International Journal of Electrical and Computer Engineering (IJECE)
Vol. 13, No. 1, February 2023, pp. 948~956
ISSN: 2088-8708, DOI: 10.11591/ijece.v13i1.pp948-956

Implementation of a decision support process for evaluating the correlation between IT investment and of information systems success

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Article Info

Article history:

Received Nov 29, 2021
Revised Aug 8, 2022
Accepted Sep 3, 2022

Keywords:

Criteria
Evaluation
Information system
Investment
Technique for order preference by similarity to ideal solution

ABSTRACT

The main objective of this paper is to study the correlation between investment in information technologies and especially information systems and information system success based on data collection and a multi-criteria decision-making approach using technique for order preference by similarity to ideal solution (TOPSIS) and analytical hierarchy process (AHP) methods. The criteria of the hierarchical model for evaluating the information system success are chosen from Delone and McLean information systems (IS) success model. The proposed approach has been implemented in 3 sectors recognized by their variation in the use of information systems: the financial sector, the service companies sector, and the construction industry sector. Therefore, the results of this implementation show that massive investment in information systems does not always guarantee good information system success, and information system success is not always the result of massive investment in the information system.

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1. INTRODUCTION

Business leaders are constantly seeking to create value through the implementation of information systems (IS) that bring tangible and intangible gains [1]. This is why they invest heavily in IS for improving the success of their IS [2]. In recent years, the investment value has become exponential due to competitive intelligence and the enormous evolution of technology, which has changed the basic structure of the company as well as its modes of production, management, and marketing [3]. This extra investment pushes managers as well as researchers in the field to question the effectiveness and relevance of these investments concerning the success of their IS. Thus, the main problem consists in answering the following question: if I invest massively in IS, do I have an efficient IS and if I have an efficient IS, have I necessarily invested massively in my IS?

Returning to the literature, we observe that the majority of studies [4]–[7] that have dealt with this issue have focused on collecting data and analyzing the results obtained without proposing a structured approach or a general hierarchical evaluation model that can be adopted regardless of the field of study [8]. The main purpose of this paper is to develop a multi-criteria decision support approach [9] based on data collection and multiple-criteria decision-making (MCDM) methods to study the correlation between IS investment and IS

success while implementing a hierarchical model of IS success. This approach will be implemented in the three sectors of the study: financial, service companies, and construction industry.

The structure of this paper is as: section 2 presents a literature review to demonstrate the contribution of this paper. Right after, the MCDM method named technique for order preference by similarity to ideal solution (TOPSIS) is explained. In the following section: we explain the purpose of the study, the work methodology, and the implementation of the approach in the three sectors. The following section is a discussion of the results of the implementation and their analysis. Finally, we conclude with a general conclusion and the perspectives for future work

2. LITERATURE REVIEW

2.1. Information system success

The evaluation of IS success appeared at the same time as the concept of the IS itself. In the literature, it is equated an information technology (IT) audit [10]. In some research work, the performance of the IS has been limited, to the success of the IS [11] and the impact of the IS [12]. Zhou *et al*. [13] have pointed out the difference between the performance and value of the IS. The evaluation of IS performance measures both the efficiency and the satisfaction of the stakeholders of the system, while the value is complementary.

Academics and practitioners have given many definitions but they remain relative to the research context [11]. Evaluating IS success is identified as one of the most critical issues [14] and remains a difficult task to accomplish. There is a vast typology of models, which are based on several theories and measurement criteria [15]: the moment of measurement concerning the action, the position of the person carrying out the measurement, and the internal objectives of the company. Among the most cited models in the literature, we find these models: the technology acceptance model [16], the two DeLone and McLean models (initial and updated) [11], the functional assessment model [14], and prospective dashboards [14].

2.2. IS investment and IS success

From a purely economic point of view, IT is just an input that interacts with other elements [17]. Thus, information technology brings benefits to the company and is more important than human or material capital [18], to ensure the performance of their companies; managers must invest in information technology [19]. Returning to the literature, the researchers analyzed investment in information technologies according to several criteria [20], [21]: the level of investment, the use and perception of information technologies, and the degree of involvement of information technologies in the decision-making process. Investments in information technology have an impact on economic growth: a consequence of constant innovation and the use of technology that allows new processes to be created, which leads to increased results [22]. In addition, information technology provides communication and exchange platforms that allow access to accurate information in real-time around the world [23]. In the literature, we do not find articles that have studied the correlation between IS investment and IS success. The majority of studies focus on the correlation between IS investment and firm performance [7], [24]–[26], hence the real contribution of this paper.

