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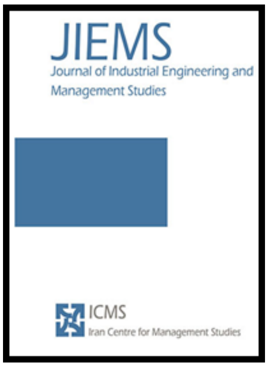

A new approach for KPI ranking and selection in ITIL processes: Using simultaneous evaluation of criteria and alternatives (SECA)

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Abstract
The importance of IT services in the life of businesses has led organizations to seek continuous evaluation of the quality of their IT services. In this regard, IT service management best practices such as Information Technology Infrastructure Library (ITIL), have introduced several processes for management of IT services and defined different KPIs for evaluation of each process, so that organizations can evaluate and analyze the quality of their IT services through these KPIs. Despite this fact that evaluation of each ITIL process using mentioned KPIs requires considerable time and money, organizations are looking for solutions to invest on the most effective KPIs to improve their ITSM processes in pursuit of their business requirements. Although there are some researches over process evaluation methods in different areas, there is no scientific research in ITSM process evaluation. This study proposes the unique method for ITSM evaluation using ITIL KPIs based on defined critical success factors (CSF). In addition to that, Simultaneous Evaluation of Criteria and Alternatives (SECA) model as one of the newest MCDM methods has been used for KPI prioritization. Based on the results, we recommended the order of KPIs in ITSM process performance evaluation. This research helps organizations to improve their ITSM processes by investment on the most effective KPIs.

Keywords: IT service management; ITIL processes; simultaneous evaluation of criteria and alternatives (SECA); key performance indicator (KPI); critical success factor (CSF).

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1. Introduction

In recent decade, the course of business has been significantly changed by Information Technology through the improvement of both the quality and quantity regardless of the business size or sector. Managers have been encouraged by nonstop hard work and determination concerning return on investment and the use of IT in business to use services as a rich information source for strategic decision-making (Melendez, Dávila, Pessoa, 2015).

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Accordingly, the increased use of information management technologies and their significant advantages led to highly efficient groundbreaking technological services and solutions in favor of IT usage-dependent organizations (Arcill et al., 2013; Lema et al., 2015). As the dependence on information technology is increasing, IT has undergone transformation the most critical position at which IT services are acknowledged as strategic organizational assets to be addressed for business achievement (Valiente, Garcia-Barriocanal, Sicilia, 2012). The significant involvement of IT and IT services in business success necessitates methods and techniques that pave the way for design, implementation, and management of IT services for business success. Information Technology Service Management (ITSM) includes implementation and management of high-quality IT services matching the business requirements (International Organization for Standardization (IOS), 2010). ITSM best practices are applied among multitude IT service providers round the world (Office of Government Commerce (OGC), 2011d). According to statistical reports, approximately 90% of US companies are currently taking advantage of an ITSM framework (Melendez et al., 2015) and it is considered as a main strategic tool to survive in the competitive world (Jäntti and Hotti, 2015). ITIL is the most widely exploited IT service management framework (Lahtela and Jäntti, 2010). It is a blend of people, process, and technology (Orta, Ruiz, Hurtado, Gawn, 2104) for achieving various business goals. Achieving a specific level of IT processes standardization in the information technology (IT) department (Kießling, Marrone, Kolbe, 2010) is believed to be one of its objectives.

Nowadays, performance metrics are being used by Chief Information Officers (CIOs) for controlling and directing their IT Service Management (ITSM) organizations. Known as Key Performance Indicators (KPIs), the performance metrics determine the ITSM organization's capability of operating numerous processes and measures in the ITSM environment. For instance, CIOs use these KPIs to show the achievement of the process-related quality and effectiveness targets of their ITSM organizations (their own or outsourced). Since several widely known ITSM frameworks like the Information Technology Infrastructure Library (ITIL) define these KPI-driven management practices and they are reportedly relatively simple and straightforward way to direct ITSM organizations, they have recently achieved practically an institutionalized position to determine how CIOs should direct their ITSM organizations (Riitta Bekkhus, 2016-Digital CIO).

KPIs are capable of providing data on how the goals of the business and IT are achieved. Nevertheless, no KPIs are appropriately associated since developing KPIs is a non-trivial task necessitating a comprehensive understanding of the business or operation to be done correctly (Meyers and Hester 2011). According to some estimations, 70 % of performance measurement systems experienced failure after implementation, Thus, an organization tries to reconsider their selected KPIs (Neely and Bourne 2000, Baggett and Hester 2013).

Organizations have handled a number of KPI's covering different areas. Each indicator defines a specific activity/feature of the company. Thus, the set of successful indicators is required by managers. Nonetheless, because of various metrics and their effect on enterprise performance, the management had difficulty in selecting the right metrics (Kaganski, Majak, Karjust, 2018). Establishing a comprehensive mechanism is vital for efficiency and effectiveness assessment upon implementation of ITIL processes. ITIL describes Key Performance Indicators (KPI) for each process for assessing process success (OGC, 2011c).

This paper is mainly focused on recognizing the most appropriate KPI's to assess ITIL process performance.

The rest of the paper is organized as follows. Section 2 reviews the literature including the overview of ITIL history, its processes and the KPI's associated with each process. then research problems and hypothesizes are described. Section 3 presents a demonstration of SECA method in prioritizing KPIs. Section 4 discusses the research results and finally the conclusion of the paper is explained in Section 5.

2. Literature review

Followed by a paradigm shift, IT service management has come into prominence since it emphasizes customer and service centric orientation. ITSM struggles to implement an IT service management coherently and efficiently through synergistic cohort of people, processes, and IT. This discipline is established on providing some framework for accommodating the IT-related tasks and interactions of all types of stakeholders. ITSM dedicates itself to most operational issues of information technology management rather than technology development (Orta et al., 2014). ITSM is best included under the service sciences ranking its concerns on IT operations (Marrone and Kolbem, 2010). For improving IT processes, the stakeholders can start diverse frameworks and standards among which, undoubtedly, the IT Infrastructure Library is the most widely used one (ITIL) (Lahtela and Jäntti, 2010). ITIL framework has been delivered with its best practices for aligning IT and business strategies as well as enhancing the transparency and quality of IT-related efforts comprising processes and services (Erek, Proehl, Zarnekow, 2014).

The last decades has witnessed the evolution of ITIL. ITIL V2, published in 2001, was a great measure for consolidating the bulk of ITIL strategies and materials. Two of these publications, namely service support and service delivery, have been widely circulated and applied (Dabade, 2012). The ITIL V2 describes top practices for service delivery including processes such as Configuration Management, Problem Management and Change Management (OGC, 2002a) as well as service support including processes such as Service Level Management, Capacity Management and availability Management (OGC, 2002b). Afterwards, ITIL V3 was released in 2007 with a new structure known as service life cycle with diverse processes in each life cycle. The structure of the ITIL version 3 deals with the service lifecycle covering Service Strategy (OGC, 2007a), Service Design (OGC, 2007b), Service Transition (OGC, 2007c), Service Operation (OGC, 2007d), and Continual Improvement (OGC, 2007e). Another edition of ITIL was published in 2011 and main structure of ITIL service lifecycle continued to be valid, but some new processes such as strategy management for IT services and business relationship management in service strategy were added. It is believed that ITIL V3 2011 is more business oriented (OGC, 2011a). In response to the industry 4 requirements, ITIL4 was released in 2019 altering the concept of processes to practices. This version of ITIL covers almost all the processes in ITIL V3 plus a section introducing some new practices including business analysis, architecture management, and strategy management (Axelos, 2019).

ITIL provides different information surrounding its processes, such as main purpose, aims, key activities, critical success factors (CSF), key performance indicators (KPI's), as well as input and outputs. In the last decades, ITIL has had diverse versions and processes or practices were its integral and practical component. In spite of the variations in the number and categorization of processes from ITIL V2.0 to ITIL4, some processes directly influencing service support have continued to be constant.

Companies find process improvement as an effective approach to reduce their cost and improve quality of their products and services (Emamgholizadeh, Jafarzadeh Afshari, Shabani Bahmand, 2018)

ITIL includes diverse processes with their own implementation priorities. For instance, support processes are the chief process improvement targets on the part of many IT companies. These processes are significant for their direct link to customer interface. Processes directly affecting service support consist of incident management, problem management, change management, configuration management, as well as release management (Lahtela and Jäntti, 2010).

In many companies, service support interface is established based on the incident management process. Incident management is achieved by service desk function and is apparently the most tangible part of the IT organization for outsiders. The important function of incident management process is to restore normal service operation as quickly as possible by mitigating the adverse influences on business operations for optimum levels of agreed-upon quality. The typical activities performed through incident management process include recording, classifying, escalating to investigating, resolving, and closing the incident (OGC, 2011b).

Problem management handles the life cycle of problems that are the fundamental causes of incidents. The reason of problem management is handling the lifecycle of problems from first identification up to further investigation, documentation, and eventually removal. It strives to decrease the adverse impact of incidents and problems on the business by highlighting errors within the IT infrastructure. Problem management process covers significant activities like detecting, categorizing and prioritizing, investigating and diagnosing, which recognizes known errors and workaround, as well as resolution and closure (OGC, 2011b).

Changes are multifaceted phenomena caused by numerous reasons that should be tackled for mitigating the negative effect and enhancing the risk of exposure and disruption with simultaneous provision of commensurate communication concerning the change. Change management process aims to increase the number of useful changes by controlling the life cycle of all changes. Changes have numerous categories such as standard, normal, and major impact changes. The process for managing normal impact changes represents such key activities as creating and recording, assessing and evaluating, authorizing changes, coordination, building and testing, coordinating deployment, plus reviewing and closing changes (OGC, 2011c).

