BUSTECH 2019

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BUSTECH 2019 Editors

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BUSTECH 2019

Forward

The Ninth International Conference on Business Intelligence and Technology (BUSTECH 2019), held between May 5 - 9, 2019 - Venice, Italy, continued a series of events covering topics related to business process management and intelligence, integration and interoperability of different approaches, technology-oriented business solutions and specific features to be considered in business/technology development.

The conference had the following tracks:

- Modeling and simulation
- BPM and Intelligence
- Information Technology-enabled Organizational Transformation

Similar to the previous edition, this event attracted excellent contributions and active participation from all over the world. We were very pleased to receive top quality contributions.

We take here the opportunity to warmly thank all the members of the BUSTECH 2019 technical program committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and effort to contribute to BUSTECH 2019. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations and sponsors. We also gratefully thank the members of the BUSTECH 2019 organizing committee for their help in handling the logistics and for their work that made this professional meeting a success.

We hope BUSTECH 2019 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the area of business intelligence and technology. We also hope that Venice provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

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A Framework of Warranty Risk Management

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Abstract—**Warranty is a useful tool for a manufacturer to reflect its product quality and combat competition. It, however, introduces various risks that may have a direct impact on the profitability and reputation of the manufacturer. Although managing such risks is crucial in reducing the number of warranty incidents and warranty related cost, little research has systematically investigated warranty risk management (WaRM). As such, this paper aims to (1) analyse the existing literature on warranty-related risks; (2) develop a generic WaRM framework; (3) investigate the existing WaRM techniques and methods by surveying the warranty decision makers in the automotive industry in the UK, and then (4) propose a warranty hazard identification tool through utilising social media data.**

Keywords–warranty risk management; social media; automotive industry

I. Introduction

Nowadays, manufacturers may offer a competitive warranty policy to their customers to maintain or increase their market shares. However, offering warranty may introduce various risks that can have a significant impact on the manufacturer's profit and reputation. For instance, General Motors (GM) spent $2billion to recall 13.1 million vehicles in 2014 due to its ignition switch issue, which may cause safety problems for drivers and passengers.

In the literature, WaRM is not often discussed and only mentioned as a side topic in some papers. For example, [1] investigates the problem of efficiency in warranty programme. [2] adapts a method, or a Quality Function Deployment (QFD) method, to prioritise warranty-related activities that may affect customers' satisfaction. [3] proposes a warranty management framework that outlines the main issues in achieving the goal of a warranty programme and meet customers' satisfaction. [4] identifies the top contributors to warranty incidents and costs and then proposes a warranty hazard taxonomy.

This research therefore seeks answers to the following questions: How should a manufacturer plan its WaRM? What tools should be used to identify warranty hazards, assess warranty risks, and mitigate warranty risks, respectively? Accordingly, the novelty of this research includes: (1) It is the first research paper that systematically analyses WaRM and develops a generic WaRM framework; and (2) it is the first research paper that applies social media data to identify warranty hazards.

In this paper, Section II discusses WaRM tools; Section III designs a questionnaire and analysis it. Section IV develops a WaRM framework; Section V identifies warranty hazards from social media data; and Section VI concludes the paper.

II. Warranty Risk Management Tools

Risk is defined as "the effect of uncertainty on objectives" [5]. The effect can be a positive or negative deviation from what was planned. [5] defines risk management as a set of activities and methods employed to direct and control an organisation risks that can affect the ability to achieve its objectives. These activities have five stages: (1) risk planning; (2) hazards identification; (3) risk assessment; (4) risk evaluation, and (5) risk controlling and monitoring. Analogously, the definition of risk management, or Warranty Risk Management (WaRM), can be defined as the process that identifies and assesses warranty hazards, and then manages the associated risks that occur during warranty period, as elaborated below.

Warranty risk planning involves assigning roles and liabilities in order to avoid contrary decisions in respect of emerging risks and allocating the necessary budget, efforts and resources. Additionally, aligning the procedures of the managerial works (e.g., reporting and passing risk-related information to the interested departments) is necessary in developing a warranty risk plan. Techniques such as project network diagrams [6], precedence diagram method [7] and generalised activity networks [8] can be adapted. As the risk management programme is a continuous process during the warranty programme, warranty cost analysis needs reviewing periodically. The thresholds that determine the level of an acceptable risk is significantly important as it will be used as a reference point.