3. GLOBAL RESOLUTION APPROACH

3.1. Purpose of study

The study offers a decision support approach for the evaluation using the two MCDM methods: analytical hierarchy process (AHP) and TOPSIS [27]–[29]. The TOPSIS method was used to rank the different alternatives representing companies operating in the three sectors of the study [30]. The AHP method was used to aggregate the criteria (sub-criteria) of the hierarchical model of IS success evaluation [31], [32]. The paper implements the proposed approach in the three sectors and offers the particularity of proposing a well-defined framework to study the correlation as well as a valid evaluation model whatever the sector of the company wants to evaluate the IS success. Unlike the work cited in the literature which is based solely on the data collection and analysis, this paper offers both the possibility of evaluating the IS success based on the criteria of the proposed hierarchical model as well as a practical approach to assessing the correlation.

3.2. Work methodology

The main objective of this paper is to analyze the correlation between IS investment and IS success; we will focus on the TOPSIS method and its results [31], [32]. In the next section, we will present the results of the TOPSIS method as well as the correlation between IS investment and IS success. It should be noted that the same approach would be used for the three sectors. For each sector, we rely on data from the

20 companies. We used the results of the implementation of the AHP method for the weight of criteria (sub-criteria). The hierarchical model of the evaluation is shown in Table 1.

Table 1. Hierarchical model

Criteria	Sub-criteria
System quality (SQ)	Accessibility (A), Flexibility (F), Reliability (RL), Response Time (RS), Security (S)
Information quality (IQ)	Accuracy (A), Completeness (C), Adapted format (AF), Accessibility (AI), Utility (U)
Service quality (SQ)	Reliability (RLS), Assurance (ASS), Tangibles elements (T), Empathy (E), Responsiveness (RS)
User satisfaction (US)	Adequacy (AD), General satisfaction (GS)
System use (SSU)	Use frequency (FU), Use duration (DU), Learning (LR), Loyalty (LL), Decision support (DS)
Nets benefits (NB)	Customer satisfaction (CS), Handle time (HT), Process improvement (PI), Cost minimization (CM), Competitive advantage (CA), Market expansion (ME), Communication (CC)

4. IMPLEMENTATION OF THE PROPOSED APPROACH

This section illustrates the implementation of the proposed approach within the three research sectors selected. The application of the approach to the sectors had two objectives: to validate the principles of the approach and to participate in its construction. To respect confidentiality, the names of the companies are anonymous and certain other data will not be presented. The following sections respectively illustrate the different stages of the methodology as well as the results obtained in each research sector.

4.1. Implementation: financial sector case

4.1.1. Evaluate the IS success

This section will present the first results concerning the evaluation of IS success within the financial sector. This first part consists of implementing the hierarchical model as shown in Table 1 using the AHP method. The treatment of the results gave rise to the Table 2, in which columns 2 to 7 represent the matrix of the relative importance of the IS and the last column represents the vector of their relative weights W_{dim}.

Table 2. Dimensions of IS success (sector 1)

	SQ	IQ	SRQ	US	SSU	NB	W_{dim}
SQ	0.49	0.69	0.50	0.30	0.40	0.16	0.42
IQ	0.09	0.13	0.36	0.18	0.17	0.16	0.11
SRQ	0.69	0.02	0.07	0.42	0.17	0.16	0.18
US	0.09	0.04	0.01	0.06	0.17	0.27	0.06
SSU	0.06	0.04	0.02	0.01	0.05	0.16	0.15
NB	0.16	0.04	0.02	0.01	0.01	0.05	0.05

The second level of our conceptual model includes the sub-criteria of each information system dimension. Note that, we will present the results of the second level just for this first sector. The matrix of the relative weights of the sub-criteria according to performance aspects $Q^{'}$ is shown in Table 3.

4.1.2. IS investment and IS success

The TOPSIS method was used to classify the 20 alternatives each representing company. This is based on the weights of the criteria and the sub-criteria obtained by the AHP method. In the Table 4, we have presented the results concerning the ranking of the 20 companies (IS success and investment). Thus, we will model the results using a graph as shown in Figure 1.