The exclusive feature of an efficient or effective organization is capability of handling its assets properly, particularly the ones that are essential to the cause of the organization. Service asset and configuration management process strives for appropriate control of assets and provision of accurate and reliable information covering details of asset configuration and their relationship. The configuration management process includes core activities such as planning, recognizing, controlling, reporting, and status accounting as well as verification (OGC, 2011c).

The release and deployment management aims to plan, schedule, and control the build, test and deployment of releases, and to fulfil new functionality demanded by the business while keeping the effectiveness and integrity of the current services. The release management process helps companies to speed up changes with a reasonable cost and customers and users can use the new or changed services that are well matched with the business objectives at the least risk. Generally, release management process includes important activities such as release planning, build and test, deployment and review (OGC, 2011c).

Daniel introduced the critical success factor (CSF) concept in 1961; however, John Rockart was the pioneer for using this methodology in the field of information systems. Critical success factors (CSFs) are those few key areas requiring distinct and frequent attention for ensuring managerial or organizational achievement. Consequently, the CSF approach has many applications in various project implementations such as ERP, Six Sigma and TQM. However, a few researches studied the CSFs of ITSM implementation compared with the many studies on these projects (Zhang Y, Zhang J, Chen, 2013).

The Office of Government Commerce (OGC) was the pioneer to recognize the CSFs for each individual process (CSF 2). Each ITIL process has some Critical success factors (CSF) to make sure that process is capable of achieving its objectives. Furthermore, ITIL describes Key Performance Indicators (KPI) for each process (OGC, 2011c). It is possible to use KPI's for assessing the performance of processes (Valverde and Talla,, 2014). The following tables display the CSF's and KPI's linked to the afore-mentioned ITIL processes.

Table 1. CSFs related to ITIL processes

	IT Service Support processes				
	Incident Management	**Problem Management**	**Change Management**	**Configuration Management**	**Release Management**
Critical Success Factors	CSF IM-01 Resolve incidents as quickly as possible minimizing impacts to the business	CSF PM-01 Minimize the impact to the business of incidents that cannot be prevented	CSF CHM-01 Responding to business and IT requests for change that will align the services with the business needs while maximizing value	CSF CM-01 Accounting for, managing and protecting the integrity of CIs throughout the service lifecycle	CSF RM-01 Defining and agreeing release plans with customers and stakeholders
	CSF IM-02 Maintain quality of IT services	CSF PM-02 Maintain quality of IT services through elimination of recurring incidents	CSF CHM-02 Optimizing overall business risk	CSF CM-02 Supporting efficient and effective service management processes by providing accurate configuration information at the right time	CSF RM-02 Ensuring integrity of a release package and its constituent components throughout the transition activities
	CSF IM-03 Maintain user satisfaction with IT services	CSF PM-03 Provide overall quality and professionalism of problem handling activities to maintain business confidence in IT capabilities	CSF CHM-03 Ensuring that all changes to configuration items are well managed and recorded in the configuration management system	CSF CM-03 Establishing and maintaining an accurate and complete configuration management system (CMS)	CSF RM-03 Ensuring that the new or changed service is capable of delivering the agreed utility and warranty
	CSF IM-04 Increase visibility and communication of incidents to business and IT support staff				CSF RM-04 Ensuring that there is appropriate knowledge transfer
	CSF IM-05 Align incident management activities and priorities with those of the business				
	CSF IM-06 Ensure that standardized methods and procedures are used for efficient and prompt management of incidents to maintain business confidence in IT capabilities				

Table 2. KPI’s related to ITIL processes

					IT Service Support processes
	Incident Management	**Problem Management**	**Change Management**	**Configuration Management**	**Release Management**
Key Performance Indicators	KPI IM-01 Percentage of incidents closed by the service desk	KPI PM-01 The number of known errors added to the KEDB	KPI CHM-01 Increase in the percentage of changes that meet the customer’s agreed requirements	KPI CM-01 Reduction in business impact of outages caused by poor configuration management	KPI RM-01 Increased number and percentage of releases that meet customer expectations
	KPI IM-02 Mean Time to Resolution	KPI PM-02 Percentage of incidents closed by the service desk	KPI CHM-02 Reduction in the backlog of change requests	KPI CM-02 Improvement in time to identify poor performing and poor-quality Cis	KPI RM-02 Reduced number of deployments from sources other than the DML
	KPI IM-03 Percentages of reduction in total number of incidents	KPI PM-03 Average incident resolution time for those incidents linked to problem records	KPI CHM-03 Increase in accuracy of predictions for time, quality, cost, risk, resource and commercial impact	KPI CM-03 Reduction in the average time and cost of diagnosing and resolving incidents and problems	KPI RM-03 Decreased customer dissatisfaction of service issues resulting from poorly tested or untested services
	KPI IM-04 Percentages of reduction in number of Major incidents	KPI PM-04 Total numbers of problems	KPI CHM-04 Increase in change success rate	KPI CM-04 Increase in reuse and redistribution of under-utilized Cis	KPI RM-04 Increased customer and user satisfaction with the services delivered
	KPI IM-05 Percentages of user satisfaction from quality of services	KPI PM-05 Size of current problem backlog for each IT service	KPI CHM-05 Reduction in the percentage of changes lead to service disruption	KPI CM-05 Reduced number of exceptions reported during configuration audits	KPI RM-05 Reduced number of incidents due to incorrect components being deployed
	KPI IM-06 Number of user complaints from quality of services	KPI PM-06 Number of repeat incidents for each IT service	KPI CHM-06 Reduction in the percentage of emergency changes	KPI CM-06 Reduced percentage of changes not completed successfully because of poor impact assessment, incorrect data in the CMS, or poor version control	KPI RM-06 Reduced number of incidents of new releases due to incorrect testing
	KPI IM-07 Percentage of incidents handled within agreed SLA target	KPI PM-07 Number and percentage of problems incorrectly assigned	KPI CHM-06 Reduction in the number of unauthorized changes identified		KPI RM-07 Increased percentage of incidents solved by level 1 and level 2 support
	KPI IM-08 Percentage of incidents related to changes and releases.	KPI PM-08 Percentage of problems closed successfully	KPI CHM-07 number of incidents attributed to changes		KPI RM-08 Reduced resources and costs to diagnose and fix incidents and problems in deployment and live use
	KPI IM-09 percentage of incidents incorrectly assigned	KPI PM-09 Size of current problem backlog for each IT service	KPI CHM-08 Reduction in the number and percentage of changes with incomplete change specifications		
	KPI IM-10 Average cost per incident	KPI PM-10 Average cost per problem			

KPI can be selected through diverse methods. Various criteria have been used in KPI selection from long time ago and experts have developed a value function for each criterion. Value functions capture experts’ evaluation of the value of a criterion. For developing a value function, criteria value based KPI ranking and selection has been applied for selecting KPI (Kibira and Feng, 2017).

The NIST/VMASC KPI Assessment Method offers a mechanism for scoring key performance indicators (KPI) under a range of different criteria. Through this methodology, stakeholders

will be able to compare the KPIs to an ideal score for each criterion through a workshop in which the main stakeholders rank the KPI–criteria and score the KPIs (Collins, Hester, Ezell, Horst, 2016).
A new methodology was designed by Jesús Peral et al. to extract the pertinent KPIs from the business strategy model of a particular enterprise/activity. They demarcated a novel process based on Data Mining techniques for identifying the relevant KPIs (Peral, Mate, Marco, 2016).
It is possible to use Multi Criteria Decision Making (MCDM) for KPI selection.
The following table presents these methods:

Table 3. MCDM Selection Method

MCDM KPI Selection Method	Author/ Authors	Main Characteristics
SAW	MacCrimmon , 1968	Old, simple, easy to use and easy to understand method
WASPAS	Zavadskas, et al., 2012	A combination of the SAW or weighted sum model (WSM) and weighted product model (WPM).
COPRAS	Zavadskas et al., 1994	a ratio based on two measures (the summation of beneficial criteria performance and the summation of non-beneficial criteria performance) is used to evaluate alternatives
TOPSIS	Hwang and Yoon, 1981	alternatives are ranked according to their distances from two reference points called ideal (positive-ideal) and nadir (negative-ideal) solutions
VIKOR	Opricovic, 1998	similar to the TOPSIS method, able to solve decision problems with non-commensurable and conflicting criteria
EDAS	Keshavarz Ghorabaee et al., 2015	Measures the desirability of alternatives based on the distance from an average solution
SECA	Keshavarz Ghorabaee et al., 2018	The newest method in MCDM methods. Covering benefits of other MCDM Methods. concurrent assessment of criteria and alternatives in a multi-criteria decision-making problem
MOPSP-TOPSIS	Adeli,, Zandieh1, Motameni, 2019	A combination of TOPSIS and MOPSP which has all TOPSIS positive points.

Although different KPI selection method proposed for various domains, there is no specific method for ITIL processes KPI prioritization. The main purpose of this research is to evaluate and rank the KPI's for key ITIL processes based on Simultaneous Evaluation of Criteria and Alternatives (SECA) model. Unlike many other MCDM methods, SECA model can be used for concurrent assessment of criteria and alternatives in a multi-criteria decision-making problem (Keshavarz Ghorabaee, et al., 2018).
This model helps organizations to select the most effective KPI's among all KPI's. The focus of this research is on the ITSM processes with a profound impact on IT operation including: configuration management, change management, release management, incident management, and problem management.
To this end, there are 5 main questions as follows:
1. What are the most effective KPI's in Incident management process?
2. What are the most effective KPI's in Change management process?
3. What are the most effective KPI's in Problem management process?
4. What are the most effective KPI's in Configuration management process?
5. What are the most effective KPI's in Release management process?

3. Methodology

The main difference between the SECA method and other decision-making techniques is that in this method, the weight of the criteria and the value of the options are calculated simultaneously based on the decision matrix, while in the other methods, the weight of the criteria must first be calculated by other approaches and then introduced to a technique as input. Figure 1 shows the key steps in the methodology of this research.

