2528-9705

Örgütsel Davranış Araştırmaları Dergisi
Journal Of Organizational Behavior Research
Cilt / Vol.: 3, Sayı / Is.: S2, Yıl/Year: 2018, Kod/ID: 81S2137

MEASURING THE MATURITY LEVEL OF INFORMATION TECHNOLOGY GOVERNANCE IN TAVANIR COMPANY USING COBIT FRAMEWORK

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ABSTRACT

Nowadays, information technology (IT) is regarded as an essential tool for achieving organizational goals. IT supports for business processes and its usage is rapidly growing. IT has been recognized as a major driver for development of successful organizations. Due to its close proximity to the equipment, infrastructure and main processes involved in the power industry, this technology has generated a high added value for Tavanir Company. Therefore, the present study aimed to measure the maturity level of IT in Tavanir and proposed some measures required for reaching the target maturity level. This research was an applied one in terms of the purpose with a descriptive–correlational design and carried out using a survey method. The statistical population included all employees working at different management level and expertise of Tavanir. This study was conducted using COBIT 5 framework. Fieldwork research and questionnaires were utilized for analyzing the subject and answering the research questions as well as the current and target maturity levels have been determined after analyzing the results. The IT processes were ranked using fuzzy AHP based on Chang method. Necessary measures were suggested to improve the status in order to reach the maturity level; this is done through analyzing the gap and taking into consideration all the features of IT processes within the COBIT model. The results of this study showed that Tavanir has not reached its desired level of IT maturity. It is necessary for Tavanir to take additional actions to reach an appropriate level of IT maturity.

Keywords: *IT Maturity level, Electric Power Industry, Tavanir, COBIT 5 Model, Fuzzy AHP, Chang Method*

INTRODUCTION

Today, information and communication technology (ICT) is considered one of the main infrastructure domains supporting all business processes of organization and its role and functioning is increasingly growing in such a way that some researchers believe that IT is the driving force behind the development of successful organizations. In addition, IT forms a major part of a business strategy in successful companies (Mahmoudi et al., 2009). In recent years, there has been increasing interest in a number of issues including the maturity level of information technology, IT governance, assessment of IT maturity level, IT governance and management standards in various organizations and industries such as automotive industry, petroleum industry, banking, and public and private companies. The Electric Power Industry will not remain an exception. In this regard, while analyzing and reviewing the relevant standards, especially COBIT, Tavanir Company has established a specialist-working group to examine and formulate the governance standard as well as determine the ICT maturity level. Further, in close cooperation with Tehran University (2012), the company attempted to develop a prototype for

Geliş tarihi/Recieved: 12.10.2017 – Kabul tarihi/Accepted: 17.03.2018 – Yayın tarihi/Published: 21.08.2018

determining the maturity level of information technology in a number of power plants operating as a subsidiary of Tavanir Company through a pilot test. In addition to assessing the existing theoretical and applied models, COBIT 4.1 framework was considered as the basis for development of the model (Tavanir, 2012). As the most widely accepted and most frequently used IT governance framework, COBIT not only assesses the maturity level of information technology, but also provides a framework for IT managers to create an IT strategic plan and information architecture. It also ensures the continuity of IT services and monitors the performance of IT systems within the organization as well as helps them to make decisions using these tools (Ronaghi et al., 2015). Compared to its previous versions, COBIT 5 includes some key changes. The COBIT 5 processes are split into governance and management "areas". These two areas contain a total of 5 domains as follows (ISACA, 2012): a) IT Governance: Evaluate, Direct and Monitor (EDM), b) IT management: Align, Plan and Organize (APO), Build, Acquire and Implement (BAI), Delivery, Service and Support (DSS) and Monitor, Evaluate and Assess (MEA). One of the tasks of top managers is to use the capabilities of information and communication technology in order to generate value and promote the quality of the organization's operations. In this regard, assessing the current state of information and communication technology and determining the maturity level of organization are key issues to be considered, because the relevant analysis of distance of an organization to each maturity level can support senior managers to take some measures required for improving the maturity level of information technology. Furthermore, like other organizations and administrative entities agencies, Tavanir, as a responsible organization for the country's Electric Power Industry, needs to specifically focus on information technology and takes some actions to assess and promote its current maturity level. There are many important reasons why IT needs to be integrated into the main body of the company: long-term and continuous use of IT, growing dependence of business activities on IT, numerous challenges in the implementation of current operations, lack of proper use of IT capabilities and global experiences, lack of proper alignment of business strategies with IT strategies, requirements and regulations notified by the legislative and upstream institutions for implementing business operations using modern technologies, especially IT, increased stakeholder expectations and their awareness on IT capabilities to provide optimal and high-quality services, the necessity to upgrade the quality level of IT activities and services provided to stakeholders in order to achieve the goals and requirements of the business, an increase in the share of annual budgeting and resources allocated to IT and finally the need for optimal use of the resources in order to create value for the organization (Tavanir, 2015) and (Tavanir, 2016). According to the above-mentioned explanations, in order to assess the maturity level of information technology and to meet some objectives including building relationships using business requirements, utilizing a framework with a specific structure, identifying core resources, describing management control objectives, ...we made a decision to utilize a framework called COBIT characterized by focusing on business, process orientation, control orientation and measurement capability. The COBIT framework is characterized by features that, in addition to focusing on satisfying the technical requirements of IT domain, persuade senior managers and decision makers to adopt it within their organization. Here are the most important features of COBIT framework: the need for managers to oversee the organization's resources, reducing the total cost of delivering organization's services through IT resource control, decreasing the uncertainty and concern of managers regarding the failure to meet the