4.2. Implementation: construction industry sector case

4.2.1. Evaluate the IS success

This section will present the results concerning the evaluation of the IS success within this sector. The treatment of the results by applying the AHP method gave rise to the Table 5. We will present just the results of the first level of the hierarchical model.

4.2.2. IS investment and IS success

In the same way as the first sector as shown in Table 4, the TOPSIS method is used to classify the 20 alternatives each representing company. This is based on the weights of the criteria and the sub-criteria obtained by the AHP method. In Figure 2, we presented the results concerning the ranking of the 20 companies in terms of performance of their IS as well as the ranking of their investment in IS.

4.3. Implementation: service companies sector case

4.3.1. Evaluate the IS success

This section will present the results concerning the evaluation of the IS' success within this sector. This part consists in implementing the same conceptual model as shown in Table 1 with the AHP method, without going over the models and the explanations already presented. The treatment of the results by applying the AHP method gave rise to the Table 6, in which columns 2 to 7 represent the matrix of the relative importance of the IS dimensions and the last column on the right represents the vector of their relative weights W_{dim}. For the two sectors, we will present just the results of the first level of the hierarchical model.

Table 3. Relative weights of sub-criteria according to criteria (sector 1)

	Matrix Q'					
	SQ	IQ	SRQ	US	SSU	NB
	Information System Success					
A	0.1720	0.0000	0.0000	0.0000	0.0000	0.0000
F	0.0377	0.0000	0.0000	0.0000	0.0000	0.0000
RL	0.1199	0.0000	0.0000	0.0000	0.0000	0.0000
RS	0.0196	0.0000	0.0000	0.0000	0.0000	0.0000
S	0.0705	0.0000	0.0000	0.0000	0.0000	0.0000
A	0.0000	0.0482	0.0000	0.0000	0.0000	0.0000
C	0.0000	0.0286	0.0000	0.0000	0.0000	0.0000
AF	0.0000	0.0088	0.0000	0.0000	0.0000	0.0000
AI	0.0000	0.0183	0.0000	0.0000	0.0000	0.0000
U	0.0000	0.0059	0.0000	0.0000	0.0000	0.0000
T	0.0000	0.0000	0.0718	0.0000	0.0000	0.0000
RLS	0.0000	0.0000	0.0460	0.0000	0.0000	0.0000
RS	0.0000	0.0000	0.0256	0.0000	0.0000	0.0000
ASS	0.0000	0.0000	0.0244	0.0000	0.0000	0.0000
E	0.0000	0.0000	0.0119	0.0000	0.0000	0.0000
AD	0.0000	0.0000	0.0000	0.0450	0.0000	0.0000
GS	0.0000	0.0000	0.0000	0.0149	0.0000	0.0000
FU	0.0000	0.0000	0.0000	0.0000	0.0360	0.0000
DU	0.0000	0.0000	0.0000	0.0000	0.0197	0.0000
LR	0.0000	0.0000	0.0000	0.0000	0.0054	0.0000
LL	0.0000	0.0000	0.0000	0.0000	0.0137	0.0000
DS	0.0000	0.0000	0.0000	0.0000	0.0749	0.0000
CS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0144
HT	0.0000	0.0000	0.0000	0.0000	0.0000	0.0082
PI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0087
CM	0.0000	0.0000	0.0000	0.0000	0.0000	0.0061
CA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0077
CC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013
ME	0.0000	0.0000	0.0000	0.0000	0.0000	0.0033

Table 4. TOPSIS results for IS success

Alternative	Measurement coefficient	Rank (TOPSIS)	Rank (Investment)
F_1	0.5511	7	2
F_2	0.6471	2	5
F_3	0.2767	20	17
F_4	0.6372	3	7
F_5	0.4481	19	18
F_6	0.6269	4	6
F_7	0.4882	16	13
F_8	0.4690	18	20
F_9	0.6603	1	3
F_{10}	0.5471	8	9
F_{11}	0.5461	9	12
F_{12}	0.5386	12	16
F_{13}	0.4957	15	11
F_{14}	0.5403	11	14
F_{15}	0.5454	10	8
F_{16}	0.4776	17	19
F_{17}	0.5898	5	1
F_{18}	0.5382	13	15
F_{19}	0.5032	14	10
F_{20}	0.5614	6	4