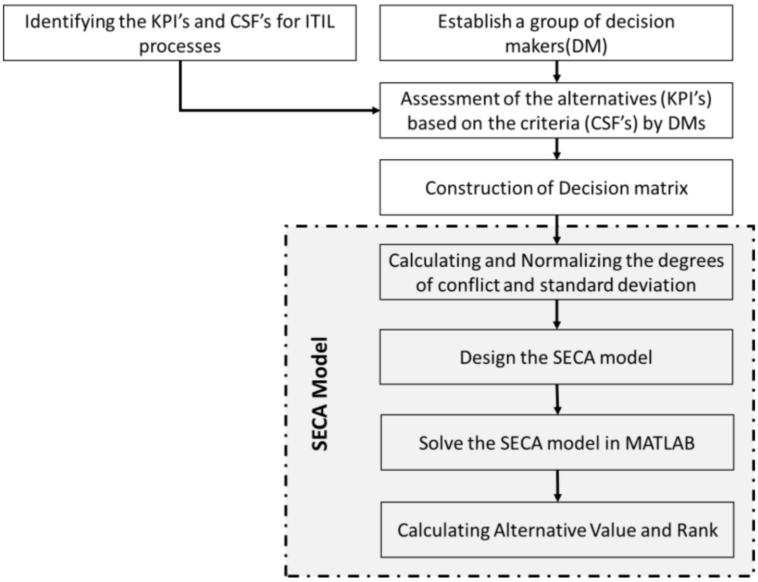

Figure 1. Key steps in the methodology of this research

In this study, based on the literature review, the KPIs and CSFs associated with each of the five IT service management processes have been identified in Tables 1 and 2. In addition, CSFs are the Criteria in the SECA method and KPIs considered as alternatives.

The first step in conducting research to implement the SECA method is to establish decision matrices, based on which the effect of each KPI on the related CSFs is determined. For this purpose, the opinions of Decision makers have been used.

In this regard, a questionnaire was developed and published among a statistical population including 35 senior executives and ITIL process managers from organizations and companies in the telecommunications industry (25%), information technology industry (50%), and banking industry (25%) who had two main criteria: Firstly, they had passed the ITIL Foundation course. Secondly, ITSM had been implemented in their company. The combination of judgmental sampling and snowball sampling was used as non-probability sampling methods. In the designed questionnaire, experts were asked to explain the extent to which each of the KPIs was effective in achievement of CSFs, and they selected their answers from 1 to 5. Finally, the average opinion of experts in the form of a value of 1 to 5 (1 for minimum effect and 5 for maximum effect of KPI on a CSF) is included in the decision matrices related to each management process. These decision matrices have been indicated in the tables 3 to 7 of the results section.

In this method, the weight of the criteria (CSFs) and the value of the options (KPIs) have been calculated simultaneously and the results of these two are used to rank KPIs. The following a multi-objective non-linear programming mathematical model is used to simultaneously calculate the weight of the criteria (CSFs) and the value of the options (KPIs):

$$\max Z = \lambda_a - \beta(\lambda_b + \lambda_c) \tag{1-1}$$

$$s.t.\ \lambda_a \leq S_i, \quad \forall i \in \{1,2,\dots,n\} \tag{1-2}$$

$$S_i = \sum_{j=1}^{m} w_j x_{ij}^N, \quad \forall i \in \{1,2,\dots,n\} \tag{1-3}$$

$$\lambda_b = \sum_{j=1}^{m} \left(w_j - \sigma_j^N\right)^2 \tag{1-4}$$

$$\lambda_c = \sum_{j=1}^{m} \left(w_j - \pi_j^N\right)^2 \tag{1-5}$$

$$\sum_{j=1}^{m} w_j = 1 \tag{1-6}$$

$$\varepsilon \leq w_j \leq 1, \quad \forall j \in \{1,2,\dots,m\} \tag{1-7}$$

According to the above model (model 1), m is the number of criteria, n is the number of options. Also, if $X = [x_{ij}]_{n\times m}$ is the decision matrix, then $X^N = [x_{ij}^N]_{n\times m}$ is the normal decision matrix whose elements are obtained from the following relations:

$$x_{ij}^N = \begin{cases} \frac{x_{ij}}{\max_k x_{kj}} & if\ j \in BC \\ \frac{\min_k x_{kj}}{x_{ij}} & if\ j \in NC \end{cases} \tag{2}$$

Where, BC are a set of criteria that have a profit (or positive) aspect and NC is a set of criteria that have a cost (or negative) aspect.

Also, if $V_j = [x_{ij}^N]_{n\times 1}$ is the vector of the j-th criterion ($j = 1,2,\ldots,m$), then σ_j is defined as the standard deviation of the j-th criterion vector. We also define:

$$\pi_j = \sum_{l=1}^{m}(1 - r_{jl}) \tag{3}$$

Where, r_{jl} is the correlation between the j-th criterion vector and the l-th criterion vector. Then the following summation (π_j) can reflects the degree of conflict between j-th criterion and the other criteria.

Also, the normalized values of σ_j and π_j are obtained from the following relations:

$$\sigma_j^N = \frac{\sigma_j}{\sum_{l=1}^{m}\sigma_l} \tag{4}$$

$$\pi_j^N = \frac{\pi_j}{\sum_{l=1}^{m}\pi_l} \tag{5}$$

S_i is the overall performance of each alternative, and the λ_b and λ_c are deviations of criteria weights from the reference points for each criterion. Eq. (1-6) guarantees that the sum of weights is equal to 1. Eq. (1-7) sets the weights of criteria to some values in the interval [ε,1]. It should be noted that ε is a small positive parameter considered as a lower bound for criteria weights.

According to the objective function of Model 1, the minimum of the overall performance score of options (λ_a) is maximized. Since the deviations from reference points should be minimized, they are subtracted from the objective function with a coefficient β (β>0). This coefficient affects the importance of reaching the reference points of criteria weights. The overall performance score of each option (S_i) and the objective weight of each criterion (w_j) are determined by solving Model 1.

As described in Model 1, β is a positive value (i.e. β≥0) and is determined in a way that by changing it, the weights obtained from solving the model are almost constant. For this purpose, the value of β increases from zero with steps of 0.1, and for each value of β, model 1 is solved separately. The constant weight in mathematical language is translated in such a way that the weight of the solution of the model for two consecutive βs is less than 0.01. In other words, the difference between all the corresponding weights is less than 0.01. The following algorithm explains this process.

$k = 1$ (6-1)
$\beta = 0$ (6-2)
$While\ e > 0.01$ (6-3)
    $Solve\ Model\ 1\ and\ calculate\ W^k\ vector$
    $e = |W^k - W^{k-1}|$ (6-4)
    $\beta = \beta + 0.1$ (6-5)
    $k = k + 1$ (6-6)

end while

It should be noted that the reason which justifies the approximate constant weights in the main article by reviewing the diagrams is the convergence of weights with β variation. Therefore, it can be said that the algorithm presented in this section is justifiable and valid due to this convergence property.
Therefore, for the criteria or CSFs of each information technology service management process, the corresponding weight matrix is formed for different values of β and the value matrix of KPIs is created at the same time. Finding the values of these two matrices will continue until the difference between the two consecutive weights in all criteria of a process is less than 0.01. The CSFs weight difference diagram for different β values has been also presented in separate graphs for each of the processes. Then, according to the results of these two analyses, the rank of KPIs in achievement of each CSF is determined.

4. Discussion

4.1. Incident management

As explained in the methodology section, in order to determine the priority of the indicators using the SECA method, a decision-making matrix established according to the experts' comments to determine the effect of each KPI on the relevant CSFs. Incident management process has ten KPIs and six CFSs. Given the high number of KPIs and the importance of this process, prioritizing KPIs is of great importance in this process.
In this regard, the decision-making matrix of the incident management process completed as follows by placing the average expert opinion in each cell of the table.

Table 4. Incident management decision matrix

Incident Management KPIs		**CSF-IM 1**	**CSF-IM 2**	**CSF-IM 3**	**CSF-IM 4**	**CSF-IM 5**	**CSF-IM 6**
KPI IM-01	Percentage of incidents closed by the service desk	3	2.6	2.2	1.5	2	4
KPI IM-02	Mean Time to Resolution	3	2	2.4	3	3	3.8
KPI IM-03	Percentages of reduction in total number of incidents	2	3	1.8	2	2	3
KPI IM-04	Percentages of reduction in number of Major incidents	2	3	3.5	1.1	4.6	1.5
KPI IM-05	Percentages of user satisfaction from quality of services	3	2	3	4.8	4	1.5
KPI IM-06	Number of user complaints from quality of services	4	2	4.6	4	2	1.5
KPI IM-07	Percentage of incidents handled within agreed SLA target	4.8	4.6	4	4	4.8	4.6
KPI IM-08	Percentage of incidents related to changes and releases.	1.5	3.3	1.1	2	1.5	2
KPI IM-09	percentage of incidents incorrectly assigned	4.6	4.6	4	4	4	3.8
KPI IM-10	Average cost per incident	2	1.5	2	1.8	1.3	1.1

In the next step, the weight matrix of CSFs of the incident management process and simultaneously the value matrix of KPIs of this process have been established and as shown in the CSF weight matrix (table5), the weight of CSFs for different β values is calculated until the value of 1.7 to achieve a difference of less than 0.01 between two consecutive weights for all CSFs. The weight matrix of CSFs and the value matrix of KPIs of the incident management process are as follows.