Warranty hazard identification answers the question of what could go wrong during the warranty period. To answer this question, an in-depth analysis of the product, during the pre-launched and post-launched stages, is required. To this end, general tools such as SWOT (Strength, Weakness, Opportunities and Threats) analysis and the analogy approach can be adapted to obtain a board view of potential warranty hazard. To obtain a detailed identification, one may use tools, such as Failure Mode and Effect Analysis (FMEA), interviewing experts, assumption analysis, documents reviews, Delphi technique, and brainstorming, among others. The identification of warranty hazards is a challenge due to its interacts with other departments, such as design, manufacturing, marketing, logistics departments. Data collected from those departments are important in identifying warranty hazards in addition to warranty data which is collected from the warranty service providers [9]. With the development of data warehousing and Big Data techniques, it is possible to collect a huge amount of data from different sources. Warranty-related data can also be collected from structured datasets (e.g., CRM, ERP, etc.)

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or unstructured datasets (e.g., social networks, specialized forums, blogs, etc.). Analysing both types through the Big Data analytics tools can provide useful information that is difficult to acquire with traditional tools of data analysis. The application of such techniques may detect warranty hazards at the early stage of the product lifecycle.

Warranty risk assessment may be based on qualitative or/and quantitative analysis. Qualitative analysis may aim to look for repetitive events and then decide any required actions, whereas quantitative analysis aims to assess the probabilities and consequences of warranty risk. The probability of warranty risk is the likelihood of occurrence of a hazard during the warranty period, and the consequences is the expected loss of the hazard, which can be determined by experts or by the comparison with similar events occurred in the past. In order to quantitatively measure warranty risk, one may use methods, such as sensitivity analysis, FMEA and Failure Mode Effect and Criticality Analysis (FMECA), fault tree analysis and event tree analysis [10], and sensitivity analysis variable [11].

Warranty risk evaluation is concerned with the ranking of warranty risks. Such risks are evaluated to determine the magnitude of each risk based on its impact severity and likelihood. The impact may have different criteria, such as warranty cost, manufacturers' reputation, human safety and environmental damage. To this end, methods such as decision tree analysis [11], portfolio management [12] and Multi-Criteria Decision-Making methods (MCDM), may be applied.

Warranty risk mitigation is concerned with the application of pre-specified mitigation plans in response to emerged warranty risks. Such plans aims to avoid the occurrence of risk, mitigate the impact of risk, transfer risk or retain risk. Some factors are essential to be considered to opt the appropriate plan: for example, (1) the severity of a consequence, (2) cost needed to deal with the risk, (3) required time, (4) warranty programme context, and (5) the impact of a consequence.

Warranty risk monitoring and review is essential in controlling the identified warranty risks. Consequently, such risks are periodically evaluated to understand whether or not they are within the controlled regions or need further actions.

III. QUESTIONNAIRE ANALYSIS

In order to better understand WaRM tools used in practice, we surveyed warranty decision makers. A questionnaire, including 9 questions, was designed and then distributed to organisations of three types: suppliers, OEMs and dealers, in the automotive industry in the UK. These questions include two main sections, (1) respondents and their organisations' information, and (2) the existing WaRM tools used in their firms. Out of 70 questionnaires that were distributed by Qualtrics (https://www.qualtrics.com), 40 respondents were collected. The survey results are analysed in this section.

A. Organisations and the Respondents' Information

This subsection tries to understand the firms and the experience of the respondents.

Figure 1 shows the revenue distribution of the organisations that the respondents were working for: Most (i.e., 32%) of the respondents were from firms with revenue less than $100 million. Figure 2 shows their current management levels: the majority (60%) of respondents are in the middle-level management. Their experiences are grouped into four categories, and the large portion (51%) is the group of over-10-years' experience (see Figure 3). It is important in this research to survey those people who have a long period of experience as the hazard identification process relies heavily on the decision makers' experiences.

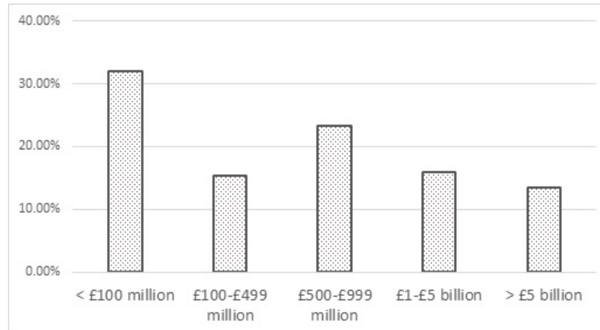

Figure 1. Organisations sizes.