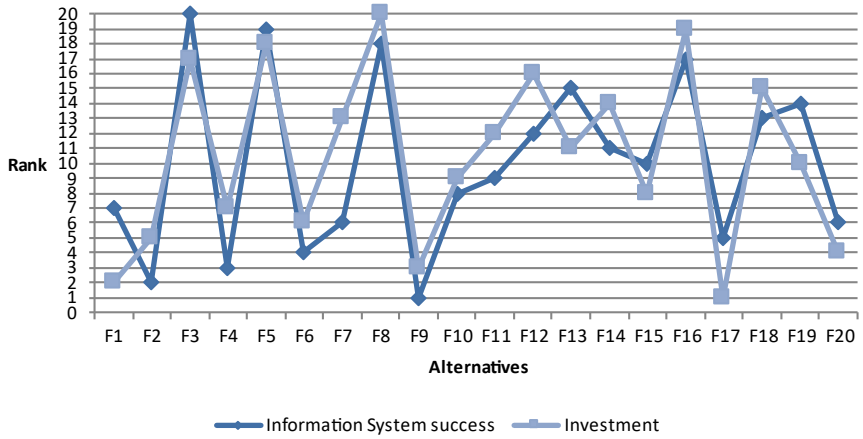

Figure 1. Correlation between IS success and IS investment (sector 1)

Table 5 Dimensions of IS success (sector 2)

	SQ	IQ	SRQ	US	SSU	NB	W_{dim}
SQ	0.53	0.50	0.77	0.29	0.30	0.28	0.45
IQ	0.07	0.07	0.02	0.17	0.30	0.17	0.13
SRQ	0.07	0.36	0.11	0.17	0.30	0.17	0.20
US	0.11	0.02	0.04	0.06	0.01	0.17	0.07
SSU	0.11	0.01	0.02	0.29	0.06	0.17	0.11
NB	0.11	0.02	0.04	0.02	0.02	0.06	0.04

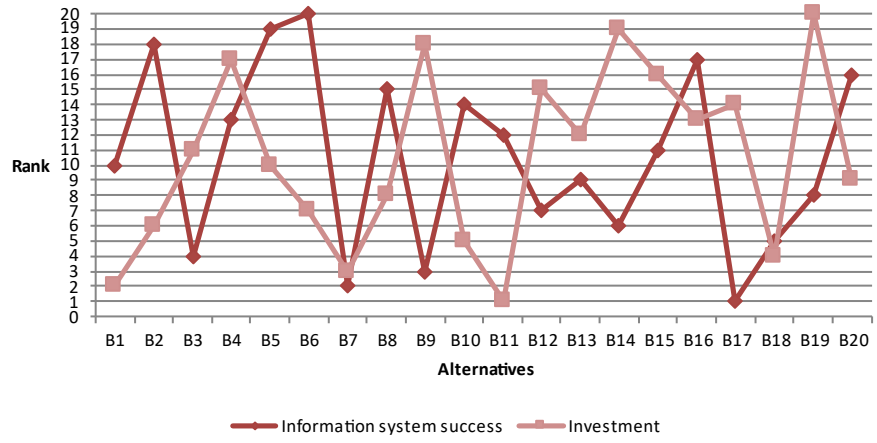

Figure 2. Correlation between IS success and IS investment (sector 2)

Table 6. Dimensions of IS success (sector 3)

	SQ	IQ	SRQ	US	SSU	NB	W_{dim}
SQ	0.45	0.60	0.30	0.21	0.40	0.33	0.38
IQ	0.15	0.20	0.50	0.21	0.24	0.23	0.26
SRQ	0.15	0.04	0.10	0.21	0.24	0.14	0.15
US	0.10	0.04	0.02	0.04	0.02	0.01	0.04
SSU	0.10	0.06	0.03	0.20	0.08	0.23	0.12
NB	0.06	0.04	0.03	0.12	0.02	0.05	0.05

4.3.2. IS investment and IS success

In the same way as the first and second sectors as shown in Table 4, the TOPSIS method is used to classify the 20 alternatives each representing company. This is based on the weights of the criteria and the sub-criteria obtained by the AHP method. In Figure 3, we presented the results concerning the ranking of the 20 companies in terms of performance of their IS as well as the ranking of their investment in IS.