organizational objectives, establishment of improved communication between managers, users and auditors, aligning IT with business goals and vice versa, describing roles, responsibilities and duties in clear and precise process-driven way, improving the quality of information technology services and measuring the effectiveness of IT (Haghighie, 2008). The Control Objectives for Information and related Technology (CobiT) is a set of best practices for Information technology (IT) management created by ISACA and the IT Governance Institute (ITGI) in1996. It provides managers, auditors, and IT users with a set of generally accepted measurements, processes, indicators, and best practices to assist them in maximizing the benefits derived through the use of information technology. Moreover, it allows managers, auditors, and users to better understand their IT systems and identify the level of security and control that is necessary to protect their companies' assets through the development of an IT governance model. The present study aimed to analyze and assess the level maturity of ICT governance in Tavanir known as specialized holding company responsible for management of generation, transmission and distribution of electric power in Iran. The authors decided to focus on this specific issue because, on the one hand, Tavanir is a specialized holding company which its policy making, planning and operations have a direct impact on all or most of its subsidiaries activities and on the other hand, significant resources are directed towards the development of information and communication technology domain and its maturity level assessment every year. Additionally, recently, the government has placed special emphasis on improving the information technology status and deployment of e-government in executive agencies including Tavanir. In this regard, the authorities and regulatory and governance bodies such as Management and Planning Organization, Information Technology Organization, Supreme Court of Audit, General Inspection Organization, and ... have evaluated and monitored the performance of executive agencies in the field of information technology and, ranked them in many different ways. Since this issue is directly linked to the maturity level of corporate' information technology, a further study with more focus on this issue is therefore suggested.

Review of Literature

So far, various studies have been conducted on measuring the different aspects of process /organizational maturity and several models have been proposed. Today, organizations have a collection of the best experiences that help them select the model or models close to their business prospects to boost their organization effectively. In the paper "information technology and business process management performance: a case study of ITIL implementation in the financial services industry", all aspects of performance including hardware, software, data, networks, organizations and key business processes should be audited completely to evaluate performance of information technology. The main aim of to investigate information technology processes is measuring the performance of information technology and analyzing the implementation of ITIL in the process of information technology services in the financial industry. The author believes that adopting the ITIL framework will help boost the organizational processes. After the implementation of ITIL, the management understood that the costs previously hidden were pinpointed clearly (Spremic et al, 2008). Aghazadeh and Esfidani studied the maturity level of the top exporters in the field of e-commerce in Iran. In this study, by combination of e-commerce implementation models, a six-step model for e-commerce maturity was designed with an organizational approach so that exporters can take measures to start up and complete e-commerce and perform exports and increase their exports by running

this model (Aghazadeh et al., 2008). Ghazanfari et al. (2011) evaluated the maturity level of information technology governance in Iranian financial services industry. In this study, data were collected from 17 large public and private banks. The results showed that private banks have higher maturity levels in terms of the application and adaptation to information technology because of the structure and maturity of information technology governance and organizational strategies (Ghazanfari et al., 2011). Information and communication technology (ICT) has a long history and use in the country's electric power industry so that it has been one of the pioneers of economic and industrial sectors in applying IT since its inception (Ministry of Energy, 2011). In recent years, several efforts have been made to develop and promote the use of information and communication technology in electricity power industry (Ministry of Energy, Tavanir and subsidiary companies); for example, development of strategic documents, macro plans and actions, or the formulation and implementation of ICT strategies. These activities have been carried out in cooperation with prominent companies operating in the field of Information and Communication Technology (ICT) or reputable universities. These can be summarized as follows:

A. Development of a long-term vision document and strategic plan for Ministry of Energy in cooperation with SAMA Management Research Institute and Electric Power Research Institute
B. Development of information technology and communication technology vision in the electricity power industry in cooperation with Tehran University
C. Providing a prototype for determining the maturity level of information technology in the selected power plants of Tavanir's subsidiary companies in cooperation with Tehran University
D. Development of an organizational architecture master plan for Tavanir Company in cooperation with Shahid Abbaspour Power and Water University of Technology and MAGFA Company

Research Model

In addition to using previous research literature, COBIT 5 framework has been used as a basis for analyzing and assessing Tavanir's information technology maturity level. The maturity levels have been shown in accordance with COBIT 5 framework in six domains. (Figure 1).

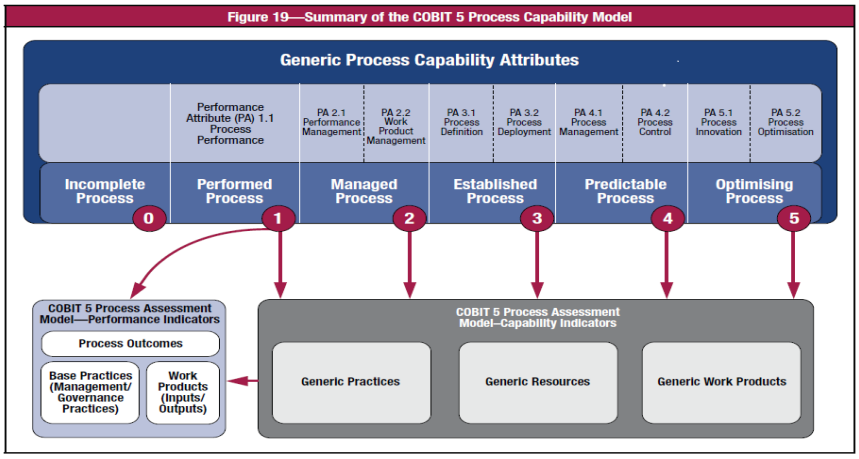

Figure 1. Information technology maturity levels according to the COBIT 5 framework

Level 0: Incomplete process. The process is not implemented, or fails to achieve its process purpose.
Level 1: Performed process. The implemented process achieves its process purpose.
Level 2: Managed process. Performed process is now implemented in a managed fashion (planned, monitored and adjusted)
Level 3: Established process. Managed process is now implemented as a defined process that is capable of achieving its process outcomes.
Level 4: Predictable process. Established process now operates within defined limits to achieve its process outcomes, as a measured and controlled process.
Level 5: Optimizing process. Predictable process is continuously improved to meet relevant, current and projected business goals, incorporating process innovation and optimization.

