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Research paper

Assessing Information System Performance in Banks Based on Multi-Criteria Decision Making Techniques

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Abstract

The objective of this paper is to introduce a new technique to evaluate and analyze the performance of information system based on the DeLone and McLean information systems success model. The technique presented is derived from the research done on measuring information system success and multi criteria decision making techniques. In this work, a framework has been developed to select the most performing information system via a combined approach of two most popular methods: AHP and TOPSIS. The work methodology consists of three main steps. In first step, the main criteria are chosen from the Delone and McLean model (2003). In the second step, the weights of the main criteria and sub-criteria are calculated using the AHP method. In the final step, alternatives are ranked by using TOPSIS. A demonstration of this methodology on five Moroccan banks is presented.

Keywords: *banks; criteria; decision making techniques; evaluation models; information system.*

1. Introduction

Information systems are extremely crucial for the survival and the development of business organizations in world for all sectors. Companies dependent on the information system for the management and the store of important information and data. The nature of banking sector [1] involves information and trust; it is the most need of information. Also, being in the service sector, banks needed to store information to improve their services and gain a competitive advantage over their competitors.

The strategic decision supported by bank is to implement information system effectively to increase productivity, safety; security…The choice of a performing information system amid many alternatives is a very complex decision. As selection of information system is crucial in a bank quality success, leaders must analyze and evaluate its information systems to select the most suitable ones to deal with the banks challenges.

The general steps for making decisions mostly consist of the following steps [2]: select the important criteria according to the context of study, develop alternatives and select the best alternative evaluated. To evaluate the selection process, different methods have been widely used in the literature [3] [4]: AHP, TOPSIS, SAW, MEW, and Electre...

In this study, a combined approach of AHP (Analytical Hierarch Process) and TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) methods has been used to evaluate the information system performance.

The objective of this study is to offer a work methodology to evaluate the information system in banking sector. Furthermore, the paper displays the results of evaluating five banking information systems. The evaluation is based on AHP method to determine the weights of criteria chosen from the information system success model (DeLone & McLean 2003) and for ranking systems, TOPSIS method has been used.

2. MCDM Methods

Multiple Criteria Decision Making (MCDM) or multiple-criteria decision analysis (MCDA) [5] is a sub-discipline of operation research consists of evaluating several criteria of different weights in the decision-making process.

It is based on the design of tools that ensure the subjective evaluation of a fixed number of alternatives based on a finite number of performance criteria and even sub-criteria. [6].According to Fulop [7] a_{m*n} is the score of alternative n related to criteria m.

Many different types of MCDM methods are referred, the choice of use depends on the field of application as well as the degree of complication. Among the most cited methods in the literature [5] [8]: WSM, WPM, AHP, TOPSIS, SMART, ELECTRE…

In this paper, two methods have been used; AHP and TOPSIS. The first is used for calculating the weight of the evaluation criteria and the second is used to rank the alternatives in order to choose the best one.

2.1. AHP Method

AHP is a multiple criteria decision making, firstly developed by Thomas L. Saaty [9] [10], it decomposes a complex MCDM problem into a system of hierarchies: main goal, criteria (sub-criteria) and alternatives to the problem. A pairwise comparison matrix was developed using 1-9 preference scale [11] to obtain the degree of importance of element at each level.

The procedure of the AHP involves the following steps [12] [13] [14]:

Step 1: Construct the structural hierarchy, this is known as the AHP decision

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Step 2: Construct the pairwise comparison matrix of attribute i with attribute j yield a square matrix A_{n*n}. In this matrix, $a_{ij}=1$ when i=j and $a_{ji}=1/a_{ij}$

Step 3: Construct normalized decision matrix

$$C_{ij}=b/\sum_{j=1}^{n} b \quad /i=1,2,3,..., n , j=1,2,3,\ldots,n \text{ and } b=a_{ij} \tag{1}$$

Step 4: Construct the weighted normalized decision matrix

$$W_{i=}\sum_{j=1}^{n} d \quad /n,i=1,2,3,..., n \quad \text{and } d=C_{ij} \tag{2}$$

$$W=\begin{bmatrix} w1 \\ w2 \\ \ldots \\ wn \end{bmatrix} \tag{3}$$

Step 5: Calculate Eigenvector and Row matrix

$$E=N^{th} \text{ rootvalue}/\sum Nth \text{ rootvalue} \tag{4}$$

$$\text{Rowmatrix}=\sum_{j=1}^{n} X \quad / X=a_{ij}*e_{j1} \tag{5}$$

Step 6: Calculate the maximum Eigenvalue, λmax

$$\lambda max = \text{Rowmatrix}/E \tag{6}$$

Step 7: Calculate the consistency index and consistency ratio

$$CI= (\lambda max - n) / (n-1) \tag{7}$$

$$CR= CI/RI \tag{8}$$

2.2. TOPSIS Method

The TOPSIS method developed by Hwang and Yoon [15], it is based on the distance between each alternative and the ideal positive solution on the one hand and the ideal negative solution on the other hand.