Table 5. Incident management CSF weights

Betta	W CSF-IM 1	W CSF-IM 2	W CSF-IM 3	W CSF-IM 4	W CSF-IM 5	W CSF-IM 6
0	0.0011	0.3317	0.6642	0.0010	0.0010	0.0010
0.1	0.2604	0.1958	0.3046	0.2371	0.0010	0.0010
0.2	0.2273	0.1426	0.2735	0.2168	0.0785	0.0614
0.3	0.1969	0.1499	0.2356	0.2038	0.1089	0.1049
0.4	0.1817	0.1536	0.2166	0.1973	0.1241	0.1267
0.5	0.1726	0.1558	0.2052	0.1934	0.1332	0.1398
0.6	0.1666	0.1573	0.1976	0.1908	0.1393	0.1485
0.7	0.1622	0.1583	0.1922	0.1889	0.1436	0.1547
0.8	0.1590	0.1591	0.1882	0.1875	0.1469	0.1594
0.9	0.1564	0.1597	0.1850	0.1864	0.1494	0.1630
1	0.1544	0.1602	0.1825	0.1856	0.1514	0.1660
1.1	0.1527	0.1606	0.1804	0.1848	0.1531	0.1683
1.2	0.1514	0.1609	0.1787	0.1843	0.1544	0.1703
1.3	0.1502	0.1612	0.1772	0.1837	0.1556	0.1720
1.4	0.1492	0.1615	0.1760	0.1833	0.1566	0.1734
1.5	0.1483	0.1617	0.1749	0.1829	0.1575	0.1747
1.6	0.1476	0.1619	0.1739	0.1826	0.1582	0.1758
1.7	0.1469	0.1620	0.1731	0.1823	0.1589	0.1767

Table 6. Incident management KPI values

	Betta / KPIs	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Final KPI Values	**KPI IM-01**	0.5074	0.4945	0.5073	0.5208	0.5275	0.5316	0.5343	0.5362	0.5377	0.5388	0.5397	0.5404	0.5411	0.5416	0.5420	0.5424	0.5427	0.5430
	KPI IM-02	0.4935	0.5565	0.5820	0.5933	0.5989	0.6023	0.6045	0.6062	0.6074	0.6083	0.6091	0.6097	0.6102	0.6106	0.6110	0.6113	0.6116	0.6118
	KPI IM-03	0.4782	0.4553	0.4578	0.4707	0.4772	0.4811	0.4837	0.4855	0.4869	0.4880	0.4889	0.4896	0.4901	0.4906	0.4911	0.4914	0.4918	0.4921
	KPI IM-04	0.7237	0.5236	0.5407	0.5443	0.5461	0.5472	0.5479	0.5485	0.5489	0.5492	0.5494	0.5496	0.5498	0.5499	0.5500	0.5501	0.5502	0.5503
	KPI IM-05	0.5802	0.6849	0.6846	0.6706	0.6636	0.6594	0.6566	0.6546	0.6531	0.6519	0.6510	0.6502	0.6496	0.6491	0.6486	0.6482	0.6479	0.6475
	KPI IM-06	0.8109	0.8051	0.7582	0.7143	0.6922	0.6790	0.6702	0.6639	0.6592	0.6556	0.6526	0.6502	0.6482	0.6465	0.6451	0.6438	0.6427	0.6417
	KPI IM-07	0.9132	0.9208	0.9282	0.9353	0.9389	0.9410	0.9424	0.9434	0.9442	0.9448	0.9453	0.9457	0.9460	0.9463	0.9465	0.9467	0.9469	0.9470
	KPI IM-08	0.3983	0.3942	0.3803	0.3900	0.3948	0.3978	0.3997	0.4011	0.4021	0.4030	0.4036	0.4041	0.4046	0.4050	0.4053	0.4056	0.4058	0.4060
	KPI IM-09	0.9128	0.9096	0.8950	0.8907	0.8886	0.8873	0.8864	0.8858	0.8854	0.8850	0.8847	0.8845	0.8843	0.8842	0.8840	0.8839	0.8838	0.8837
	KPI IM-10	0.3983	0.3942	0.3773	0.3644	0.3579	0.3540	0.3514	0.3495	0.3481	0.3471	0.3462	0.3455	0.3449	0.3444	0.3440	0.3436	0.3433	0.3430

Figure 2 shows the reducing trend of CSF interval weights for different β values for the incident management process. As it turns out, as the β value increases, the convergence increases to reach the acceptable level. Figure 2 illustrates the sensitivity analysis for the main factor of this research which is β.

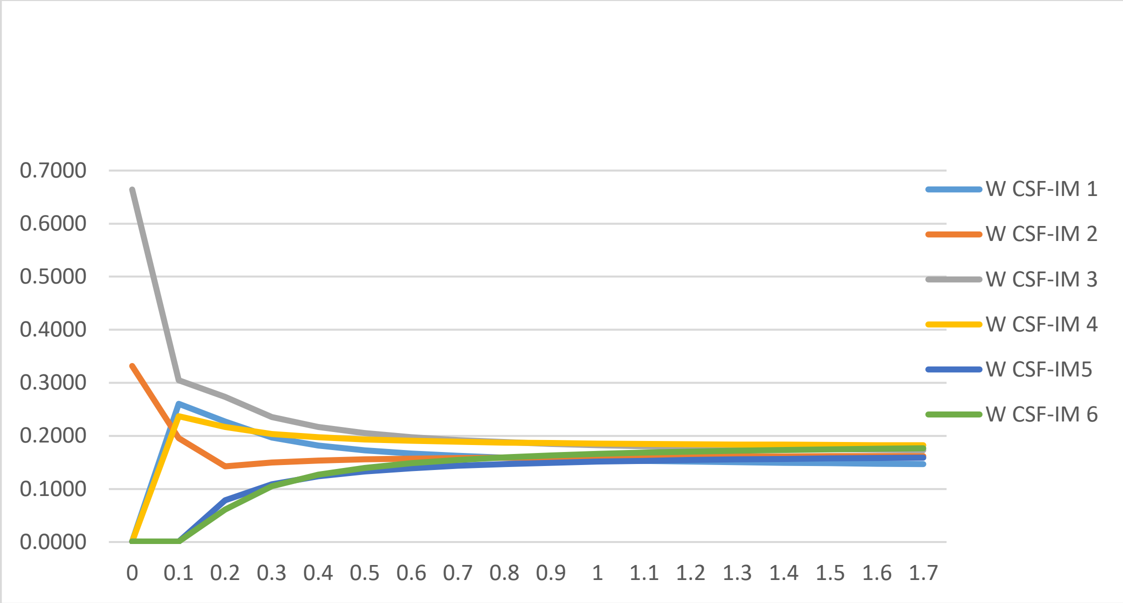

Figure 2. The variation of the criteria weights related to Beta for Incident Management

Finally, the KPI ranking matrix based on different β values is resulted from the two above matrices. As shown in the table below, KPI IM-07, KPI IM-09 and KPI IM-05 are indicators ranked first to third respectively.

Table 7. Final incident management KPIs ranks

	Betta KPIs	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Ranks	KPI IM-01	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	KPI IM-02	7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	KPI IM-03	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	KPI IM-04	4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	KPI IM-05	5	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3
	KPI IM-06	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
	KPI IM-07	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	KPI IM-08	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	KPI IM-09	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	KPI IM-10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Incident management is one of the most significant processes in ITIL. It is vital for all companies to restore their services in time of disruption as quickly as possible. Regarding the time and cost of implementing 10 KPIs of incident management process, companies are more willing to select and invest on the most effective ones instead. Based on the results of our research, the most important KPI in incident management is "Percentage of incidents handled within agreed SLA target". The value of this KPI outweighs the others to the extent that industry experts believe in the key role of implementing this KPI in improvement of their incident management process effectiveness.

To our surprise, the research results indicated that the least important KPI is" Average cost per incident" which means that in case of service disruption, cost is not a decisive factor whereas time matters a lot for all stakeholders.

4.2. Change management

The change management process, as described in the literature review section, has nine KPIs and three CFSs. According to what was stated for the incident management process, an expert decision matrix was also created for change management process based on the opinion of experts and the SECA method. Table 9 in the appendix shows the detailed analysis done for this process.
After that, the weight matrix of CSFs and the value matrix of KPIs for change management process were conducted simultaneously. The weight of CSFs for different β values is calculated until the value of 1.7 to achieve a difference of less than 0.01 between two consecutive weights for all CSFs. Tables 10 and 11 of appendix, indicate the weight matrix of CSFs and the value matrix of KPIs of the change management process.
Finally, the KPI ranking matrix for different β values is resulted from the weight CSF matrices and the KPI value matrix of the change management process. Table 12 of Appendix presents the KPI ranking matrix in which the KPI CHM-01, KPI CHM-05 and KPI CHM-03 are indicators that have the first to third priorities, respectively.
Similar to the incident management process, the KPI has been selected which is directly related to business requirements. The most important KPI in change management based on the results is "Increase in the percentage of changes that meet the customer's agreed requirement" which directly related to business value of delivered changes. The second KPI is related to the technical aspect of change management process which is "Reduction in the percentage of changes lead to service disruption.

4.3. Problem management

The problem management process also has a significant number of KPIs. This process has 10 KPIs. The decision-making matrix of the problem management process has been prepared by obtaining the opinions of experts, which can be seen in Table 13 in the appendix. Then the weight matrix of CSFs of the problem management process and simultaneously the value matrix of KPIs of this process have been formed and the weight of CSFs for different β values up to 0.8 has been calculated to achieve a difference of less than 0.01 between two consecutive weights for all CSFs. The CSF weight matrix and the KPI value matrix of the problem management process have been provided in Tables 14 and 15 in the appendix.
Finally, the KPI ranking matrix for different β values is resulted from the above two matrices. As shown in Table 16 of Appendix, the KPI PM-08, KPI PM-03 and KPI PM -09 are indicators ranked first to third, respectively. These KPIs are as follows:

- Percentage of problems closed successfully
- Average incident resolution time for those incidents linked to problem records
- Size of current problem backlog for each IT service

The selected KPI show that industry experts believe that closing problem successfully is more important than closing them more quickly. In other word, in problem management effectiveness is more important than efficiency.

4.4. Release management

The release management process in ITIL has eight KPIs and four CSFs. Like what has been done for other processes, for establishing the decision matrix, experts first answered the question of how effective each KPI is in measuring the presence of CSFs in the organization. The average experts' answer to questions about the release and deployment management process has been given in Table 17 of Appendix.