Research questions

Since we employed the COBIT 5 framework to assess the maturity level of ICT, there is no specific hypothesis. However, this research seeks to answer the research questions regarding the core domains of COBIT 5 framework:

1. What is the maturity level of Tavanir Company in the Evaluate, Direct and Organize process for information technology?
2. What is the maturity level of Tavanir Company in the Align, Plan and Organize process for information technology?
3. What is the maturity level of Tavanir Company in the Build, Acquire and Implement process for information technology?
4. What is the maturity level of Tavanir Company in the Deliver, Service and Support process for IT?
5. What is the maturity level of Tavanir Company in the Monitor, Evaluate and Assess process for information technology?
6. What is the maturity level of Tavanir Company in the information technology domain and what is its target maturity level?
7. What actions should Tavanir Company take to reach its target maturity level?

METHOD

This research was an applied one in terms of the purpose with a descriptive –correlational design and carried out using a survey method. The statistical population included all employees working at different management level and expertise of Tavanir Company (specialized holding company responsible for management of generation, transmission and distribution of electric power in Iran), with a special focus on employees working in Tavanir Information, Communication Technology and Statistics Bureau. In addition, in order to maximize the accuracy of our results, the comments from a number of IT managers of regional electric companies under the supervisory of Tavanir Company have also been used.
"The maturity level of Tavanir Company in the field of information technology using COBIT 5 framework" was identified as the main variable of this research.
The following multifaceted framework is used to measure the maturity level in COBIT 5:

- There are five processes in COBIT 5.
- Each domain has its own unique processes. In total, there are 5 domains and 37 processes.

- Each process contains a number of criteria that should be evaluated and measured. In total, there are 169 criteria in COBIT 5 framework.
- The maturity level for each process, process domain, and eventually Tavanir Company is determined based on the results of the above criteria assessment and according to the calculations and the predefined method.

The studied variables were defined in three levels of process domain, process, and criterion according to the above explanations

Research questionnaires were prepared based on COBIT processes and criteria and the overall format of the questionnaire was designed based on the item templates. The questionnaires were distributed among the participants to determine the maturity level of information technology in Tavanir Company.

The data used in this study is based on the opinions of 24 Tavanir Company IT experts and selected regional electricity companies in two parts. The first addresses evaluating and determining the maturity level of Tavanir information technology that is numerical in terms of the features and is expressed in percentages for each criterion. The second part focuses on the ranking and prioritizations of the processes that are expressed through verbal items and are related to the paired comparison of processes to determine their importance versus each other. Regarding the basis of the subject, the descriptive statistics techniques such as calculating the mean have been used in different stages of the research. In addition, Excel and MATLAB software were applied to gather data and perform calculations; Fuzzy AHP hierarchy process based on Chang's method was applied as well.

The research roadmap was shown in Figure 2.

Figure 2. Research roadmap

Regarding the validity of the collected data, the questionnaires were prepared based on the COBIT 5 model using standard pairwise tables. A number of IT experts working in electric power industry responded the questionnaires. The results have been confirmed by the supervisor, managers and experts of the industry.

FINDINGS

The result of the second assessment for measuring the maturity level was determined by calculating the average scores of the experts based on each process. The final maturity level of the processes was calculated according to Table (1).

Table 1. Maturity level of IT processes in Tavanir Co.

Code	Domain/Process	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Maturity level
Evaluation, Guidance and Monitoring (EDM)								
EDM01	Ensuring the establishment and maintenance of the governance framework		L					1
EDM02	Ensuring the delivery of benefits		P					۰
EDM03	Ensuring optimization of risk		P					۰
EDM04	Ensuring optimization of resources		L					۱
EDM05	Ensuring stakeholder transparency		L					1
Align, plan and organize (APO)								
APO01	Framework Management, ICT Management		F	L				۲
APO02	Strategy Management		L					۱
APO03	Organizational Architecture Management		L					۱
APO04	Innovation Management		P					۰
APO05	Project portfolio management		L					1
APO06	Budgeting and costs management		F	L				2
APO07	Human resource management		P					۰
APO08	Communication management		L					1
APO09	*Service* Level *Agreements* management		L					1
APO10	Supply Chain Management		L					1
APO11	Quality management		L					1
APO12	Risk management		P					۰
APO13	Security management		L					۱
Build, Acquire and Implement (BAI)								
BAI01	Program and project management		L					۱
BAI02	Defining requirements management		L					1
BAI03	Management of Identifying and Implementing Solutions		L					۱
BAI04	Availability and Capacity Management		L					۱
BAI05	Management of Organizational Change Capabilities		P					۰
BAI06	Change management		P					۰
BAI07	Adoption and Transfer Management		P					۰

BAI08	Knowledge management		P					۰
BAI09	Asset Management		L					۱
BAI10	Configuration Management		P					۰
Deliver, Service and Support (DSS)								
DSS01	Operation Management		F	L				2
DSS02	Event and Service Request Management		F	L				۲
DSS03	Management problems and challanges		L					۱
DSS04	Continuity management		L					۱
DSS05	Security Services Management		F	L				2
DSS06	Business process controls management		L					1
Monitor, Evaluate and Assess (MEA)								
MEA01	Monitor, evaluate and assess performance and compliance		L					1
MEA02	Monitoring, evaluation and assessment of internal control system		L					1
MEA03	Monitoring, evaluation and assessment of compliance with external requirements		F	P				۱

According to the findings, the maturity level of process domains in Tavanir Company was presented in Table 2.

Table 2. Maturity levels of process domains in Tavanir Company

Process domains	Calculated maturity level	Current Level of maturity (rounded off)	Target maturity level	Code
Evaluate, Direct and Monitor (EDM)	0.6	1	2	EDM
Align, plan and organize	0.9	1	2	APO
Build, Acquire and Implement	0.5	1	2	BAI
Deliver, service and support	1.5	2	3	DSS
Monitor, evaluate and assess	1	1	2	MEA

Using the fuzzy hierarchy process to prioritize processes

After investigating the maturity level of the processes, they should be prioritized based on their significance. This step is taken in order to analyze and compare the current gap, the optimal conditions, and suggesting corrective measures to Tavanir Company to boost their maturity level, and setting maturity as their prime objective. Process prioritization was done using pairwise comparison through fuzzy AHP method and expert opinion.