Figure 3. Correlation between IS success and IS investment

5. ANALYSIS RESULTS

5.1. Information system success

The main objective of this paper is to test the conceptual model developed previously in the three study sectors to construct a generic model allowing the analysis of the IS success. The Figure 4 shows the weights of the evaluation criteria for each sector. The figure presents the weight of the criteria for each sector. We can conclude that the weight of the criteria varies according to the type of sector. We will present the contributions and implications concerning the criteria: system quality, information quality, service quality, and system use, as they are the most important and at the same time common to the three sectors.

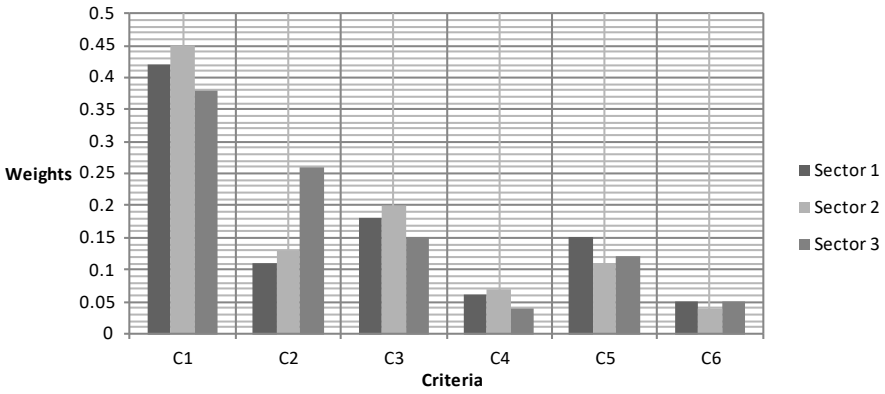

Figure 4. Comparison of the weights of the evaluation criteria

5.1.1. System quality

The system quality is a criterion that according to the results is present in the IS evaluation model of the three sectors. It is evaluated through five sub-criteria as shown in Table 1. We first focus on the sub-criteria that have disappeared from the evaluation models. This means that in terms of the system quality, these are not expected qualities. We can explain this result by the fact that response time and security are expectations for designers and programmers and so obvious expectations for managers.

The weight of this first criterion is always ranked first with a percentage of 42%, 45%, and 38% respectively for the three sectors, regarding the expectations of managers in terms of system quality, the three most significant sub-criteria are those related to accessibility, flexibility, and reliability. These expectations are quite logical and follow the evolution of technology that must take into account competitive pressure and the achievement of objectives relating to each sector.

5.1.2. Information quality

The evaluation of the information quality is the result of five sub-criteria as shown in Table 1. For the financial sector and the service companies sector, the sub-criteria with the most important weight are

accuracy, completeness, and accessibility. There is an imbalance between the two sectors just mentioned and the construction industry sector regarding the sub-criterion of the adapted format of information.

According to the expectations of decision-makers in the construction industry sector, the adapted format of the information has great importance that can be explained by the specificities of this sector, unlike the two other sectors, which focus more on the accuracy and the completeness of the information to the detriment of the information format. The rejection of the sub-criterion of the utility of information for the three sectors can be explained by the essential reason behind the implementation of an IS within the company which has above all the guarantee of useful information for purposes specific to each sector.

5.1.3. Service quality

To evaluate the expectations of decision-makers in terms of service, we relied on the SERVQUAL model [33]. We have come up with an evaluation instrument that consists of five sub-criteria as shown in Table 1. For the financial sector, the first three sub-criteria were retained, unlike the last two. This result can be explained by the nature of the financial sector, which requires by default a good level of competence for its employees, and personalization of the offers. For the construction industry sector and the service companies sector, only the sub-criteria relating to tangibles elements, reliability, and assurance are retained. As for the other two sub-criteria, they are rejected. This can have several reasons, among them it can be seen that the trades relating to these two sectors are based on thoughtfulness in responses and individualized attention.