The TOPSIS method procedure steps are presented as follows [16]:

Step 1: Construct the decision matrix:

$$Amn=\{aij/i\epsilon(1,2,3,\ldots,m) \text{ and } j\epsilon(1,2,3,\ldots,n)\} \tag{9}$$

Step 2: Construct normalized decision matrix:

$$rij=xij/\sqrt{\sum_{j=1}^{J} Y} \quad , Y=xij2 \ ,j=1,2,3,..., J \text{ and } i=1,2,3,\ldots,n \tag{10}$$

Step 3: Construct the weighted normalized decision matrix. It is obtained as follows:

$$Vij=wi*rij, \ j=1,2,3,..., J \text{ and } i=1,2,3,\ldots,n \tag{11}$$

Step 4: Determined the positive ideal solution (PIS) and negative ideal solution (NIS)

$$A^*= \{v1^*, v2^* \ldots vn^*\}/$$
$$vi^* = \{\max(vij) \text{ if } j\epsilon J; \min(vij) \text{if } j\epsilon J\} \tag{12}$$

$$A^-= \{v1^-, v2^- \ldots vn^-\}/$$
$$vi^- = \{\min(vij) \text{ if } j\epsilon J; \max(vij) \text{ if } j\epsilon J^-\} \tag{13}$$

Step 5: Calculate the separation measures of each alternative from PIS and NIS

$$di^*=\sqrt{\sum_{j=1}^{n} X1} \quad , X1= (vij-vj^*)\ 2 \ j=1,2,3,..., J \tag{14}$$

$$di^-=\sqrt{\sum_{j=1}^{n} X2} \quad , X2= (vij-vj^-)\ 2 \ j=1,2,3,..., J \tag{15}$$

Step 6: Calculate the relative closeness coefficient

$$CCi=di^-/ (di^*+di^-)/i=1,2,3,..., J \tag{16}$$

Step 7: Based on the decreasing values of closeness coefficient, alternatives are ranked from most valuable to worst. The alternative having highest closeness coefficient (CCi) is selected.

3. Implementation and Results

3.1. Purpose of Study

Returning to the literature, MCDM methods have been used in several fields and sectors, the objective of this paper is to apply one of the two most used methods namely AHP and TOPSIS to measure the information systems performance in banking sector.

This study aims to introduce a new technique to evaluate the performance of banking information systems. The technique presented in this work is a combination of two MCDM methods. The criteria were chosen by referring to the D & M model (Fig.1) [17]. To test the model it was applied on five Moroccan banks to arrive at the end to distinguish the best alternative.

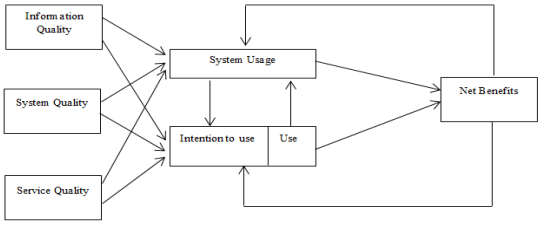

Fig. 1: DeLone and McLean model (2003).

3.2. Work Methodology

The work methodology we followed in this article is based on six steps. The result of each one is considered as the input values of the next as shown in the figure below:

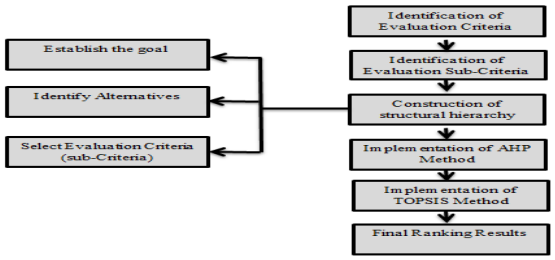

Fig. 2: Steps of work methodology.

Phase 1: identification of evaluation criteria;
Phase 2: verification the existence of sub-criteria;
Phase 3: establishment of the hierarchical model of the AHP method;
Phase 4: implementation of the AHP method;
Phase 5: implementation of the TOPSIS method;
Phase 6: Achieve the final results of ranking.
Each of these phases will be developed in the next sections.