First, the experts' opinions were obtained and replaced with their corresponding fuzzy numbers. For example, Table 3 shows one of the expert's opinion and its corresponding fuzzy number.

Table 3: Fuzzy pairwise comparisons based on expert opinion

Objective	Evaluate, Direct	Align, Plan and	Build, Acquire	Deliver, service	Monitor, Evaluate

	and Monitor (EDM)			Organize (APO)			and Implement			and support			and Assess		
Evaluate, Direct and Monitor (EDM)	1	1	1	0.33	0.40	0.50	0.40	0.50	0.67	0.50	0.67	1.00	0.50	1.00	1.50
Align, Plan and Organize (APO)	2.00	2.50	3.00	1	1	1	0.50	1.00	1.50	1.00	1.50	2.00	1.50	2.00	2.50
Build, Acquire and Implement	1.50	2.00	2.50	0.67	1.00	2.00	1	1	1	0.50	1.00	1.50	1.00	1.50	2.00
Deliver, service and support	1.00	1.50	2.00	0.50	0.67	1.00	0.67	1.00	2.00	1	1	1	1.00	1.50	2.00
Monitor, Evaluate and Assess	0.67	1.00	2.00	0.40	0.50	0.67	0.50	0.67	1.00	0.50	0.67	1.00	1	1	1

Likewise, other experts' pairwise comparison tables are calculated, which are not presented here due to limited space. Next step is to gather all opinions using the following equation. Since the opinions of 24 power industry experts were used for paired comparison matrix, k is equal to 24 in all the computations.

$$\tilde{Z}_{ij} = \left(\sqrt[k]{l_1 \times l_2 \times \ldots \times l_k}, \sqrt[k]{m_1 \times m_2 \times \ldots \times m_k}, \sqrt[k]{u_1 \times u_2 \times \ldots \times u_k}\right)$$

Table 4. Summary of Experts' viewpoints

Objective	Evaluate, Direct and Monitor (EDM)			Align, Plan and Organize (APO)			Build, Acquire and Implement			Deliver, service and support			Monitor, Evaluate and Assess		
Evaluate, Direct and Monitor (EDM)	1	1	1	0.2112	0.3824	0.5806	0.3720	0.5205	0.7827	0.3720	0.5205	0.8271	1.4979	1.6566	1.9345
Align, Plan and Organize (APO)	1.7225	2.6153	4.7343	1	1	1	0.8819	1.0960	1.5517	0.9188	1.0700	1.4660	1.4436	1.6872	1.9034
Build, Acquire and Implement	1.2776	1.9213	2.6884	0.6445	0.9124	1.1339	1	1	1	0.9019	1.1764	1.7139	1.3117	1.5019	1.8991
Deliver, service and support	1.2090	1.9213	2.6884	0.6821	0.9346	1.0884	0.5835	0.8500	1.1087	1	1	1	1.1939	1.3171	1.8653
Monitor, Evaluate and Assess	0.5169	0.6037	0.6676	0.5254	0.5927	0.6927	0.5266	0.6658	0.7624	0.5361	0.7593	0.8376	1	1	1

Now, the consistency rate of the above matrix is calculated for the data integrity. In order to study the consistency of experts' answers, suppose n factors $C_1, C_2, \ldots, C_n$ should be compared to calculate their weight after building the decision matrix. During the pair comparison, the two factors C_i and C_j and building of the decision matrix is influenced by the following limitations:

$$a_{ij} = \begin{cases} \frac{1}{a_{ji}} \; ; \forall i \neq j \\ a_{ii} = 1 \; ; \forall \; i = j \end{cases}$$

Then the resulting decision matrix is called the two-way decision matrix (reciprocal), which yields consistent weights. If the following relationship is built, then the weights will be completely consistent. In fact, the elements of the decision matrix must be transitive.

$$a_{ij} = a_{ik} a_{kj} \quad \forall \quad i, j, k$$

If the decision matrix is reciprocal and its elements are completely transient, then the weights will be completely consistent. However, the decision making process of human mind will not yield a decision matrix with completely transient elements in reality. Thus, a lack of consistency is natural in the decision-making matrix.

Regarding the triangular fuzzy number $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, if the definite matrix A that consist of all m of the triangular fuzzy numbers for paired comparisons is consistent, then the fuzzy matrix A is consistent as well. In order to calculate the CI (Consistency Index), it is required to calculate the specific value (λ_{max}). The specific value of the pairwise comparison matrix $\tilde{A}$ is determined as:

$$\tilde{A}.W = \lambda_{\max}.W$$
$$[\tilde{A} - \lambda_{\max}].W = 0$$

Where the W indicates the special vector of $\tilde{A}$.

After calculating λ_{max} , CI (Consistency Index) is calculated. The Consistency Ratio (C.R.) is required to confirm the consistency of the pairwise comparison matrix. .C.I and C.R. are defined as:

$$C.I. = \frac{\lambda_{\max} - n}{n-1}$$
$$C.R. = \frac{C.I.}{R.I.}$$

The value of the random variable (RI) depends on the matrix dimension (See Table 5).

Table 5: Random index used to calculate the consistency index

n	1	2	4	4	5	6	7	8	9	10	11	12	13
RI	0	·	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.59	1.51	1.48	1.56

If we have $C.R. < 0.1$, the matrix is consistent; thus, the final ranking is done and the necessary decisions are made. Otherwise, we have to review the experts' opinion and correct the gathered information.