After that, the weight matrix of CSFs of the deployment management process and at the same time, the value matrix of KPIs of this process have been formed and the weight of CSFs for different β values is calculated up to the value of 2.4 to achieve a difference of less than 0.01 between two consecutive weights for all CSFs. The weight matrix of CSFs and the value matrix of KPIs of the release management process are presented in Tables 18 and 19 in the Appendix of this article.

Finally, the KPI ranking matrix for different β values as an output of two above matrices is conducted. As shown in Table 20 of Appendix, the KPI RM -06, KPI RM -03 and KPI RM -01 are the top indicators respectively.

The result related to release management process is interesting. The most valuable KPI for evaluating this process is "Reduced number of incidents of new releases due to incorrect testing". It shows that based on the expert opinion it is vital to carefully evaluate the quality of new release and oversee the incidents that occurred after each release.

4.5. Configuration management

The configuration management process has fewer KPIs than other processes. This process has six KPI and three CSF. Table 21 in the Appendix shows the results of the experts' opinion about the importance of KPIs in reaching the process CSFs in the form of decision matrix. Then the weight matrix of CSFs and the value matrix of KPIs are calculated based on SECA method. According to the research method, the weight of CSFs for different values of β up to 1.7 is calculated to achieve a difference of less than 0.01 between two consecutive weights for all CSFs. The weight matrix of CSFs and the value matrix of KPIs of the configuration management process have been provided in Tables 22 and 23 in the Appendix of this article.

Finally, the KPI ranking matrix for different β values of the above two matrices is concluded. As shown in Table 24 of Appendix, the KPI CM-03, KPI CM-01 and KPI CM-06 ranked first to third with respectively.

The remarkable point about the configuration management KPIs is that, except for the three mentioned KPIs, others had very low value from the experts' point of view.

The top KPI is "Reduction in the average time and cost of diagnosing and resolving incidents and problems". It demonstrates that based on the expert judgment the most important responsibility of configuration management is providing accurate information for incident and problem management process in order to optimize the cost and time of disruptions.

4.6. Managerial implications

As discussed before, the quality of IT services is vital for all organization. Therefore, it is highly important to carefully monitor and evaluate quality of IT services and processes. All ITIL processes have many KPIs and implementing them is a complicated task for organization considering the required time and cost.

In this research all KPIs related to ITIL support processes evaluated attentively in order to find the most effective ones for organization. The results of this research help organizations in two ways. Firstly, the results of this research help managers and their organizations to save their time and cost to find and invest on the most effective KPIs in order to make a noticeable improvement in their IT processes and ultimately to their IT services. Secondly, each KPI shows the necessity of a concept which is behind the KPI. For example, the research illustrates that "Increase in the percentage of changes that meet the customer's agreed requirement" is the most effective KPI in change management process. The mindset behind this ranking is that based on the expert judgment, the most important responsibility in this process is delivering business value to the customers rather than deliver it on time or without any issue.

The result of this research can help organizations to efficiently monitor their IT services by selecting the most important KPIs. In the other words, implementing two or three KPIs and monitor them carefully is better than implementing 10 KPIs in an incomplete manner.

5. Conclusion and future research

Nowadays Information technology is a key tool that helps organizations to have a sustainable business and empowers them to grow in today's competitive market. Although IT has been able to help organizations a lot, it has become one of the most important points of their vulnerability, because the low quality of IT services affects the quality of products and business services directly. That's why organizations are increasingly looking to closely monitor the quality of IT services. So, best practices like ITIL have introduced a significant number of KPIs to assess the quality of IT services. However, the implementation of KPIs has become an important issue because implementing all of them imposes a lot of cost and time on organizations. That's why organizations have to prioritize KPIs but in the best practices like ITIL or other international models, priority has not been given to KPIs. Over the years, different methods have been identified for prioritizing KPIs in different areas, however, in the field of information technology there is no clear solution for prioritization of the process KPIs.

In this paper a new model designed for evaluating and prioritizing the KPIs for ITIL processes. Regarding this fact that ITIL encompasses more than 30 processes, scope of this research is limited to main support processes including five key processes.

In this research, Critical success factors have been used as the main criteria for KPI selection and ranking. For designing the prioritization model, SECA method is used to select the best of the KPIs for the five main ITIL processes, so that organizations can emphasize the most effective KPIs instead of implementing all of them. Table 8 shows the final list of KPIs that have the top priorities in ITSM implementation for 5 mentioned processes.

Table 8. The best ITSM KPIs based on SECA model

Process Name	**The best ITSM KPIs based on SECA model**	
Incident Management	KPI IM-07	Percentage of incidents handled within agreed SLA target
	KPI IM-09	percentage of incidents incorrectly assigned
	KPI IM-05	Percentages of user satisfaction from quality of services
Change Management	KPI CHM-01	Increase in the percentage of changes that meet the customer’s agreed requirement
	KPI CHM-05	Reduction in the percentage of changes lead to service disruption
	KPI CHM-03	Increase in accuracy of predictions for time, quality, cost, risk, resource and commercial impact
Problem Management	KPI PM-08	Percentage of problems closed successfully
	KPI PM-03	Average incident resolution time for those incidents linked to problem records
	KPI PM-09	Size of current problem backlog for each IT service
Release Management	KPI RM-06	Reduced number of incidents of new releases due to incorrect testing
	KPI RM-03	Decreased customer dissatisfaction of service issues resulting from poorly tested or untested services
	KPI RM-01	Increased number and percentage of releases that meet customer expectations
Configuration Management	KPI CM-03	Reduction in the average time and cost of diagnosing and resolving incidents and problems
	KPI CM-01	Reduction in business impact of outages caused by poor configuration management
	KPI CM-06	Reduced percentage of changes not completed successfully because of poor impact assessment

To sum up, this paper argued that it is not a good idea for organization to implement all ITIL KPIs which needs huge investment. The presented findings confirm that each KPI has the unique level of effectiveness and efficiency in comparison with others. So, it is highly

recommended to apply these KPIs based on their rank and order which is obtained by scientific method in this research.
Future research should develop the scope of this research to other process areas such as strategy, design and continual improvement processes. In addition, future research should consider the potential effects of applying these KPIs on process quality in a case study approach. Furthermore, the proposed prioritization method can be used to rank KPIs in any process model in addition to ITIL which defines critical success factors for their processes."

References

Adeli, M., Zandieh, M., and Motameni, A., (2019). "Integrated sourcing and inventory decisions considering sources' disruptions with a hybrid simulation-MOPSO-TOPSIS approach: A Pharmaceutical case study", *Journal of Industrial Engineering and Management Studies*, Vol. 6, No. 2, pp. 103-119.

Alavi, M., and Leidner, D.E., (2001). "Knowledge management and knowledge management systems: conceptual foundations and research issues", *Management Information Systems Quarterly*, Vol. 25, No. 1, pp. 107-136, http://dx.doi.org/10.2307/3250961.

Ali, I., Musawir, A.U., and Ali, M., (2018). "Impact of knowledge sharing and absorptive capacity on project performance: the moderating role of social processes", *Journal of Knowledge Management*, Vol. 22, No. 2, pp. 453-477.

Alp, U., and Cevikcan, E., (2017). Industry 4.0: managing the digital transformation, Springer.

Arcilla, M., Calvo-Manzano, JA, and San Feliu, T., (2013). "Building an IT service catalog in a small company as the main input for the IT financial management", *Computer Standards & Interfaces*, Vol. 36, No. 1, pp. 42-53.

Argote, L., and Miron-Spektor, E., (2011). "Organizational learning: From experience to knowledge", *Organization science*, Vol. 22, No. 5, pp. 1123-1137.

Axelos, (2014). The Importance of ITIL: A Global view.

Axelos, (2019). ITIL Foundation, ITIL 4 edition, The Stationary Office, UK.

Azar, A., and Mostafayi, K., (2012). "fuzzy Cognitive Map a new approach in soft modeling: Budgeting Modeling in Iran Statistics Center", *Management Research in Iran*, No. 3, pp. 83-103.

Barnes, S., and Milton, N., (2014). Designing a Successful KM Strategy, Information Today, Incorporated.

Chang, D.Y., (1996). "Applications of the extent analysis method on fuzzy AHP", *European Journal of Operational Research*, Vol. 95, pp. 649-655.

Chatti, M.A., (2012). "Knowledge management: a personal knowledge network perspective", *Journal of Knowledge Management*, Vol. 16, No. 5, pp. 829-844.

Collins, A.J. Hester, P. Ezell, B., and Horst, J., (2016). "An improvement selection methodology for key performance indicators", *Springer Science + Business Media New York*, Vol. 36, pp.196–208.

Dabade, T.D., (2012). "Information technology infrastructure library (ITIL) ", In: *proceedings of the 4th national conference*, pp. 25-26.

De Long, D., (1997). Building the knowledge-based organization: How culture drives knowledge behaviors, Ernst & Young Center for Business Innovation, Working Paper, Boston.

Emamgholizadeh, M., Jafarzadeh Afshari, A., and Shabani Bahmand, M., (2018). "Developing customer relationship management (CRM) processes using standard frameworks and MCDM technique", *Journal of Industrial Engineering and Management Studies*, Vol. 5, No. 1, pp. 66-84.

Erek, K., Proehl, T., and Zarnekow, R., (2014). "Managing cloud services with IT service management practices", In: *Engineering and Management of IT-based Service Systems* (pp. 67-81), Springer, Berlin, Heidelberg.

Firestone, J.M., (2001). "Knowledge management process methodology: an overview", *Knowledge and Innovation: Journal of the KMCI*, Vol. 1, No. 2, pp. 54-90.

Gonzalez, R.V.D., and Martins, M.F., (2017). "Knowledge Management Process: a theoretical-conceptual research", *Gestão & Produção*, Vol. 24, No. 2, pp. 248–265, https://doi.org/10.1590/0104-530X0893-15.