3.3. Implementation

For confidentiality reasons, the five banking information systems that were the subject of this study were named respectively: B_1, B_2, B_3, B_4 and B_5. In the rest of the article we will consider this nomination.
The hierarchical model contains six criteria and thirty eight sub-criteria as shown in Table 1. The data were collected by an online questionnaire and the weights of main (sub) criteria are calculated using the several steps of AHP method. The normalized matrix has been calculated as pointed in (1). (Table 2).

Table 1: Evaluation criteria and sub-criteria

Criteria	Sub-criteria
System Quality (C_1)	Availability, Employees Occupancy, Longest Delay, Answer Speed, Abandons, Blockage, Average hour of operation, Self-service availability
Information Quality (C_2)	Grammar and spelling(email), Data accuracy, Secure, Complete, Relevant and correct, Data Understandability
Service Quality (C_3)	On Time delivery, Knowledge and competency, Error Network, Availability, Access, Rate Delay, Reliability
Use (C_4)	Frequency of use, Amount of use, Number of reports generated, Technical support, Managerial support, Financial transactions use
User Satisfaction (C_5)	Handle Time, Average Number of employees connected, Training Investment, Employee Turnover, Average Satisfaction
Net Benefits (C_6)	Return on Investment, Productivity, Profit, Market Share, Growth in customer base, Increased Sale

Table 2: Normalized decision matrix

	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)
(C_1)	0.49	0.69	0.50	0.30	0.40	0.16
(C_2)	0.09	0.13	0.36	0.18	0.17	0.16
(C_3)	0.69	0.02	0.07	0.42	0.17	0.16
(C_4)	0.09	0.04	0.01	0.06	0.17	0.27
(C_5)	0.06	0.04	0.02	0.01	0.05	0.16
(C_6)	0.16	0.04	0.02	0.01	0.01	0.05

As pointed in (3), the weights of six criteria are: w_1 =2.32/6= 0.42; w_2 =1.04/6=0.11; w_3=1.36/6= 0.18; w_4=1.02/6=0.06; w_5=0.65/6= 0.15 and w_6=0.38/6=0.05.
After the application of the first method and mainly the calculation of the weights of criteria (sub-criteria), we must proceed to the application of the second one in order to rank the five alternatives based on the study criteria.
The first TOPSIS's algorithm step is to construct the decision matrix while respecting the rules mentioned in (9). Based on (10), a normalized decision matrix of sub-criteria was constructed. Then, the weighted normalized decision matrix was obtained using (11). The positive and negative ideal solution was determined based on maximum and minimum values for each criterion using (12) (13).The separation measures of each alternative from positive ideal solution and negative ideal solution using Eqs. (14)(15) Were calculated. Finally, the closeness coefficients of five alternatives are calculated using (16). (Table 3).
The two chosen methods are classified among the most complicated methods in terms of calculation, so as to not load the paper we chose to display the basic data and the final result.

Table 3: Ranking of banks

Alternatives	D_i^*	D_i^-	CC_i	Rank
B_1	0,196	0,116	0,372	4
B_2	0,203	0,164	0,446	2
B_3	0,209	0,094	0,310	5
B_4	0,166	0,204	0,551	1
B_5	0,187	0,130	0,409	3

4. Conclusion

An information system is an organized set of resources: hardware, software, personnel, data, and procedure…To store and treat different types of information. To measure the performance of IS, we have many information system models, in our case; we chose to implement the most famous model (Delone and McLean 2003).
In this study it is aimed to determine the most performing IS of five banks. For this purpose, information system criteria determined from D&M model and sub-criteria provided from literature. Then the weights of each criteria and sub-criteria are calculated using AHP method. In the latest step, using TOPSIS method banks were ranked in terms of IS performance.
It is observed that "system quality" (0.42) is the most important criteria for IS assessment followed by "service quality"(0.18) "user satisfaction"(0.15)"information quality" (0.11) "use"(0.06) and "net benefits"(0.05).
Depending on the results of relative closeness coefficient of five studied banks and based on the decreasing values, the alternative having highest closeness coefficient is Bank B_4 with CC_i =0.551 followed by B_2 with CC_i =0.446, B_5 with CC_i =0.409, B_1 with CC_i =0.372 and B_3 with CC_i =0.310. It can be contested that the IS performance of the five studied banks are close to each other due specifies of banking sector.
According to the results of this study, "system quality" was determined as the most important criterion. To optimize the IS performance or just on keeping at the seam level, banks should concentrated on the dimension of system quality such as availability, blockage, abandons, answer speed…
In the future work, we will work in other sector, to compare the different sector and to study the influence of IS use on it evaluation.

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