Using the Matlab software, the λ_{max} matrix of the table (3) is calculated as 5.0996 and since n = 5, we have:

$$C.I. = \frac{5.0996-5}{5-1} = 0.0249$$

Thus, regarding the corresponding values of RI and n in Table (4), the C.R. is calculated as follows:

$$C.R. = \frac{0.0249}{1.11} = 0.0224$$

Since this value is less than 0.1, it is possible to understand the consistency of the combine individuals' opinions and take the next step, which is calculating the weight of the matrix. The matrix of table (3) is the result of the geometric mean of the 24 experts' opinions of the power industry in terms of process areas.

Likewise, the matrices of the combine individuals' opinions are computed for the processes of each domain.

Prioritizing the criteria by Chang development analysis

In the Chang method, each level of the paired comparison matrix is builds as follows:

$$\tilde{A} = [\tilde{a}_{ij}] = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix}$$

Where

$$\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij}) = \frac{1}{\tilde{a}_{ji}} = (\frac{1}{u_{ji}}, \frac{1}{m_{ji}}, \frac{1}{l_{ji}}); i, j = 1, \ldots, n; i \neq j$$

$\tilde{a}_{ij}$ shows the verbal judgment of the expert to compare the two criteria of i and j.

In the development analysis method, for each of the rows of the paired comparison matrix, *S_i* is itself a triangular number and is calculated as follows:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

Where

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_{j'}, \sum_{j=1}^{m} m_{j'}, \sum_{j=1}^{m} u_{j'} \right)$$

In order to calculate $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, a fuzzy reverse operation must be done:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right)$$

The fuzzy reverse operation is calculated as follows:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

The possibility degree of the two fuzzy numbers $\tilde{S}_1 = (l_1, m_1, u_1)$ and $\tilde{S}_2 = (l_2, m_2, u_2)$ is defined as:

$$V(S_2 \geq S_1) = \sup_{y \geq x}\left[\min(\mu_{S_1}(x), \mu_{S_2}(x))\right]$$

The equivalence of the above equation can be expressed as follows:

$$V(S_2 \geq S_1) = hgt(S_1 \cap S_2) = \mu_{S_2}(d)$$

$$= \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{Otherwise} \end{cases}$$

The magnitude of a triangular fuzzy number against another triangular fuzzy number is calculated from the following equation:

$$V(S_1 \geq S_2, \ldots, S_K) = V(S_1 \geq S_2), \ldots, V(S_1 \geq S_K)$$

The weight of the indices in the paired comparison matrix is calculated through the following equation:

$$d'(A_i) = Min\{V(S_i \geq S_k)\}, k = 1, 2, \ldots, n; k \neq i$$

Hence, W_i' is the weight vector of indices that is the same as the non-normal coefficient vector of the fuzzy hierarchy process. Using the following equation, the abnormal results from the above equation can be normalized.

$$W_i = \frac{W_i'}{\sum_{i=1}^{n} W_i'}$$

Using the aforementioned basis regarding Chang development analysis method, and MATLAB software, the prioritization vector is calculated.

$$\left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right]^{-1} = (0.0278 \quad 0.0361 \quad 0.0448)$$

$$\begin{pmatrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \end{pmatrix} = \begin{pmatrix} 0.0961 & 0.1473 & 0.2295 \\ 0.1661 & 0.2696 & 0.4772 \\ 0.1429 & 0.2351 & 0.3778 \\ 0.1299 & 0.2174 & 0.3471 \\ 0.0864 & 0.1307 & 0.1774 \end{pmatrix}$$

In Chang's method, after calculating S_k values, their degree of magnitude against each other should be calculated as well. The elements of matrix V matrices show the magnitude $S_k$against each other (for example, v_{11} represents their degree of magnitude against S_1 to S_2.

$$\begin{pmatrix} 1.0000 & 0.3415 & 0.4965 & 0.5867 & 1.0000 \\ 1.0000 & 1.0000 & 1.0000 & 1.0000 & 1.0000 \\ 1.0000 & 0.8598 & 1.0000 & 1.0000 & 1.0000 \\ 1.0000 & 0.7763 & 0.9204 & 1.0000 & 1.0000 \\ 0.8308 & 0.0751 & 0.2480 & 0.3536 & 1.0000 \end{pmatrix}$$

The elements of W' vector are the minimum of each row of the matrix V, which shows the magnitude of S_k the corresponding S_k of its row against the other S_k, which is the same as the vector of the non-normal fuzzy coefficients. For example, the first element of the vector W ' represents the magnitude of the S_1 against the other S_k; in fact, it is the priority coefficients of non-normal criterion of C_1 (area of evaluation, direction and supervision) to prioritize the COBIT processes.

$$W' = (0.3415 \quad 1 \quad 0.8598 \quad 0.7763 \quad 0.0751)^T$$

Now, based on the equation of zed weights of the indices are , the normali $w_i = \frac{w_i'}{\Sigma w_i'}$ calculated:

$$W = (0.1119 \quad 0.3276 \quad 0.2816 \quad 0.2543 \quad 0.0246)^T$$

Likewise, weights of the tables are calculated against the other paired comparisons.
To calculate the final weight of each sub criteria indicating the importance of each criterion based on expert opinion, it is necessary to multiply the sub-criteria weights by the corresponding main criterion weight. Table (6) shows the weight of the first and second level criteria and the final weight of each sub criteria for prioritizing processes.