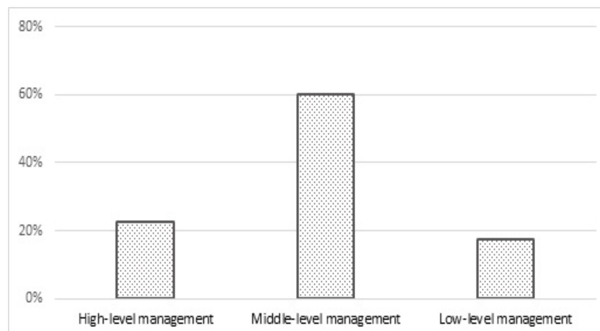

Figure 2. The management level of respondent.

B. Tools for hazard identification and risk assessment

To gain a better understanding of the existing WaRM in the automotive industry in the UK, this subsection aims to survey tools used in identifying warranty hazards and assessing their associated risks. Hence, the respondents were asked "Which tools are used by your organisation to identify warranty hazards?" Figure 4 shows that the most common tool (16%) used by their organisations is the root cause analysis technique, followed by both techniques, checklist analysis (15%) and information gathering (15%), respectively. The effectiveness of such tools in identifying warranty hazards relies on the accessibility to the required data at the proper time. For example, root cause analysis requires time to identify product failure causes and find the solutions accordingly 04 March 2019. Such a technique requires detailed information from the warranty services provider (dealer in this research) about product failures (e.g., failure symptoms, usage status, etc.). Unfortunately, collaboration among the organisations of the three types are often insufficient. Additionally, it takes time for the OEMs to aggregate the required information and then pass it to other parties (e.g., suppliers).

With regard to warranty risk assessment, the respondents were asked about the existing tool(s) used to assess warranty risk.

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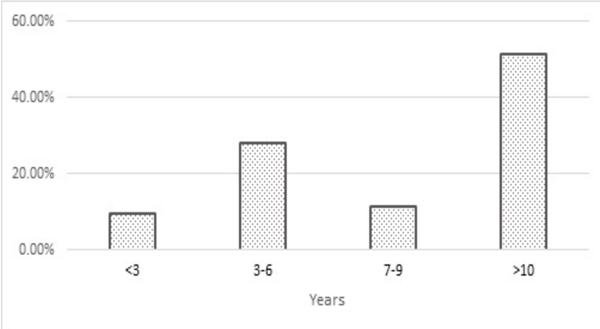

Figure 3. The respondents' experiences.

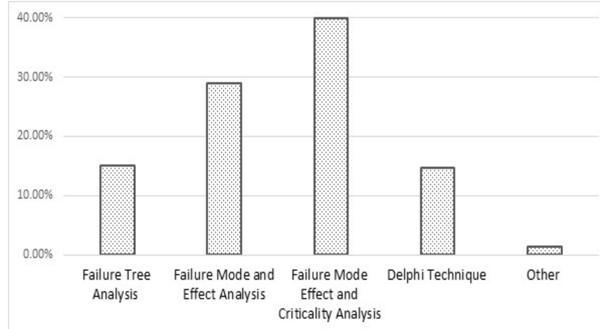

Figure 5. Warranty risk assessment tools.

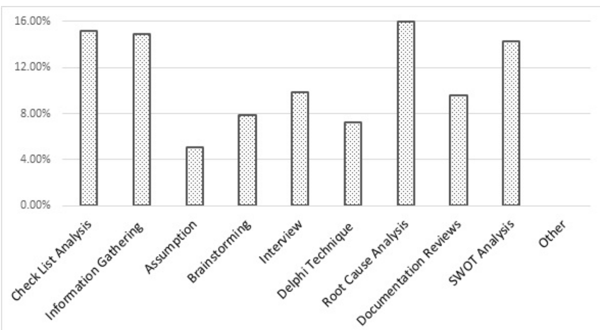

Figure 4. The existing hazards identification tools.

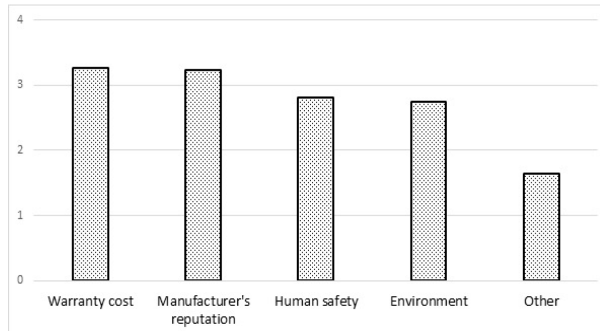

Figure 6. Criteria influenced by warranty risk.

