 | ½,1,3/2 | 1,3/2,2 | **0.20** | |
| RA P-8 | 2/5, ½,2/3 | 2/3,1,2 | 1,1,1 | 3/2,2,5/2 | **0.26** | |
| RA P-9 | 2/3,1,2 | ½,2/3,1 | 2/5,½, 2/3 | 1,1,1 | **0.16** | |
| **CA** | CA P-10 | CA P-11 | CA P-12 | Weight | | |
| CA P-10 | 1,1,1 | ½,1,3/2 | 3/2,2,5/2 | **0.44** | | |
| CA P-11 | 2/3,1,2 | 1,1,1 | 1,3/2,2 | **0.40** | | |
| CA P-12 | 2/5, ½,2/3 | ½,2/3,1 | 1,1,1 | **0.17** | | |
| **I&C** | I&C P-13 | I&C P-14 | I&C P-15 | Weight | | |
| I&C P-13 | 1,1,1 | ½,1,3/2 | ½,1,3/2 | **0.33** | | |
| I&C P-14 | 2/3,1,2 | 1,1,1 | ½,1,3/2 | **0.33** | | |
| I&C P-15 | 2/3,1,2 | 2/3,1,2 | 1,1,1 | **0.33** | | |
| **MO** | MO P-16 | MO P-17 | Weight | | | |
| MO P-16 | 1,1,1 | ½,1,3/2 | **0.50** | | | |
| MO P-17 | 2/3,1,2 | 1,1,1 | **0.50** | | | |

Table (11) shows the relative importance of the COSO-17 principles in achieving COSO-components to which they related. Regarding to achieve the control environment the principle of integrity and ethical values contributes the highest local weight percentage which is 37%. Besides the principles of setting the suitable objectives contributes the highest local weight percentage which is 40% in achieving the risk assessment. While in achieving information and communication all its relevant principles contribute equally with 33% as local weight percentage for each one, as well as the monitoring with 50 local weight percentage of each of its relevant principles.

***Phase 4: Using ANP approach to determine the inner dependence among COSO -components***

After calculating the local weights of the COSO elements (strategies, components, and principles), the next phase aimed to determine the inner dependence weights of each component with respect to other COSO-components. This is done by conducting pairwise comparison to analyse the influence of each component on other components. The study depended on internal control experts, interviews with participant at DOF in Dubai Government, and previous studied to formulate the interdependent among COSO-components as shown in Figure (4). It shows the relations among COSO-components that will be used to make a pairwise comparisons among them

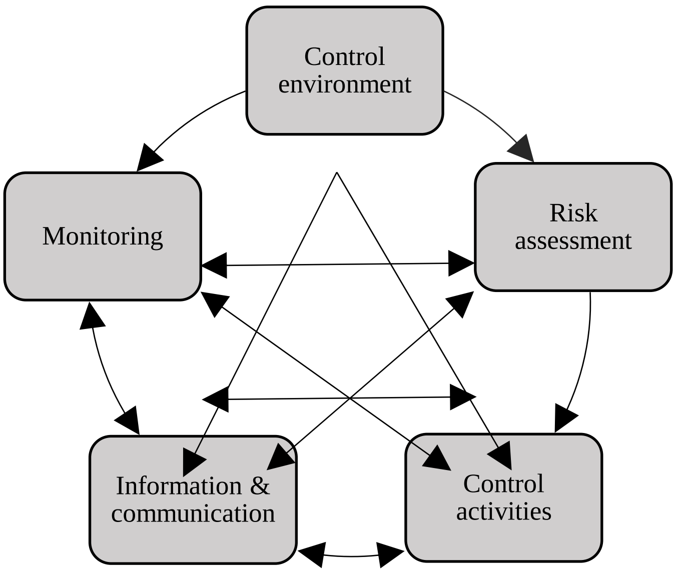


**Figure (4): Interdependent among COSO-component (the researcher)**

Based on these relations among COSO-components, the pairwise comparisons are created for them as tables (12), (13), (14), and (15).

Table (12)

*The inner dependence matrix of the components with respect to risk assessment (RA)*

| **RA** | CE | I & C | MO | Weight |
|---|---|---|---|---|
| CE | 1,1,1 | 1, 3/2,2 | 1,3/2,2 | **0.43** |
| I & C | ½, 2/3,1 | 1,1,1 | ½,1,3/2 | **0.27** |
| MO | ½,2/3,1 | 2/3,1,2 | 1,1,1 | **0.30** |

The table (12) shows that control environment obtains the highest local weight percentage which is 43% in achieving the risk assessment.