Table 6. Weight and final rating (priority) of processes and process domains

Main criteria (Process domains)	Weight	Processes (sub-criteria)	Weight (domain)	Final weight	Rank

Evaluate, Direct and Monitor (EDM)	0.1119	Evaluation, Guidance and Monitoring (EDM)	0.2984	0.03339	10
		Ensuring the delivery of benefits	0.1865	0.02087	27
		Ensuring optimization of risk	0.1579	0.01767	33
		Ensuring optimization of resources	0.1903	0.02129	26
		Ensuring stakeholder transparency	0.167	0.01869	31
Align, plan and organize (APO)	0.3276	Framework Management, ICT Management	0.0012	0.00039	37
		Strategy Management	0.1153	0.03777	8
		Organizational Architecture Management	0.0565	0.01851	32
		Innovation Management	0.0979	0.03207	11
		Project portfolio management	0.1181	0.03869	7
		Budgeting and costs management	0.1234	0.04043	6
		Human resource management	0.0839	0.02749	17
		Communications management	0.0577	0.01890	30
		Service Level Agreements management	0.0733	0.02401	21
		Suppliers Management	0.0786	0.02575	19
		Quality management	0.0618	0.02025	29
		Risk management	0.0628	0.02057	28
		Security management	0.0709	0.02323	23
Build, Acquire and Implement (BAI)	0.2816	Program and project management	0.0757	0.02132	25
		Defining requirements management	0.1117	0.03145	12
		Management of Identifying and Implementing Solutions	0.1004	0.02827	16
		Availability and Capacity Management	0.109	0.03069	13
		Management of Organizational Change Capabilities	0.0825	0.02323	22
		Change management	0.0905	0.02548	20
		Acceptance and Transfer Management	0.1236	0.03481	9
		Knowledge management	0.1076	0.03030	14
		Asset Management	0.1024	0.02884	15
		Configuration Management	0.0965	0.02717	18
Deliver, service and support (DSS)	0.2543	Operation Management	0.1762	0.04481	3
		Event and Service Request Management	0.1667	0.04239	5
		Management problems and challenges	0.1722	0.04379	4
		Continuity management	0.1994	0.05071	1
		Security Services Management	0.0863	0.02195	24
		Business process controls management	0.1992	0.05066	2
Monitor, evaluate and assess (MEA)	0.0246	Monitor, evaluate and assess performance and compliance	0.2982	0.00734	35
		Monitoring, evaluation and assessment of internal control system	0.2721	0.00669	36
		Monitoring, evaluation and assessment of compliance with external requirements	0.4297	0.01057	34

The details of the current maturity levels and the calculated target of each process have been presented in Table (7).

Table 7. The final maturity level of Information Technology in Tavanir Company in general and by process domains

Code	Domain/Process	Current maturity level	Target maturity level
Evaluation, Guidance and Monitoring (EDM)		1	2
EDM01	Ensuring the establishment and maintenance of the governance framework	1	2
EDM02	Ensuring the delivery of benefits	0	2
EDM03	Ensuring optimization of risk	0	2
EDM04	Ensuring optimization of resources	1	2
EDM05	Ensuring stakeholder transparency	1	2
Align, plan and organize (APO)		1	2
APO01	Framework Management, ICT Management	2	2
APO02	Strategy Management	1	2
APO03	Organizational Architecture Management	1	2
APO04	Innovation Management	0	2
APO05	Project portfolio management	1	2
APO06	Budgeting and costs management	2	2
APO07	Human resource management	0	2
APO08	Communications management	1	2
APO09	Service Level Agreements management	1	2
APO10	Suppliers Management	1	2
APO11	Quality management	1	2
APO12	Risk management	0	2
APO13	Security management	1	2
Build, Acquire and Implement (BAI)		1	2
BAI01	Program and project management	1	2
BAI02	Defining requirements management	1	2
BAI03	Management of Identifying and Implementing Solutions	1	2
BAI04	Availability and Capacity Management	1	2
BAI05	Management of Organizational Change Capabilities	0	2
BAI06	Change management	0	2
BAI07	Adoption and Transfer Management	0	2
BAI08	Knowledge management	0	2
BAI09	Asset Management	1	2
BAI10	Configuration Management	0	2
Deliver, Service and Support (DSS)		2	3
DSS01	Operation Management	2	3
DSS02	Event and Service Request Management	2	3
DSS03	Management problems and challenges	1	3
DSS04	Continuity management	1	3
DSS05	Security Services Management	2	3
DSS06	Business process controls management	1	3
Monitor, Evaluate and Assess (MEA)		1	2

MEA01	Monitor, evaluate and assess performance and compliance	1	2
MEA02	Monitoring, evaluation and assessment of internal control system	1	2
MEA03	Monitoring, evaluation and assessment of compliance with external requirements	1	2

CONCLUSION

Since this research was based on the COBIT5 framework, the factors affecting the maturity level of information technology were specified in terms of maturity criteria of the COBIT5 framework.

Answering the first through fifth questions: Given the calculated maturity levels for the five areas of the COBIT5 framework, it is understood that Tavanir Company has dedicated most of its attention and attempt in the first phase on the process of delivery, service, and support. Next, it focused on the process of monitoring, evaluation, and assessment and paid less attention to other process areas. Regarding the processes, indices and control objectives of the COBIT5 framework, it can be said that Tavanir IT department focuses more on measures to provide and promote the available and operational services to keep them centered and under control; less attention was paid to strategic management issues such as IT consistency with business, planning, organization, direction, and supervision.

Answering the six question. it should be pointed out that determining the maturity level of each of the process area, the calculated level of maturity from the questionnaires should be rounded up; then one unit is added to it to calculate the target maturity level. Besides, in order to challenge the maturity level of each process, the calculated target maturity level for process area were considered for all areas of that process and were calculated equally and independently from the calculated maturity level for the process. Hence, the evaluation of the current maturity level and determining the maturity level of each process and process areas have been conducted through a pessimistic approach. This brought about, in some processes, the difference between the current maturity level and the maturity level of the two target units (For example, from zero to level two or from one to level three). Regarding this processes and specifying the corrective actions to achieve the target maturity level, more attempts should be undertaken. In answering to the six question, it could be said that total maturity level of Tavanir information technology is around 1 and its target maturity level is around 2.

Answering the seventh question. after prioritizing of the processes through the fuzzy hierarchical analysis method and MATLAB software; reviewing the documents of the COBIT5 framework; studying the features and requirements of the maturity levels of each process; focusing on the current status of Tavanir information technology and expert judgment, a list of the proposed corrective actions were specified by for each separate processes as described in Table (8).

Table 8. A list of proposed corrective actions to reach the target maturity level by processes

Priority	Process	Corrective Actions
1	Continuity management	•Continuous standardization of service practices and process monitoring, and defining and clarifying responsibilities for planning and continuous evaluation of service.