Haimila, S., (2018). "100 COMPANIES That Matter in Knowledge Management", *KM world*, Vol. 27, No. 2.

Huber, G., (1991). "Organizational learning the contributing processes and the literatures", *Organization Science*, Vol. 2, No. 1, pp. 88-115, http://dx.doi.org/10.1287/orsc.2.1.88.

Hwang, C.L., and Yoon, K.P., (1981). Multiple attribute decision making methods and applications: A state-of-the art survey, Springer, London.

International Organization for Standardization, (2010). ISO/IEC 20000:1, Part 1, Service management system requirements, ISO/IEC JTC 1 Secretariat.

Jäntti, M., and Hotti, V., (2015). "Defining the relationships between IT service management and IT service governance", *Information Technology and Management*, Vol. 17.

Kaganski, S., Majak, J., and Karjust, K., (2018). "Fuzzy AHP as a tool for prioritization of key performance indicators", In: *Procedia CIRP 72*, pp.1227–1232.

Keshavarz Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z., and Antuvicheciene, J., (2018). "Simultaneous evaluation of criteria and alternatives (SECA) for multi-criteria decision-making", *Informatica*, Vol. 29, No. 2, pp. 265–280.

Keshavarz Ghorabaee, M., Zavadskas, E.K., Olfat, L., and Turskis, Z., (2015). "Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS) ", *Informatica*, Vol. 26, No. 3, pp. 435–451

Khuram, S.h., Bajwa, S.U., Siddiqi, A., Ahmadi, F., and Sultani, R., (2016). "Integrating knowledge management (KM) strategies and processes to enhance organizational creativity and performance", *Journal of Modelling in Management*, Vol. 11, pp. 154-179. 10.1108/JM2-07-2014-0061.

Kibira, D., and Feng, C.S., (2017). "Environmental KPI selection using criteria value and demonstration", *National Institute of Standards & Technology*.

Kießling, M., Marrone, M., and Kolbe, L.M., (2010). "Influence of IT service management on innovation management: First insights from exploratory studies", In: *Management of the Interconnected World* (pp. 129-136), Physica-Verlag HD.

Kok, K., (2009). "The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil", *Glob. Environ. Change*, Vol. 19, pp. 122–133.

Lahtela, A., and Jäntti, M., (2010). "Improving IT service management processes: A case study on IT service support", In: *European conference on software process improvement* (pp. 95-106), Springer, Berlin, Heidelberg.

Lawson, S., (2004). Examining the relationship between organizational culture and knowledge management.

Lema, L., Calvo-Manzano, J.A., Colomo-Palacios, R., and Arcilla, M., (2015). "ITIL in small to medium-sized enterprises software companies: towards an implementation sequence", *Journal of software: evolution and process*, Vol. 27, No. 8, pp. 528-538.

Marrone, M., and Kolbe, L., (2010). "ITIL and the Creation of Benefits: An Empirical Study on Benefits", *Challenges and Processes*, In ECIS (p. 66).

Massingham, P., (2014). "An evaluation of knowledge management tools: Part 1 – managing knowledge resources", *Journal of Knowledge Management*, Vol. 18, No. 6, pp. 1075–1100, https://doi.org/10.1108/JKM-11-2013-0449.

MacCrimmon, K.R., (1968). Decision making among multiple-attribute alternatives: A survey and consolidated approach", RAND Corporation, Santa Monica.

McNaughton, B., Ray, P., and Lewis, L., (2010). "Designing an evaluation framework for IT service management", *Information & Management*, Vol. 47, 219-225. 10.1016/j.im.2010.02.003.

Melendez, K., Dávila, A., and Pessoa, M., (2015). "Information technology services management models applied to medium and small organizations: A systematic literature review", *Computer Standards & Interfaces*, 47.10.1016/j.csi.2015.10.001.

Mirghani, S.M., Ribiere, V., O'sullivan, K.J., and Mohamed, M., (2008). "The re-structuring of the information technology infrastructure library (ITIL) implementation using knowledge management framework", *The journal of information and knowledge management systems*, Vol. 38, No. 3, pp. 315-333.

Mohammed, A. (2015). "Knowledge Management Process in several organizations: Analytical Study of modeling and several processes", *Procedia Computer Science*, Vol. 65, pp. 726-733.

Mohamed, M.S., Ribière, V.M., O'Sullivan, K.J., and Mohamed, M.A., (2008). "The re-structuring of the information technology infrastructure library (ITIL) implementation using knowledge management framework", *Vine*, Vol. 38, No. 3, pp. 315-333.

Neniˇckova, H., (2011). "Critical success factors for ITIL best practices usage", *Economics and Management*, Vol. 16, pp. 839–845.

Nonaka, I., and Takeuchi, H., (1995). The knowledge-creating company: How Japanese companies create the dynamics of innovation, Oxford university press.

Office of Government Commerce, (2002a). "ITIL Service Delivery". The Stationary Office, UK.

Office of Government Commerce, (2002b). "ITIL Service Support". The Stationary Office, UK.

Office of Government Commerce, (2007a). "ITIL Service Strategy". The Stationary Office, UK.

Office of Government Commerce, (2007b). "ITIL Service Design". The Stationary Office, UK.

Office of Government Commerce, (2007c). "ITIL Service Transition". The Stationary Office, UK.

Office of Government Commerce, (2007d). "ITIL Service Operation". The Stationary Office, UK.

Office of Government Commerce, (2007e). "ITIL Service Transition". The Stationary Office, UK.

Office of Government Commerce, (2011a). "ITIL Service Strategy edition 2011". The Stationary Office, UK.

Office of Government Commerce, (2011b). "ITIL Service Operation edition 2011". The Stationary Office, UK.

Office of Government Commerce, (2011c). "ITIL Service Transition edition 2011". The Stationary Office, UK.

Office of Government Commerce, (2011d)." ITIL Service Strategy". The Stationary Office, UK.

Opricovic, S., (1998). Multicriteria Optimization of Civil Engineering Systems, Faculty of Civil Engineering, Belgrade (in Serbian).

Orta, E., Ruiz, M., Hurtado, N., and Gawn, D., (2014). "Decision-making in IT service management: A simulation-based approach", *Decision Support Systems*, Vol. 66, pp. 36-51.

Papageorgiou, E.I., Markinos, A., and Gemtos, T., (2009). "Application of fuzzy cognitive maps for cotton yield management in precision farming", *Expert Syst. Appl*, Vol. 36, No. 10, pp. 12399–12413.

Papageorgiou, E.I., and Kontogianni, A., (2012). "Using fuzzy cognitive mapping in environmental decision making and management: A methodological primer and an application", *International Perspectives on Global*.

Peral, J. Mate, A., and Marco, M., (2016). Application of data mining techniques to identify relevant key performance indicators, Department of Software and Computing Systems, University of Alicante, Spain.

Probst, G., Romhardt, K., and Raub, S., (2000). Managing knowledge: Building blocks for success.

Radovanovic, S., (2018). Globalisation and challenges of the modern world: education and knowledge management, Economic and Social Development: Book of Proceedings: 1-5.

Saleh, A.A., Sani, M.K.J., Noordin, S.A. (2018). “Conceptualizing Knowledge Management, Individual Absorptive Capacity and Innovation Capability: A Proposed Framework”, International Journal of Academic Research in Business and Social Science, 8(9), 385-395.

Spender, J.C. (1996). “Making knowledge the basis of a dynamic theory of the firm”, Strategic management journal, 17(S2), 45-62.

Valiente, M.C., Garcia-Barriocanal, E., and Sicilia, M.A., (2012). "Applying an ontology approach to IT service management for business-IT integration", *Knowledge-Based Systems*, Vol. 28, pp. 76-87.

Valverde, R., and Talla, M., (2014). "DSS based it service support process reengineering using ITIL: A case study", In: *Engineering and Management of IT-based Service Systems* (pp. 35-65), Springer, Berlin, Heidelberg.

Zack, M.H., (1999). "Managing codified knowledge", *Sloan Management Review*, Vol. 40, No. 4, pp. 45-48.

Zavadskas, E.K., Kaklauskas, A., and Sarka, V., (1994). "The new method of multicriteria complex proportional assessment of projects", *Technological and Economic Development of Economy*, Vol. 1, No. 3, pp. 131–139.

Zavadskas, E.K., Turskis, Z., Antucheviciene, J., and Zakarevicius, A., (2012). "Optimization of weighted aggregated sum product assessment", *Elektronika ir Elektrotechnika*, Vol. 122, No. 6, pp. 3–6.

Zhang, Y., Zhang, J., and Chen, J., (2013). "Critical Success Factors in IT Service Management Implementation: People, Process, and Technology Perspectives", In: *international conference on service science*.

This article can be cited: Baradari, I., Shoar, M., Nezafati, N., Motadel, M., (2021). "A new approach for KPI ranking and selection in ITIL processes: Using simultaneous evaluation of criteria and alternatives (SECA)", *Journal of Industrial Engineering and Management Studies*, Vol. 8, No. 1, pp. 152-179.

Appendix A.