Figure 5 shows that the most common (40%) technique used to assess warranty risk is FMECA, followed by FMEA (29%). The respondents were also asked "What are the limitations of the existing tool(s) used to assess warranty risk?" in order to determine the weaknesses. They listed different limitations, and mainly focused on the importance of updating the existing tools by taking the advanced technology into consideration. Additionally, the time issue required to process and access such tools is a challenge, these tools are unable to detect warranty hazards at the early stage of the product's lifecycle. For example, some of their answers regarding the limitations of such tools are: "Require human interaction" and "risks tend not to be known until an incident has happened on a recurring basis, and the tools do not always identify this as a risk". These responses imply that such tools need to be improved to identify hazards systematically, though some said: "there are no limitations".

Once a warranty incident has occurred, its impacts can be analysed based on different criteria. Therefore, the respondents were requested to answer this question "Once a warranty incident has occurred, what are the top criteria that can be severely influenced?" and they were asked to choose the impact severity level from "None" to "Catastrophic" for each criterion. From Figure 6, it can be seen that warranty risks have a medium to a severe impact on warranty costs and the manufacturer's reputation. On the other hand, the impact of such risks on human safety and environment ranges from minor to medium. The respondents were also asked about their warranty risk mitigation plans. Generally, they use different techniques, which can be grouped into (1) mitigation plans, such as recall, insurance, manufacturer support, and problem diagnosis; (2) software, such as CRM (customer relationship management); and (3) methods, such as Delphi, historical data collection and experience.

IV. A WaRM Framework

The ISO 31000 risk management framework [13] can be adopted in the development of a WaRM framework. As a result, a WaRM framework, as shown in Figure 7, is developed and interpreted in the following.

1) Determining the internal and external stakeholders who should be communicated or consulted with to gain inputs for each step of the framework. The engineering, marketing, finance, legal and accounting departments are examples of internal stakeholders, whereas suppliers, dealers, and distributors are examples of external stakeholders who may affect the decision of managing warranty risk. The communication and consultation is a continuous process through all the WaRM steps. It is important to understand the objectives of the stakeholders. Accordingly, such objectives can then be considered in setting a warranty risk plan.
2) Setting a warranty risk plan by determining warranty programme objectives and the factors that influence the achievement of such objectives. It is also important to determine the mitigation plans for each potential hazard by consulting experts or learning from the similar cases occurred at competitors.
3) Collecting hazard-related data from different sources. This step is the cornerstone in this framework as the warranty programme involves a high level of uncertainty, due to the complexity of products and the long warranty period, which makes it difficult to be planned at the previous

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steps. Additionally, since warranty management relates many parts of the manufacturer, identification of warranty hazards becomes more challenging. As such, this step is divided into four phases.

- *Data collection*: Data should be collected from all stakeholders, including the internal and external stakeholders. Due to difficulties in obtaining real-time data from these stakeholders, other sources of data such as customers' comments posted on the social media can be a good source. Combining information of both sources can improve the efficiency of the process of warranty hazard identification.
- *Data cleansing*: The collected data may include noisy data that are incompatible with the manufacturer database system, so one needs to pre-process and cleanse the data for further processing.
- *Data analysis*: The acquired information needs analysing to identify warranty hazards.
- *Classification*: The classification of the identified hazards is then used to facilitate the rest steps of WaRM. For example, the hazards can be broadly classified warranty hazard design related, manufacturing related, warranty-servicing related, customers related or information related hazards.