5.1.4. System use

Evaluating use is one of the critical issues in the field of IS. We evaluate it through five sub-criteria as shown in Table 1. For the financial sector, the sub-criteria having the most important weight are use frequency, use duration, and decision support. On the other hand, the sub-criteria relating to loyalty and learning are rejected which makes sense given that the use of IS in the financial sector is an obligation. According to the expectations of managers in the construction industry sector, learning has great importance to assess the system use which can be explained by the new tools recently developed for this sector which is starting to use IS, although, for this sector, the IS can in no case help to make decisions given the specificities of this field. For the last sector of service companies, the sub-criteria retained are use frequency, use duration, learning, and loyalty, while; the sub-criterion relating to decision support was rejected. This can be explained by the fact that even though this industry uses IS, it does not have complete confidence in IS in decision-making.

To conclude on these first contributions, we can say that the evaluation is a prerequisite relating to the specificities of the sector and that it is almost impossible to have a generic model which makes it possible to evaluate the IS. We have demonstrated by the analysis of this sample that the criteria, as well as the sub-criteria, change according to the sector. In addition, these results indicate to decision-makers and information systems managers which criteria they should focus on if they want to have a better perception of their information system success.

5.2. IS success and IS investment

This section aims to analyze the study results of the correlation between IS investment and IS success in the three sectors. We will start with the results of the financial sector. According to Figure 2, we notice certain parallelism between the first curve which represents the ranking of the company in terms of IS success and the second which represents the investment in IS. Although we remarque a small lag in the ranking of the two variables, it remains insignificant. This proves, that there is a significant correlation between the percentage of company investment in IS and the IS success at least in the sample that consists of 20 companies in the financial sector.

Unlike the results of the first sector, we remarque a large lag of difference between the two curves in the construction industry sector as shown in Figure 3. Taking the example of alternatives (B5) and (B6), they occupy 19 and 20 respectively in terms of their IS success, and yet they have a good ranking in terms of IS investment. This implies that for this second sector we cannot consider the correlation between the percentage of the company's investment in IS and the achievement of the IS success.

Based on the results of the last sector as shown in Figure 4, we remarque the same conclusion as for the financial sector. The two curves are almost parallel. This proves that there is a significant correlation between the two variables at least in the sample that consists of 20 companies in this sector. As part of this research, we adopted a hierarchical model for evaluating the IS success that includes combined criteria from two models cited in the literature [11]. The results of implementing this model in the three sectors have shown that the criteria of the evaluation model remain almost the same, but the sub-criteria change from one sector to another, which required having three evaluation models.

Thus, the correlation between investment in IS and their success remains relative. Aside from the financial and the service companies sectors where IS is integrated into strategic processes, the results of the construction industry sector show that investing in IS does not increase their success. Thus, information systems are still perceived in the construction industry sector as a factor that generates financial losses and is not exploited as an element that can bring tangible and intangible gains. To conclude, the correlation between IS investment and IS success is not a cause-and-effect correlation as long as the leaders have not integrated the IS into their strategy. Massive investment in IS without realizing the importance of its use or its integration into production and decision-making processes does not increase in any case its success.

6. CONCLUSION AND PERSPECTIVES

This study is based on the results collected from 150 companies operating in three sectors: financial, construction industry, and service companies. The main objective is to determine the correlation between IT investment and IS success while implementing a new hierarchical model for evaluating IS success. This work mainly uses the MCDM methods; the AHP method was used to build the hierarchical model and the TOPSIS method was used to rank the alternatives according to the IS success as well as IS investment. The first results concern the implementation of the hierarchical model in the three sectors, we can conclude that the weight of the criteria and sub-criteria change from one sector to another, hence the impossibility of having a generic and general model to evaluate IS success whatever the sector or the size of the company.

Furthermore, this article studies the correlation between IS investment and IS success based on data collection and the implementation of the TOPSIS method. From the results, it can be observed that this relation depends mainly on the sector of the company. For example: for the financial sector and the service companies sector, and according to their results, there is a significant link between the percentage of IS investment and IS success, companies that invest massively in IS have an efficient IS. Contrary to the results of these two sectors, we conclude that we cannot consider the correlation between the percentage of IS investment and the achievement of the performance of there IS; it is not necessarily that the companies who invest heavily in IS have an efficient IS. For future work, we are thinking to expand the sample size and even working on other sectors, while looking for the possibility of having a generic evaluation model and therefore the study of the correlation between IS success and IS investment. Thereby, we will be able to consider the use of machine learning techniques to study the correlation between the two variables objectively.

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