Table A1. Change management decision matrix

	Change Management KPIs	CSF-CHM 1	CSF-CHM 2	CSF-CHM 3
KPI CHM-01	Increase in the percentage of changes that meet the customer's agreed requirement	4.8	4.6	3.5
KPI CHM-02	Reduction in the backlog of change requests	1.3	2	1.1
KPI CHM-03	Increase in accuracy of predictions for time, quality, cost, risk, resource and commercial impact	4.6	4.8	3
KPI CHM-04	Increase in change success rate	4	3	3.6
KPI CHM-05	Reduction in the percentage of changes lead to service disruption	4.1	3.5	4.5
KPI CHM-06	Reduction in the percentage of emergency changes	1.3	2	4.6
KPI CHM-07	Reduction in the number of unauthorized changes identified	1.3	2	4
KPI CHM-08	number of incidents attributed to changes	2	3.3	1.1
KPI CHM-09	Reduction in the number and percentage of changes with incomplete change specification	1.1	1.5	4

Table A2. Change management CSF weights

β	W CSF-CHM 1	W CSF-CHM 2	W CSF-SHM 3
0	0.001000591	0.857284	0.1417154
0.1	0.212601362	0.5580796	0.229319
0.2	0.26015592	0.4233419	0.3165022
0.3	0.276007067	0.37843	0.3455629
0.4	0.283932947	0.3559738	0.3600932
0.5	0.28868839	0.3425002	0.3688114
0.6	0.291858672	0.3335177	0.3746236
0.7	0.294123161	0.3271017	0.3787752
0.8	0.295821559	0.3222896	0.3818888
0.9	0.297142521	0.3185469	0.3843105
1	0.298199289	0.3155528	0.3862479
1.1	0.299063917	0.313103	0.3878331
1.2	0.299784171	0.3110615	0.3891543
1.3	0.300394172	0.3093339	0.390272
1.4	0.300916548	0.3078534	0.39123
1.5	0.301369575	0.3065701	0.3920603
1.6	0.1476	0.1619	0.1739
1.7	0.1469	0.1620	0.1731

Table A3. Change Management KPI Values

β	KPI CHM-01	KPI CHM-02	KPI CHM-03	KPI CHM-04	KPI CHM-05	KPI CHM-06	KPI CHM-07	KPI CHM-08	KPI CHM-09
0	0.9304	0.3914	0.9507	0.6475	0.7646	0.4992	0.4807	0.6237	0.3914
0.1	0.9219	0.3449	0.9114	0.7054	0.8129	0.5194	0.4895	0.5271	0.4225
0.2	0.9067	0.3225	0.8791	0.7291	0.8405	0.5634	0.5221	0.4751	0.4671
0.3	0.9016	0.3151	0.8683	0.7370	0.8497	0.5780	0.5329	0.4578	0.4820
0.4	0.8991	0.3113	0.8629	0.7409	0.8544	0.5853	0.5383	0.4491	0.4894
0.5	0.8975	0.3091	0.8597	0.7433	0.8571	0.5897	0.5416	0.4439	0.4939
0.6	0.8965	0.3076	0.8575	0.7448	0.8590	0.5926	0.5438	0.4405	0.4969
0.7	0.8958	0.3065	0.8560	0.7460	0.8603	0.5947	0.5453	0.4380	0.4990
0.8	0.8953	0.3057	0.8548	0.7468	0.8613	0.5963	0.5465	0.4362	0.5006
0.9	0.8948	0.3051	0.8539	0.7475	0.8620	0.5975	0.5474	0.4347	0.5018
1	0.8945	0.3046	0.8532	0.7480	0.8627	0.5985	0.5481	0.4336	0.5028
1.1	0.8942	0.3042	0.8526	0.7484	0.8632	0.5993	0.5487	0.4326	0.5036
1.2	0.8940	0.3039	0.8522	0.7488	0.8636	0.6000	0.5492	0.4318	0.5043
1.3	0.8938	0.3036	0.8517	0.7491	0.8639	0.6005	0.5496	0.4312	0.5049
1.4	0.8936	0.3033	0.8514	0.7494	0.8642	0.6010	0.5500	0.4306	0.5054
1.5	0.8935	0.3031	0.8511	0.7496	0.8645	0.6014	0.5503	0.4301	0.5058
1.6	0.8933	0.3029	0.8508	0.7498	0.8647	0.6018	0.5506	0.4297	0.5062
1.7	0.8932	0.3028	0.8506	0.7499	0.8649	0.6021	0.5508	0.4293	0.5065

Table A4. Final Change Management KPIs Ranks

β	KPI CHM-01	KPI CHM-02	KPI CHM-03	KPI CHM-04	KPI CHM-05	KPI CHM-06	KPI CHM-07	KPI CHM-08	KPI CHM-09
0	2	9	1	4	3	6	7	5	8
0.1	1	9	2	4	3	6	7	5	8
0.2	1	9	2	4	3	5	6	7	8
0.3	1	9	2	4	3	5	6	8	7
0.4	1	9	2	4	3	5	6	8	7
0.5	1	9	2	4	3	5	6	8	7
0.6	1	9	3	4	2	5	6	8	7
0.7	1	9	3	4	2	5	6	8	7
0.8	1	9	3	4	2	5	6	8	7
0.9	1	9	3	4	2	5	6	8	7
1	1	9	3	4	2	5	6	8	7
1.1	1	9	3	4	2	5	6	8	7
1.2	1	9	3	4	2	5	6	8	7
1.3	1	9	3	4	2	5	6	8	7
1.4	1	9	3	4	2	5	6	8	7
1.5	1	9	3	4	2	5	6	8	7
1.6	1	9	3	4	2	5	6	8	7
1.7	1	9	3	4	2	5	6	8	7

Table A5. Problem management decision matrix

	Problem Management KPIs	CSF-PM 1	CSF-PM 2	CSF-PM 3
KPI PM-01	The number of known errors added to the KEDB	2	2.5	4
KPI PM-02	Percentage of incidents closed by the service desk	3.8	2.6	4
KPI PM-03	Average incident resolution time for those incidents linked to problem records	4	5	3.8
KPI PM-04	Total numbers of problems	2.6	3.1	3.6
KPI PM-05	Size of current problem backlog for each IT service	3.1	2.3	2.6
KPI PM-06	Number of repeat incidents for each IT service	3.3	4.6	2.2
KPI PM-07	Number and percentage of problems incorrectly assigned	2.6	2.3	1.3
KPI PM-08	Percentage of problems closed successfully	4.8	4.6	4.8
KPI PM-09	Size of current problem backlog for each IT service	4.3	4	3.8
KPI PM-10	Average cost per problem	1.3	1.6	3.2

Table A6. Problem management CSF weights

β	W CSF-PM 1	W CSF-PM 2	W CSF-PM 3
0	0.5929458	0.0010006	0.4060537
0.1	0.356316	0.295407	0.348277
0.2	0.339309	0.3165663	0.3441246
0.3	0.3336397	0.3236195	0.3427407
0.4	0.3308059	0.3271465	0.3420475
0.5	0.329105	0.3292624	0.3416326
0.6	0.3279711	0.3306731	0.3413559
0.7	0.3271614	0.3316808	0.3411577
0.8	0.326554	0.3324365	0.3410095

Table A7. Problem management KPI values

β	KPI PM-01	KPI PM-02	KPI PM-03	KPI PM-04	KPI PM-05	KPI PM-06	KPI PM-07	KPI PM-08	KPI PM-09	KPI PM-10
0	0.5859	0.8083	0.8166	0.6263	0.6034	0.5947	0.4316	0.9999	0.8534	0.4316
0.1	0.5864	0.7259	0.8681	0.6374	0.5547	0.6764	0.4232	0.9764	0.8312	0.4232
0.2	0.5864	0.7200	0.8718	0.6382	0.5512	0.6822	0.4226	0.9747	0.8296	0.4226
0.3	0.5864	0.7180	0.8730	0.6384	0.5500	0.6842	0.4224	0.9741	0.8291	0.4224
0.4	0.5864	0.7170	0.8736	0.6386	0.5494	0.6852	0.4223	0.9738	0.8289	0.4223
0.5	0.5865	0.7165	0.8740	0.6386	0.5491	0.6858	0.4223	0.9737	0.8287	0.4223
0.6	0.5865	0.7161	0.8742	0.6387	0.5488	0.6862	0.4222	0.9735	0.8286	0.4222
0.7	0.5865	0.7158	0.8744	0.6387	0.5487	0.6864	0.4222	0.9735	0.8285	0.4222
0.8	0.5865	0.7156	0.8745	0.6388	0.5485	0.6866	0.4222	0.9734	0.8285	0.4222

Table A8. Final problem management KPIs ranks

β	KPI PM-01	KPI PM-02	KPI PM-03	KPI PM-04	KPI PM-05	KPI PM-06	KPI PM-07	KPI PM-08	KPI PM-09	KPI PM-10
0	8	4	3	5	6	7	10	1	2	9
0.1	7	4	2	6	8	5	10	1	3	9
0.2	7	4	2	6	8	5	10	1	3	9
0.3	7	4	2	6	8	5	10	1	3	9
0.4	7	4	2	6	8	5	10	1	3	9
0.5	7	4	2	6	8	5	10	1	3	9
0.6	7	4	2	6	8	5	10	1	3	9
0.7	7	4	2	6	8	5	10	1	3	9
0.8	7	4	2	6	8	5	10	1	3	9

Table A9. Release management decision matrix

Release Management KPIs		CSF-RM 1	CSF-RM 2	CSF-RM 3	CSF-RM 4
KPI RM-01	Increased number and percentage of releases that meet customer expectations	4.2	4.2	4.8	3.1
KPI RM-02	Reduced number of deployments from sources other than the DML	1.1	1.1	1.3	4.6
KPI RM-03	Decreased customer dissatisfaction of service issues resulting from poorly tested or untested services	4.6	3.6	4.6	3.8
KPI RM-04	Increased customer and user satisfaction with the services delivered	4	2.6	3.7	2.1
KPI RM-05	Reduced number of incidents due to incorrect components being deployed	2.6	5	1.5	2.8
KPI RM-06	Reduced number of incidents of new releases due to incorrect testing	4.1	4.8	4.3	4
KPI RM-07	Increased percentage of incidents solved by level 1 and level 2 support	2.3	2.1	1.1	2.7
KPI RM-08	Reduced resources and costs to diagnose and fix incidents and problems in deployment and live use	1.6	3.8	2.6	2.1