4) Assessing warranty risk associated with the identified hazards based on their likelihood (frequency rate) and their consequences severity of the risks based on some criteria. At this stage, the identified hazards will be assessed to find the associated risks. As such, the probability of each hazard will be assessed according to its frequency. Then, its impact on different criteria will be assessed based on the decision makers' experiences. Some tools can be adapted such FMECA, FMEA and others. Based on the result of questionnaire data analysis, it is found that the most common tools used to assess warranty risk is FMECA.
5) Evaluating the risks, which includes prioritising and ranking the risks based on their severity in terms of the given criteria. The warranty decision makers can then evaluate the risks and decide the acceptable and unacceptable ones. MCDM methods may be adapted to identify the local priority of such risks and the overall priority, which is used to determine and rank the risk among others. The analytic hierarchy process (AHP), for example, is one of the most commonly used MCDM tools and its application is vast in risk assessment and evaluation.
6) Mitigating the risks based on the outcomes of the above Steps 3) & 4) and based on the mitigation plans set in Step 2). Once the probability and impact of each risk are determined, they can be visualised. There are some tools can be used to perform this task, such as the risk matrix. It is important to monitor warranty risk on a real-time basis in order to detect failures at the early stage of products' lifecycle.
7) Visualising risks to gain a better understanding of the monitoring process and the warranty risk plan. The monitoring and review step is a continuous process with the all WaRM steps. For example, a warranty risk plan including procedures liabilities documentation and others need updating in response to the new changes. Likewise, the approaches used to identify, assess, evaluate and mitigate warranty risk should be updated, if necessary, according to such changes.

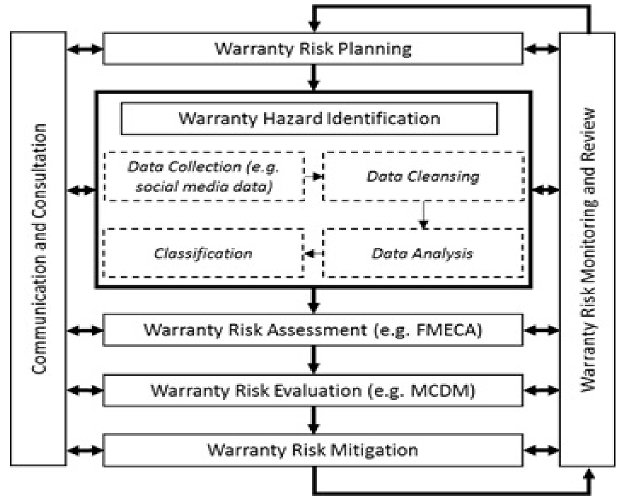

Figure 7. WaRM framework.

V. Identifying hazards from social media

Nowadays, a huge volume of information has been generated over the Internet. Many people share their unique interests and opinions through different platforms on the Internet, such as Twitter, Facebook, Instagram, YouTube, among others. Such information can reflect their experiences or complaints towards products, services and so forth. Therefore, such information is highly important and useful to different stakeholders, including manufacturers or warranty services providers. As such, analysing those data can provide useful insights and aids in developing products and improving organisations' strategies.

Conventionally, manufacturers rely on warranty data to analyse the abnormal events and then make decisions accordingly. This process, however, may take a long period (up to 2 months [14], say), which may lead to undesired consequences. As such, social media data can be used to obtain real-time information about product performance, which can help in detecting warranty hazards (e.g., product failure, service quality, etc.) at the early stage of product's lifecycle. Here, in the following, Twitter data will be used as an example of an early warning tool to identify warranty hazards. Twitter is a micro-blogging service which allows users to publicly and promptly write a tweet.

A. Illustration of the WaRM Framework

In this section, the proposed WaRM is validated through Twitter data following the process mentioned above.

Warranty risk planning, there exist several methods such as project network diagrams, design structure matrices (DSM) and others can be adapted to set a warranty risk plan. Warranty hazard identification is processed through four phases:

1) identifying the source of data and collecting data;
2) cleansing and analysing the collected datasets to obtain useful information in relation to warranty hazards;
3) analysing the cleansed data to find the characteristics of hazards;

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4) classifying warranty hazards into design-related, manufacturing-related, logistics-related, warranty-servicing-related, customer-related and information-related hazards.

To apply the phases mentioned above, we collect data in relation to Ford Fiesta issues from Twitter. Ford Fiesta is one of the most commonly used cars that were sold globally in 2016. Some of its users complained product failures on Twitter. As mentioned before, while the proposed framework should be validated on the basis of real-world data/cases, more than 100 thousand tweets have been collected from Twitter based on some keywords. These keywords were determined based on analysing 300 comments posted by customers on different forums indicating vehicles' issues. After analysing such comments, the common keywords are failure, fault, fail, failed, break down, breakdown, service, warranty and problem among others. The collected tweets was then cleansed, including replacing blank spaces, removing punctuations, removing links, removing tabs and removing blank spaces.