Table (13)
*The inner dependence matrix of the components with respect to control activities (CA)*

| **CA** | CE | RA | I & C | MO | Weight |
|---|---|---|---|---|---|
| CE | 1,1,1 | 3/2,2,5/2 | ½,1,3/2 | ½,1,3/2 | **0.29** |
| RA | 2/3,1,2 | 1,1,1 | ½,1,3/2 | ½,1,3/2 | **0.25** |
| I & C | 2/3,1,2 | 2/3,1,2 | 1,1,1 | ½,1,3/2 | **0.25** |
| MO | 1/3,2/5, ½ | 2/3,1,2 | 2/3,1,2 | 1,1,1 | **0.22** |

The table (13) shows that control environment obtains the highest local weight percentage which is 29% in achieving the control activities.

Table (14)
*The inner dependence matrix of the components with respect to control activities (CA)*

| **I & C** | CE | RA | CA | MO | Weight |
|---|---|---|---|---|---|
| CE | 1,1,1 | 1,3/2,2 | 3/2,2,5/2 | 3/2,2,5/2 | **0.41** |
| RA | ½,2/3,1 | 1,1,1 | 3/2,2,5/2 | 2,5/2,2 | **0.40** |
| CA | 2/5, ½,2/3 | 2/5, ½,2/3 | 1,1,1 | ½,1,3/2 | **0.08** |
| MO | 2/5, ½,2/3 | 1/3,2/5, ½ | 2/3,1,2 | 1,1,1 | **0.11** |

The table (14) shows that control environment obtains the highest local weight percentage which is 41% in achieving the information and communication.

Table (15)
*The inner dependence matrix of the components with respect to Information & Communication (I&C)*

| **MO** | CE | RA | CA | I & C | Weight |
|---|---|---|---|---|---|
| CE | 1,1,1 | ½,1,3/2 | 3/2,2,5/2 | 3/2,2,5/2 | **0.34** |
| RA | 2/3,1,2 | 1,1,1 | ½,1,3/2 | ½,1,3/2 | **0.24** |
| CA | 2/5, ½,2/3 | 2/3,1,2 | 1,1,1 | ½,1,3/2 | **0.21** |
| I & C | 2/5, ½,2/3 | 2/3,1,2 | 2/3,1,2 | 1,1,1 | **0.22** |

The table (15) shows that control environment obtains the highest local weight percentage which is 34% in achieving the monitoring.
We observed that the control environment obtains the highest local weight percentage in achieving each one of COSO-components separately. This results make a sense as the control environment forms the tone of the top and it is the foundation of all other components.

***Phase 5: Calculating the global weights of COSO-principles***
The next step after determine local weights of principles and the inner dependence weight of COSO-components is calculating the global weight of COSO-principles. The global weights of COSO-principles are calculated by using the interdependent weights of COSO-components with the local weights of COSO-principles to which it belongs. Following are the two steps to calculate the global weights of the principles:
Step 1: Calculating the relative importance weights of strategies with COSO-components
The global weights of COSO-components are calculated by multiplying the local weight of components as table (10) with the local weights of strategies as table (2) as follow matrix:

**Matrix 1:**

$$w = \begin{bmatrix} CE \\ RA \\ CA \\ I\&C \\ M \end{bmatrix} = \begin{bmatrix} 0.33 & 0.33 & 0.27 \\ 0.26 & 0.30 & 0.32 \\ 0.23 & 0.20 & 0.17 \\ 0.06 & 0.06 & 0.11 \\ 0.10 & 0.12 & 0.13 \end{bmatrix} \times \begin{bmatrix} 0.38 \\ 0.38 \\ 0.24 \end{bmatrix} = \begin{bmatrix} 0.32 \\ 0.30 \\ 0.20 \\ 0.07 \\ 0.11 \end{bmatrix}$$

The matrix (1) reflects the link of local weights and relationship between strategies and components. At the time that all relations among the components that participate in achieving the strategies, all the weight of these relations have to be counted in the matrix. This results reflect the varied and fuzzy relationships between the strategies and COSO-components in the forms of weights. These weights are sequentially significant as follow: CE: 37%, RA:30%, CA: 20%, M: 11%, and I&C: 7%.