Table A10. Release management CSF weights

β	W CSF-RM 1	W CSF-RM 2	W CSF-RM 3	W CSF-RM 4
0	0.1294201	0.282303	0.0010007	0.587276
0.1	0.2207752	0.2865242	0.0010037	0.491697
0.2	0.2770747	0.2735298	0.0175654	0.43183
0.3	0.2841857	0.2443703	0.0718088	0.399635
0.4	0.270443	0.2472923	0.1144873	0.367777
0.5	0.2621975	0.249046	0.140095	0.348662
0.6	0.2567005	0.2502152	0.1571665	0.335918
0.7	0.2527735	0.2510502	0.1693611	0.326815
0.8	0.2498287	0.2516768	0.1785065	0.319988
0.9	0.2475381	0.2521639	0.1856199	0.314678
1	0.2457056	0.2525537	0.1913105	0.31043
1.1	0.2442064	0.2528726	0.1959665	0.306955
1.2	0.242957	0.2531383	0.1998465	0.304058
1.3	0.2418998	0.2533631	0.2031296	0.301607
1.4	0.2409936	0.2535559	0.2059436	0.299507
1.5	0.2402082	0.2537229	0.2083825	0.297686
1.6	0.2395209	0.2538689	0.2105166	0.296094
1.7	0.2389106	0.2539964	0.2124016	0.294691
1.8	0.2383756	0.2541126	0.2140733	0.293439
1.9	0.2378897	0.2542137	0.2155726	0.292324
2	0.2374559	0.254306	0.2169203	0.291318
2.1	0.2370669	0.254391	0.2181379	0.290404
2.2	0.2367097	0.2544669	0.2192466	0.289577
2.3	0.2363838	0.2545362	0.2202588	0.288821
2.4	0.2360851	0.2545998	0.2211866	0.288129

Table A11. Release management KPI values

β	KPI RM-01	KPI RM-02	KPI RM-03	KPI RM-04	KPI RM-05	KPI RM-06	KPI RM-07	KPI RM-08
0	0.7521	0.6806	0.8188	0.5282	0.7132	0.8979	0.5282	0.5282
0.1	0.7746	0.6078	0.8342	0.5662	0.7109	0.9003	0.5196	0.5196
0.2	0.7913	0.5630	0.8476	0.5938	0.6985	0.9008	0.5109	0.5109
0.3	0.8059	0.5408	0.8591	0.6120	0.6707	0.8997	0.4958	0.5059
0.4	0.8170	0.5179	0.8620	0.6199	0.6598	0.9008	0.4812	0.5119
0.5	0.8237	0.5041	0.8638	0.6247	0.6533	0.9015	0.4725	0.5155
0.6	0.8281	0.4949	0.8650	0.6278	0.6489	0.9019	0.4666	0.5179
0.7	0.8313	0.4884	0.8658	0.6301	0.6458	0.9022	0.4625	0.5197
0.8	0.8337	0.4834	0.8664	0.6318	0.6434	0.9024	0.4593	0.5209
0.9	0.8355	0.4796	0.8669	0.6331	0.6416	0.9026	0.4569	0.5219
1	0.8370	0.4766	0.8673	0.6342	0.6402	0.9028	0.4550	0.5227
1.1	0.8382	0.4741	0.8676	0.6350	0.6390	0.9029	0.4534	0.5234
1.2	0.8392	0.4720	0.8679	0.6358	0.6380	0.9030	0.4521	0.5240
1.3	0.8401	0.4702	0.8681	0.6364	0.6372	0.9031	0.4509	0.5244
1.4	0.8408	0.4687	0.8683	0.6369	0.6364	0.9031	0.4500	0.5248
1.5	0.8414	0.4674	0.8685	0.6373	0.6358	0.9032	0.4492	0.5252
1.6	0.8420	0.4662	0.8687	0.6377	0.6353	0.9033	0.4484	0.5255
1.7	0.8425	0.4652	0.8688	0.6381	0.6348	0.9033	0.4478	0.5257
1.8	0.8429	0.4643	0.8689	0.6384	0.6344	0.9034	0.4472	0.5260
1.9	0.8433	0.4635	0.8690	0.6387	0.6340	0.9034	0.4467	0.5262
2	0.8437	0.4628	0.8691	0.6389	0.6336	0.9034	0.4462	0.5264
2.1	0.8440	0.4621	0.8692	0.6392	0.6333	0.9035	0.4458	0.5265
2.2	0.8443	0.4615	0.8693	0.6394	0.6330	0.9035	0.4454	0.5267
2.3	0.8445	0.4610	0.8693	0.6395	0.6328	0.9035	0.4451	0.5268
2.4	0.8448	0.4605	0.8694	0.6397	0.6325	0.9035	0.4448	0.5270

Table A12. Final release management KPIs ranks

β	KPI RM-01	KPI RM-02	KPI RM-03	KPI RM-04	KPI RM-05	KPI RM-06	KPI RM-07	KPI RM-08
0	3	5	2	6	4	1	8	7
0.1	3	5	2	6	4	1	8	7
0.2	3	6	2	5	4	1	8	7
0.3	3	6	2	5	4	1	8	7
0.4	3	6	2	5	4	1	8	7
0.5	3	7	2	5	4	1	8	6
0.6	3	7	2	5	4	1	8	6
0.7	3	7	2	5	4	1	8	6
0.8	3	7	2	5	4	1	8	6
0.9	3	7	2	5	4	1	8	6
1	3	7	2	5	4	1	8	6
1.1	3	7	2	5	4	1	8	6
1.2	3	7	2	5	4	1	8	6
1.3	3	7	2	5	4	1	8	6
1.4	3	7	2	4	5	1	8	6
1.5	3	7	2	4	5	1	8	6
1.6	3	7	2	4	5	1	8	6
1.7	3	7	2	4	5	1	8	6
1.8	3	7	2	4	5	1	8	6
1.9	3	7	2	4	5	1	8	6
2	3	7	2	4	5	1	8	6
2.1	3	7	2	4	5	1	8	6
2.2	3	7	2	4	5	1	8	6
2.3	3	7	2	4	5	1	8	6
2.4	3	7	2	4	5	1	8	6

Table A13. Configuration management decision matrix

	Configuration Management KPIs	CSF-CM 1	CSF-CM 2	CSF-CM 3
KPI CM-01	Reduction in business impact of outages caused by poor configuration management	4.5	4	4.5
KPI CM-02	Improvement in time to identify poor performing and poor-quality Cis	2	2	2.4
KPI CM-03	Reduction in the average time and cost of diagnosing and resolving incidents and problems	5	5	4.1
KPI CM-04	Increase in reuse and redistribution of under-utilized CIs	2	3	1.5
KPI CM-05	Reduced number of exceptions reported during configuration audits	1.3	1.5	2
KPI CM-06	Reduced percentage of changes not completed successfully because of poor impact assessment	4	3.8	4.6

Table A14. Configuration management CSF weights

β	W CSF-CM 1	W CSF-CM 2	W CSF-CM 3
0	0.00100	0.26535	0.73365
0.1	0.09033	0.26289	0.64679
0.2	0.17981	0.30237	0.51782
0.3	0.20964	0.31554	0.47482
0.4	0.22456	0.32212	0.45333
0.5	0.23351	0.32607	0.44043
0.6	0.23947	0.32870	0.43183
0.7	0.24373	0.33058	0.42569
0.8	0.24693	0.33199	0.42108
0.9	0.24942	0.33309	0.41750
1	0.25141	0.33397	0.41463
1.1	0.25303	0.33468	0.41228
1.2	0.25439	0.33528	0.41033
1.3	0.25554	0.33579	0.40868
1.4	0.25652	0.33622	0.40726
1.5	0.25737	0.33660	0.40603
1.6	0.25812	0.33693	0.40496
1.7	0.25878	0.33722	0.40401

Table A15. Configuration management KPI values

β	KPI CM-01	KPI CM-02	KPI CM-03	KPI CM-04	KPI CM-05	KPI CM-06
0	0.9309	0.4893	0.9203	0.3988	0.3988	0.9361
0.1	0.9243	0.4787	0.9297	0.4048	0.3836	0.9188
0.2	0.9103	0.4630	0.9437	0.4222	0.3626	0.8915
0.3	0.9056	0.4578	0.9484	0.4280	0.3556	0.8823
0.4	0.9033	0.4552	0.9507	0.4309	0.3521	0.8778
0.5	0.9019	0.4536	0.9521	0.4327	0.3500	0.8750
0.6	0.9009	0.4526	0.9531	0.4338	0.3486	0.8732
0.7	0.9003	0.4518	0.9537	0.4347	0.3476	0.8719
0.8	0.8998	0.4513	0.9542	0.4353	0.3469	0.8709
0.9	0.8994	0.4508	0.9546	0.4358	0.3463	0.8702
1	0.8991	0.4505	0.9549	0.4361	0.3458	0.8696
1.1	0.8988	0.4502	0.9552	0.4365	0.3454	0.8691
1.2	0.8986	0.4500	0.9554	0.4367	0.3451	0.8687
1.3	0.8984	0.4498	0.9556	0.4370	0.3449	0.8683
1.4	0.8983	0.4496	0.9557	0.4371	0.3446	0.8680
1.5	0.8981	0.4494	0.9559	0.4373	0.3444	0.8677
1.6	0.8980	0.4493	0.9560	0.4375	0.3443	0.8675
1.7	0.8979	0.4492	0.9561	0.4376	0.3441	0.8673

Table A16. Final configuration management KPIs ranks

β	KPI CM-01	KPI CM-02	KPI CM-03	KPI CM-04	KPI CM-05	KPI CM-06
0	2	4	3	5	6	1
0.1	2	4	1	5	6	3
0.2	2	4	1	5	6	3
0.3	2	4	1	5	6	3
0.4	2	4	1	5	6	3
0.5	2	4	1	5	6	3
0.6	2	4	1	5	6	3
0.7	2	4	1	5	6	3
0.8	2	4	1	5	6	3
0.9	2	4	1	5	6	3
1	2	4	1	5	6	3
1.1	2	4	1	5	6	3
1.2	2	4	1	5	6	3
1.3	2	4	1	5	6	3
1.4	2	4	1	5	6	3
1.5	2	4	1	5	6	3
1.6	2	4	1	5	6	3
1.7	2	4	1	5	6	3