It is also important to point out that there are duplicated data in the collected dataset, which results from the retweets, made by different users, and which are not deemed as duplicated tweets. As such, during the process of cleansing, they were kept as the main part of this dataset because they may reflect the concerns of other twitterers. As a result of the data pre-processing stage, around 44 thousand tweets are kept, from which tweets 23 thousand tweets are related to the research question.

Although this dataset gives information about the different warranty hazards relating to Ford Fiesta 2016, we list the four most frequently complained hazards in the following.

1) Transmission failure: The word frequency indicating this issue is 7129, which forms the highest complaint about the Ford Fiesta 2016. Customers have commented on this issue in many tweets, for example, "I experienced a problem with transmission Ford Fiesta 2016, it is lurching". In this dataset, alternative terms were used to describe this issue. For example, some tweeters have used "gearbox" where others used "gear" instead.
2) Acceleration failure: This is the second most complained issue in Ford Fiesta 2016. They complained, for example, that "♯Ford Fiesta 16, I faced the problem of acceleration twice last week, it was slow". The term "acceleration" has appeared in this dataset for 3627 times, which may need the interventions from the manufacturer.
3) Intermission failure: Some customers also complained about this issue during the taking off. They claimed that in their tweets "♯Ford Fiesta 2016 performance is not as we expected, there is an intermittent shudder when taking off". The intermittent term has been mentioned for 2941 times, all of which indicate this problem.
4) Rear door failure: Also, some customers have complained that the rear door might have a safety problem. They claimed that "Rear door of ♯Ford Fiesta may cause a higher risk of injury". As this term "rear door" has been mentioned 2850 times in this dataset, it needs paying attention.

It is important to note that there are other potential warranty hazards in this dataset but they showed less importance based on the words frequency. In order to assess the risks associated with the identified warranty hazards, the probability of each hazard will be multiplied with the expected consequences on the relevant overall of the four mentioned criteria (warranty cost, time, customer's satisfaction and firm's reputation), respectively. Consequently, those risks can be prioritised and ranked.

The severity of the risk in the identified warranty hazards varies from one manufacturer to another. Additionally, in terms of the aforementioned criteria, they may be different as well. Therefore, it is difficult to estimate the impact of such consequences unless domain experts in one firm are consulted in order to obtain their opinions regarding the impact of each hazard on each criterion.

To sum up, through the analysis of the dataset, a number of the identified warranty hazards have been observed. Mainly, customers complained about Transmission, Acceleration, Intermission and Rear Door. The frequency of such problems was 7929, 3627, 2941 and 2850, respectively, as shown in Table I.

TABLE I. THE PROBABILITY OF THE RISK ASSOCIATED WITH WARRANTY HAZARD

	Values	*Probability*
Transmission	7929	46%
Acceleration	3627	21%
Intermission	2941	17%
Rear door	2850	16%
Sum	17347	100%

From Table I, it can be seen that the four identified risks are related to the manufacturing risks which often raise warranty costs and lead to customers' dissatisfaction. Among the four hazards, the transmission in Ford Fiesta 2016 accounts for 46%. As a result, such a risk requires immediate intervention by providing the required spare parts, scheduling of maintenance and allocating the required fund and efforts, for example. The rest of the identified hazards should also be carefully checked although their probabilities are not so large as that of the transmission. That is, they should be controlled to ensure that the risks are under their acceptable levels.

In order to prioritise and rank the identified warranty risk, some tools may be used to visualise the magnitude of the identified risk, such as word cloud and link graph, as shown in Figures 8 and 9, for example.

Figure 8. Word cloud for the Ford Fiesta 2016 related Twitter data.

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Figure 9. Link graph for the Ford Fiesta 2016 related Twitter data.

VI. Conclusions

Managing warranty risk is crucial to protect manufacturers from a huge warranty cost. This paper has analysed the literature and surveyed some decision makers in the automotive industry in the UK to obtain an in-depth understanding of the WaRM in practice. A generic WaRM framework was then developed.

The main findings are that the root cause analysis is the most widely used tool in identifying warranty hazards, and the FMECA technique is the most commonly used tool for assessing warranty risk in the automotive industry in the UK. In addition, warranty cost and the manufacturer's reputation are the most susceptible criteria to warranty risk.

To demonstrate the utility of social media data in identifying warranty hazard, we collected and then analysed Twitter data as an example of a real-time warranty identification tool and analysed the collected data.