Step 2: Calculating the interdependent weights of COSO-components
With using the relative importance weights that are resulted in matrix (1), the interdependent weights of the COSO-components are calculated as follow matrix:

**Matrix 2**

$$w = \begin{bmatrix} CE \\ RA \\ CA \\ I\&C \\ M \end{bmatrix} = \begin{bmatrix} 1 & 0.43 & 0.29 & 0.41 & 0.34 \\ 0 & 1 & 0.25 & 0.40 & 0.24 \\ 0 & 0 & 1 & 0.08 & 0.21 \\ 0 & 0.27 & 0.25 & 1 & 0.22 \\ 0 & 0.29 & 0.22 & 0.11 & 1 \end{bmatrix} \times \begin{bmatrix} 0.32 \\ 0.30 \\ 0.20 \\ 0.07 \\ 0.11 \end{bmatrix} /2 = \begin{bmatrix} 0.28 \\ 0.20 \\ 0.12 \\ 0.11 \\ 0.13 \end{bmatrix}$$

In matrix (2) the interdependence weights of COSO-components are calculated by multiplying the inner dependence weight of components as tables (12), (13), (14), and (15) with the weights' results in matrix (1) in previous step. The weights that resulted in matrix (2) are sequentially significant as follow: CE: 28%, RA: 20%, MO: 13%, CA: 12%, and I&C: 11%.
After determining the relative importance of all elements in COSO hierarchal model and identifying the relationships among them, the next step is calculating the global weights of these relationships as step (3).
Step 3: Calculating the global weight of COSO-principles
By using the local weights of the principles as table (11) and the interdependent weights of the components as matrix (2), the global weight of COSO-principles will be calculated. This calculation done by multiplying the local weights of principles with the interdependent weights of components to which it belongs.

Table (16)
*Calculating the local weights of principles*

| COSO components | Interdependent weights | COSO principles | local weights | Global weights |
|---|---|---|---|---|
| **CE** | 0.28 | P-1 | 0.37 | **0.105** |
| | | P-2 | 0.24 | **0.068** |
| | | P-3 | 0.13 | **0.037** |
| | | P-4 | 0.20 | **0.057** |
| | | P-5 | 0.06 | **0.017** |
| **RA** | 0.20 | P-6 | 0.40 | **0.079** |
| | | P-7 | 0.20 | **0.040** |
| | | P-8 | 0.26 | **0.052** |
| | | P-9 | 0.16 | **0.032** |
| **CA** | 0.12 | P-10 | 0.44 | **0.051** |
| | | P-11 | 0.40 | **0.047** |
| | | P-12 | 0.17 | **0.020** |
| **I&C** | 0.11 | P-13 | 0.33 | **0.037** |
| | | P-14 | 0.33 | **0.037** |
| | | P-15 | 0.33 | **0.037** |
| **MO** | 0.13 | P-16 | 0.50 | **0.064** |
| | | P-17 | 0.50 | **0.064** |

The results in table (16) represents the global weights of COSO-principles that will be used to evaluate the effectiveness of ICS at DOF in Dubai Government.

***Phase 6: Evaluating the COSO-principles***

The final step in analysing the data is evaluating the COSO-principles in order to achieve the purpose of our study in evaluation the effectiveness of internal control system. The study adopted in evaluating the COSO-principles on linguistic variables introduced by Cheng, et al in 1999. Figure (5-6) shown the membership functions of the linguistic variables, and table (17) shown their average value.

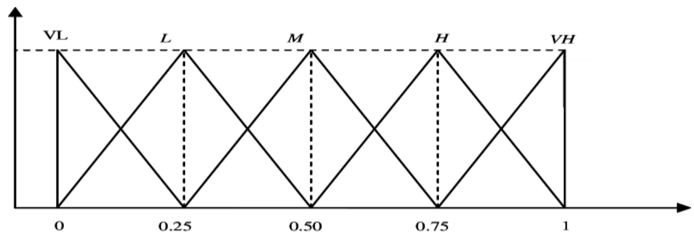


**Figure (5): Membership functions of the linguistic variables for principles rating (Yuksel & Dagdeviren, 2010)**

Table (17)
*Linguistic values and mean of fuzzy numbers*

| Linguistic values | The mean of fuzzy numbers |
|---|---|
| Very high (VH) | 1 |
| High (H) | 0.75 |
| Medium (M) | 0.5 |
| Low (L) | 0.25 |
| Very low (VL) | 0 |

By using the linguistic evaluation scales that are determined from opinions' expert through conducting the interviews in the DOF in Dubai Government and by using the global weights of COSO-principles as table (16), the effectiveness of ICS is evaluated as table (18).