		•Ensuring the commitment to providing continuous service and its principles and documentation of ongoing service plans. •Creating a database of tools, equipment, procedures, policies and components needed for critical times.
2	Business process controls management	•Defining, documenting and implementing processes necessary to maintain the integrity of information and security of information assets and clarifying roles and responsibilities, and monitoring and controlling them using codified criteria with emphasis on key assets and information of the organization.
3	Operation Management	• Defining and implementing a transparent process for the management of IT infrastructure and outsourcing of all or part of the infrastructure, according to the circumstances and with the emphasis on optimizing the cost and time required to reach the expected level of scalability, flexibility
4	Management problems and challenges	• Standardization of processes for identifying and solving problems and clarifying roles and responsibilities and ensuring its understanding and streamlining at the organization level. • Establishing an effective system for managing problems with investing in human resources, training and supporting teams of respondents, recording and tracking their problems and solutions.
5	Event and Service Request Management	•Standardization of requests management processes and the use of a comprehensive and basic tool for detecting, receiving, categorizing, prioritizing, recording, referral, and request management. •Ensuring an understanding of requests management processes at all levels of the organization and transparency of roles and responsibilities in this regard. Ensuring the effectiveness of requests management processes by documenting procedures and methods, monitoring and measuring, analyzing, reporting and continuous improvement
6	Budgeting and costs management	• Designing and deploying a comprehensive IT budget management system consistent with the policies, requirements and needs of the organization's business and its monitoring and control with standard standards.
7	Project portfolio management	• Ensuring the full understanding and acceptance of the fundamentals and principals of ICT portfolio management. • Defining and documenting the portfolio management processes in a centralized manner and clarifying all roles and responsibilities therein. • Defining a portfolio of IT projects with precise indicators and parameters, emphasizing their values and outcomes, and identifying and monitoring project communications.
8	Strategy Management	• Strategic IT planning with senior management responsibility and monitoring and control of the program and measuring its effectiveness. • Reengineering processes and ensuring compatibility and alignment of IT strategies and business strategies. •Ensuring that there are well-documented processes to balance the use of internal resources and resources outside the organization for the development of systems and operations
9	Acceptance and Transfer Management	•Defining a specific methodology for training, testing, installation, transmission, transformation, and data clearing, acceptance and operation of systems

		• Continuous monitoring of systems by defining a certain threshold of problems for them
10	Ensuring the establishment and maintenance of the governance framework	• Developing policies, strategies, and a comprehensive ICT plan with an organizational architecture approach based on up-to-date standards and methodologies and updating it in accordance with the requirements and needs of the organization.
11	Innovation Management	• Analyzing and clarifying the relationship between new technologies, their opportunities and IT on business for managers. • Paying attention to creativity and innovation at the individual level and to support creative ideas • Designing and implementing a specific organization-level ideology and describing processes for transforming ideas into products and services, and training and culture building on increasing the quantitative and qualitative level of ideas.
12	Management for describing requirements	• Defining a specific methodology for identifying ICT solutions and responding to business needs with a multi-indicator approach based on technology opportunities, economic feasibility, risk assessment, user requirements and other relevant factors.
13	Availability and Capacity Management	Determining and explaining the functional needs of systems in critical domains and ensuring the knowledge of business management about the adverse effects resulting from the lack of management performance and identifying and applying indicators and tools suitable for the detection, measurement and monitoring of performance and its problems, and capacity •Institutionalizing performance requirements and capacity as a step involving the methodology for production, acquisition and implementation of systems
14	Knowledge management	• Providing minimal opportunities for participation and culture of sharing knowledge in the organization and identifying and strengthening knowledge management patterns. • Appointing the organization's knowledge manager and defining his/her role and categorizing different types of existing and future knowledge of the organization • Developing and implementing knowledge management strategies and processes and the attention of business managers to data management in the organization. • Developing and implementing of monitoring and succession planning within the organization
15	Asset Management	• Documenting and standardizing the procedures and methods of asset management and accurate assessment of information assets. • Implementing intelligent tools for asset management, supporting all information technology and IT resources, clarifying asset associations with information technology services, and identifying and eliminating vulnerabilities and asset-related threats.
16	Management problems and challenges	• Establishing and deploying a transparent, formal and understandable framework and its acceptance by stakeholders and in partnership with them to identify solutions and software development, maintenance, support, documentation, training, and defining a process for updating the

		software and their storage and maintenance in a library accessible to stakeholders
17	Human resource management	• Developing and implementing an effective human resources management process and identifying a strategic approach for recruiting and managing staff working in ICT. • Designing and implementing an official education program to cover the training needs of staff working in ICT • Developing and implementing workflow plans to develop employee skills
18	Configuration Management	• Understanding and implementing the need for complete and correct information for configuration and the necessity of its application and development at all levels of the organization. • Documenting and standardizing procedures and practices • Implementing comprehensive systems and tools for configuration management with an emphasis on disguised management and distributed control. • Tracking changes made to software and equipment automatically to improve system stability.
19	Suppliers Management	• Ensuring management awareness of the necessity and need for a transparent policy for supplier management and the development and implementation of required procedures for the management of IT providers from identification to completion. • Evaluating and reporting business-related risks to contracts and managing communications with suppliers based on the contract
20	Change management	• Developing and streamlining the change management process with an emphasis on managing change requests, including categorization, prioritization, emergency procedures, discretion and responsibilities for changing and managing manuscripts. Analyzing of the effect of changes on business and support of senior management for the implementation of approved alterations.
21	Service Level A greements management	• Identifying services provided by ICT department and the issuance of an ID card and workflow service and transparency of responsibilities. • Designing and appointment of a ICT coordinator for the stakeholders and ensuring the agreement and acceptance of the ICA level service agreement with the stakeholders. • Developing and streamlining the process for developing ICT level management. Periodic assessment and measurement of ICT delivery quality
22	Management of Organizational Change Capabilities	• Ensuring adequate knowledge of senior management of the organization and IT managers with the implementation of systems using change management approach and implementation of changes resulting from human resources and structure perspective. • Analyzing, designing and developing of software systems with the participation of stakeholders and users of the systems and providing a clear picture of the advantages and disadvantages of developing a new system for them and offering the necessary formal training to users and system administrators. Identifying organizational stakeholders and evaluating their readiness for