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Enterprise Architecture Framework Selection Criteria: A Literature Review

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***Abstract* – To remain competitive in today's highly competitive global markets, organizations must be able to continually transform themselves, doing so at an ever-increasing pace. To succeed in their digital transformations, more and more organizations are adopting an enterprise architecture practice and related frameworks. Unfortunately, there is a plethora of EA frameworks (EAFs) available to choose from and the limitations of the EAF comparison matrices still make it difficult for organizations to select the right one. As a first step to fill this gap in the literature, this study proposes to review the academic and professional literature on the subject. The results of our scoping literature review show that there are nine criteria commonly used to compare/select EA frameworks (taxonomy, meta-model, accelerators, development process, maintenance and evolution process, principles, governance process, architecture practice and simplicity) and that the operationalization of these criteria remains elementary. We hope that our contribution will help organizations improve the success rate of their information technology-enabled organizational transformation.**

Keywords-Enterprise architecture; framework; selection criteria.

I. Introduction

In today's global economy, competition between organizations is becoming fiercer. The term 'hypercompetitive' is often used to describe this global economic market in which competition between organizations is rapidly escalating [1]. The growing competition in this landscape is mainly fueled by the increasing pace of technological innovations along with the adoption of a liberal economy by more and more developing countries [1]-[3].

To remain competitive in today's highly competitive global markets, organizations must be able to continually transform themselves and rethink every aspect of their operations, doing so at an ever-increasing pace [1][4]. An organizational transformation (OT) is an organization-wide program that aims to substantially change an organization's structure and/or practices [5] in order to enhance performance and boost organizational health [6]. A digital transformation, in addition, is an organizational transformation that changes how value is created and delivered to customers by integrating digital technologies into all areas of the organization [7].

Orchestrating an organizational transformation is extremely difficult. Indeed, the numerous challenges organizations face while transforming themselves are so important that most transformation endeavors are failures. According to a recent Mckinsey Global Survey, which garnered responses from 1,946 executives representing the full range of regions, industries, company sizes, functional specialties and tenures, only 26 percent of respondents mentioned that the transformations they're most familiar with have been very or completely successful at both improving performance and equipping the organization to sustain improvements over time [8].

Practitioners and researchers have proposed a number of initiatives and best practices that organizations can use to alleviate the challenges they face and increase the success rate of their (digital) transformation endeavors (e.g., top down direction setting; broad-based, bottom up performance improvement; cross-functional core process redesign; change management; and an integrated management system that links strategy formulation and planning with operational execution) [9]-[11].

An enterprise architecture practice is one of the best practices organizations can use to transform themselves. Indeed, recent research has demonstrated that an enterprise architecture practice can facilitate (digital) organizational transformations by managing technological complexity and setting a course for the development of their companies' IT landscape [12].

EA presents an integral view of the enterprise and greatly facilitates the alignment of various components of the organization [13][14]. An EA practice is defined as a set of coherent services, roles and people with predefined responsibilities who participate in the creation, maintenance and evolution of the EA. The resources responsible for this practice participate in organizational decisions, their implementation and their post-implementation evaluation [15].

An EA practice can support an organizational transformation in several ways. Amongst the most important, we note: (1) engage top executives in key decisions; (2) emphasize strategic planning; (3) focus on business outcomes; (4) use capabilities to connect business and IT; (5) develop and retain high-caliber talent; and (6) reduce IT operating costs through standardization and reutilization; (7) increase flexibility and agility; (8) increase innovation; and (9) reduce the complexity of the organization [12][16]-[18].

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Over the years, a great amount of progress was made in the field of EA. Indeed, many frameworks were developed to help organizations start their EA practice. An EA framework is defined as a coherent set of principles, methods and models used by practitioners to design, implement and maintain an enterprise's organizational structure, business processes, information systems and infrastructure [16]. EA frameworks can provide organizations with (1) one or more meta-models to describe the EA; (2) one or more methods used to design and maintain the EA; and (3) a common vocabulary and optional reference models used as templates or blueprints [14]. EA frameworks can also be used as tools to access, organize and communicate various architectures that describe key components of the enterprise [19][20].

There are over 25 EA frameworks in the current literature, and their number is growing [16][17][21]. The ever-increasing number of frameworks makes the selection process more and more difficult for organizations [22]. To help businesses select the right framework, several comparison matrices have been proposed in the literature [19][20][22]-[27]. For example, [19][26][27] compare many popular frameworks. Franke *et al.* [24] compare mainly frameworks targeted for governmental use. And, [20] use the Zachman framework as a basis to compare other frameworks that are mostly used by governments.