Table (18)
*Evaluation the effectiveness of internal control system*

| COSO-principles | Global weights (gw) | Linguistic evaluations | Scale value (sv) | Evaluation gw×sv |
|---|---|---|---|---|
| P-1 | 0.105 | VH | 1 | **0.105** |
| P-2 | 0.068 | VH | 1 | **0.068** |
| P-3 | 0.037 | H | 0.75 | **0.028** |
| P-4 | 0.057 | H | 0.75 | **0.043** |
| P-5 | 0.017 | M | 0.50 | **0.009** |
| P-6 | 0.079 | VH | 1 | **0.079** |
| P-7 | 0.040 | H | 0.75 | **0.030** |
| P-8 | 0.052 | VH | 1 | **0.052** |
| P-9 | 0.032 | M | 0.50 | **0.016** |
| P-10 | 0.051 | VH | 1 | **0.051** |
| P-11 | 0.047 | H | 0.75 | **0.035** |
| P-12 | 0.020 | H | 0.75 | **0.015** |
| P-13 | 0.037 | H | 1 | **0.037** |
| P-14 | 0.037 | M | 0.50 | **0.019** |
| P-15 | 0.037 | M | 0.50 | **0.019** |
| P-16 | 0.063 | VH | 1 | **0.064** |
| P-17 | 0.063 | H | 0.75 | **0.048** |
| **Evaluation the effectiveness of internal control at DOF in Dubai Government** | | | | **72%** |

In table (18), to evaluate the COSO-principles, the global weights of principles are multiplied with opposite scale value. The 72%, total of the last column, reflects evaluation the effectiveness of ICS at DOF in Dubai Government under the use of BCT. This new percentage will be considered as a standard to evaluate the effectiveness of ICS at DOF in Dubai Government in the future.

**Discussion**

By ranking the importance of control environment principles in achieving the effectiveness of ICS, we find that the commitment to integrity and ethical value, oversights responsibilities, establishing structure and authority, as well as commitment to competence are effectively applied at DOF in Dubai Government and strongly contribute in achieving the effectiveness of ICS. While the accountability of personnel does not have an urgent need and weakly contribute in achieving the effectiveness of ICS.

By ranking the importance of risk assessment principles we observe that setting suitable objectives for risk obtained the highest percentage among the principles of risk assessment. It followed by assessing the risk as the objectives are set in order to assess the risk. Identifying and analysing the risk has a moderate importance in achieving the effectiveness of ICS compared with others. Identifying and analysing changes obtained the lowest percentage in achieving the effectiveness of ICS.

By Ranking the importance of control activities principles, the selecting control activities come in the first level with the highest percentage compared with others. The researcher believes that selecting control activities over technology which comes in the second level are not less important than the first one. Both of them are of high importance in achieving the effectiveness of internal control. Once the control activities are set, it will be implemented through the policies and procedures, therefore deploy activities through policies comes in the third level.

By ranking the importance of information and communication principles, using relevant information comes in the first level with the highest percentage of importance in achieving the effectiveness of ICS. After producing relevant information, communicating it internally and externally comes in the second level with the same percentage of importance in achieving the effectiveness of ICS.

By ranking the importance of monitoring principles, conducting the evaluations comes in the first level. In BCT at DOF in Dubai Government there is a Fraud Management System (FMS) which is used to monitor activities and processes, trace problem and errors, fight espionage as well as piracy attacks, and discover fraud. In the second level comes the evaluation of deficiencies which is also considered highly important in achieving the effectiveness of ICS.

By collecting the percentages of the effectiveness evaluation of all COSO-principles, we will obtain the percentage of evaluating the effectiveness of ICS at DOF in Dubai Government which is 72% in our study. By reference to those concerned at DOF in Dubai Government, this percentage is reasonable in proportion with the percentage of implementing the BCT in the DOF as it does not exceed 75% so far, besides it is only implemented on the SMS. By the year 2020 the BCT will have been fully implemented in the Dubai Government in all fields as well as in various sectors. Consequently, the percentage of effectiveness the ICS is likely to increase in the DOF.

**Conclusion**

The study concluded that the designing model that combines COSO framework and Blockchain implementing strategies at DOF in Dubai Government is effective and strong to evaluate the effectiveness of ICS. Besides, the Blockchain implementing strategies at DOF in Dubai government have a significance role in evaluating the ICS. The control environment at DOF in Dubai Government has the highest relative importance among other components in achieving the effectiveness of ICS while the Monitoring has the lowest one. The most important conclusion of this study is the 72% percentage of the effectiveness of ICS at DOF in Dubai Government that will be used a standard percentage in future researches to evaluate the ICS.

The study recommended to continuously evaluate the ICS to determine its efficiency and effectiveness especially when applying new technology, be careful and cautious in implementing new and advanced technology such BCT to avoid the challenges that the ICS may face, Combine the COSO internal control framework with advances analysing methods in future researches to create an effective model to evaluate and improve the ICS, and conduct many future researches regarding the influence of BCT on the auditing as the researcher expects that the way of performing the audit will be changed under the use of BCT.

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