		change before developing the system and using their previous experience in this field.
23	Security Management	•Describing IT security procedures and their alignment with security policies. •Establishing an IT Security Program with an emphasis on risk analysis and explaining security solutions and clarifying security responsibilities. Perform case studies of ICT Influence and Reporting, focusing on its technical aspects
24	Security Services Management	• Developing Information Technology Security Policies • Establishing an IT security plan by identifying and analyzing risks and providing security solutions. Valuation of information assets and identifying information security risks and compiling a list of threats and vulnerabilities based on the assets
25	Program and project management	• Establishing a management team for ICT projects within the ICT department with a specific task description •Defining IT projects with clear and concrete business and technical objectives through the participation and support of ICT and senior management of the organization. Monitor all ITC projects and continuously monitor and monitor the performance indicators of those projects
26	Ensuring optimization of resources	• Categorizing IT resources and analyzing and evaluating their role in business and defining a specific framework for providing those resources in such a way that the roles, responsibilities and authorities of stakeholders within the framework of resource allocation are transparent. • Providing a short-term and medium term planning for ICT resources Evaluation and reporting of quality and amount of resources used in projects based on appropriate indicators and attention to deviations
27	Ensuring the delivery of benefits	• Ensuring knowledge of ICT stakeholders about the benefits of ICT in their business domain. • Developing and implementing a model for measuring the created value in ICT projects and benefits transfer to stakeholders. • •Monitoring and evaluation of the communication and effectiveness of ICT Strategies resulting from the project portfolio • Monitoring and controlling the alignment of ICT investments with overall business strategies and advantages of investment in comparison with the cost incurred.
28	Risk management	• Developing a clear policy and methodology for scheduling and risk assessment Compilation and documentation of the risk management process and its training to the employees of the organization and its reflection in their duties
29	Quality management	•Developing a quality management plan to provide a simple definition for quality of process components and deliverables and their monitoring. Establishment of a quality system based on quality control processes and quality assurance
30	Communicatio	•Ensuring a clear understanding of the need for effective control of

	ns management	environmental information by management, and the need for policy making in the field of communications and the formulation of communication policies as the basis for the exchange of company information outside the organization. • Continuous interaction between management and body of the organization regarding the executive procedures and standards of communications and information control of the external environment. • Defining the internal communication of different organizational units and identifying and introducing a point of contact for the IT unit to manage its interactions. • Development and updating of stakeholder identity and power-stakeholder analysis for ICT department
31	Ensuring stakeholder transparency	• Illustrating a large picture for ICT services and products, and identifying and categorizing effective and influential stakeholders in the production and provision of ICT services based on specific indicators and in line with ICT orientations. • Determining and measuring the information needs of stakeholders based on the type of communication and how they affect them. • Developing a specific mechanism for validating the data and reports planned and the information strategy for the stakeholders.
32	Organizational Architecture Management	• Ensuring understanding and acceptability of the importance of information architecture and organizational architecture, appointing a person to organizational architecture unit and delineating a specific process for planning and controlling organizational architecture. • Development of information architecture policies, strategic requirements, procedures, tools and techniques for standardization of system and information architecture
33	Ensuring optimization of risk	• Providing training and culture building for developing risk-taking culture in the organization and ensuring the awareness of the management on ICT risks and their impact on business. •Developing a macro-planning model for ICT by taking into account the specific risks of the organization in the field of ICT and business, and planning corrective actions to address risks through stakeholder participation. Developing and implementing a specific mechanism for evaluating and monitoring ICT risks and analyzing ICT decisions based on their relevant risks.
34	Monitoring, evaluation and assessment of compliance with external requirements	• Providing a charter for the Information Technology Assessment by management and detecting and understanding the environment as well as legal requirements and business terms and regulations in the evaluation process by experts and experienced staff working in the ICT •Identifying the institutions and bodies that develop the rules and regulations in the field of ICT and establishing the relationship between these provisions and regulations with the objectives of Information Technology • Developing a list of measures necessary to meet the requirements resulting from laws and regulations of the organization, institutions and bodies of government and institutions specialized in ICT

35	Monitor, evaluate and assess performance and compliance	•Defining and institutionalizing processes for IT assurance activities, as well as criteria for using internal and external resources based on the level of expertise, sensitivity and interdependence required, and the development of security requirements for all ICT processes. •Developing policies, programs, procedures, methods, techniques and scales for monitoring and evaluation with senior management support and establishing a knowledge base of approvals and best practices for assessment and evaluation. • Reporting control monitoring activities and creating a knowledge base of ICT criteria for use in the internal control monitoring process
36	Monitor, evaluate and assess of internal control system	•Allocation of responsibilities and roles for the effectiveness of monitoring the internal control by IT management and the use of domestic experts for the assessment of internal control •Implementation of internal information technology assessment as part of financial audits and application of information control reports for corrective actions •Regular participation of IT experts in the process of internal control assessment •Increasing awareness of the organization regarding internal control monitoring and the implementation of the regulatory process in a systematic manner on the effectiveness of critical internal controls
37	ICT framework management	• Development of organizational chart, roles, responsibilities, tasks and necessary qualification of the IT department in accordance with the information technology strategies and communication and providing information to all stakeholders with emphasis on the completeness of the intended functions for ICT. • Establishment of a specific plan for controlling the internal environment of ICT unit as well as establishing effective and official communications with other units.

The results of this study showed that Tavanir Company has not reached its desired level of information technology maturity; therefore, it is necessary for the company to take additional actions to reach an appropriate level of IT maturity level so that it can meet the requirements of the organization and its business needs.

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