Despite their relevance, the EAF comparison matrices currently available have several limits. Most importantly, they rely on somewhat different criteria making it difficult for organizations to identify the right set of criteria to guide their EAF selection process. These limits still make it difficult for organizations to choose the right framework to support their EA practice.

As a first step to fill this gap in the literature, this study proposes to review the academic and professional literature on the subject to identify the key criteria used by academics and practitioners to compare/select EA frameworks. The results of our scoping literature review show that there are nine criteria commonly used to compare/select EAFs and that the operationalization of these criteria remains elementary. We hope that our contribution will help organizations improve the success rate of their information technology-enabled organizational transformation.

The rest of this article is organized as follows. First, in Section 2, we describe the research methodology used to conduct our literature review. Second, in Section 3, we expose the findings of our scoping literature review. Lastly, Section 4 concludes the article by exposing the next step of our research program.

II. METHODOLOGY

Researchers can adopt several types of literature reviews to attain their research objectives [28]. In the particular case of this study, we relied on a scoping review. We relied on this type of review as the objective of this research is to examine the extent, range and nature of research activities on the subject [29] while focusing more on the breadth of coverage of the literature than the depth of the coverage [30] and being as comprehensible as possible [31].

As such, and as a first step, we focused our research efforts on articles published in the IT seniors scholars' basket of eight journals (European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems and MIS Quarterly), as well as three important professional journals in management - Harvard Business Review, Sloan Management Review, and McKinsey Quarterly. To carry out our research, we selected the ABI / INFORM Global (Proquest), as well as the Business Source Complete databases, since, when taken together, they gave us access to the previously identified journals. We also determined the search criteria to identify the articles to be included in our analysis. Specifically, the terms "enterprise architecture", "selection criteria" and "comparison matrices" were retained as search criteria. Both conceptual and empirical articles identified using these criteria were retained.

Then, as a second step, we also used Google Scholar and the ABI/INFORM Global (Proquest) database to search for other relevant articles in order to expand our research beyond the original set of articles identified. Both of these tools allowed us to conduct several searches using the same search terms identified previously and to identify articles from a wide range of scientific journals, international conferences and professional publications. Again, both conceptual and empirical articles were retained.

Then, as a final step, we read the abstracts of the articles found in steps 1 and 2. This allowed us to identify a subset of articles that merited to be scrutinized in more detail. Anchored on this subset of articles, we then used a backward approach to identify and examine the references works cited in the articles we found [32] and a forward approach to identify and examine other articles that cited all the previously found articles [32]. This last step allowed us to ensure that no important publications were forgotten and therefore that we had the widest possible coverage of the literature on EAF selection criteria.

Although our findings exposed in the following section stem from a fairly small set of articles, our scoping review allowed us to review more than 120 articles in the field.

III. RESEARCH FINDINGS

This section, which presents the findings of our scoping literature review, is subdivided into two subsections. The first presents the EAF selection criteria identified in the literature while the second presents how these EAF selection criteria have been operationalized as of today.

A. EAF Selection Criteria in the Literature

Our scoping literature review allowed us to identify eighteen articles that identified EAF selection criteria and/or proposed EAF comparison matrices (cited in order of appearance in the following nine Tables). These articles enabled us to identify nine criteria: *taxonomy, meta-model, accelerators, development process, maintenance and evolution process, principles, governance process, architecture practice and simplicity*.

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The *taxonomy* criterion evaluates how an EAF defines, describes and classifies all the models that compose the enterprise architecture [19][24]. The *meta-model* criterion evaluates how an EAF defines design rules and all components of an EAF along with their relationships [24][26][34]. The *accelerator* criterion evaluates if the EAF comprises specialized software tools, procedures, generic models, templates, patterns or blueprints to accelerate the development of the EA (adapted from) [24][33][35]. The *development process* criterion evaluates if the EAF includes a step by step method to design an enterprise architecture that is aligned with the strategy of the organization. The *maintenance and evolution process* criterion evaluates if the EAF comprises processes for maintaining and evolving the enterprise architecture and to keep it updated with the recent changes in the IT/business landscape of the organization [23][24][36]. The *principles* criterion evaluates if the EAF expresses the philosophy and rules of an organization that guide the design and evolution of the enterprise architecture [37]. The *governance process* criterion evaluates if the EAF includes processes to carry out the review of various architecture and maintenance projects to ascertain their compliance with architecture principles and business-IT alignment [24][34][36][38]. The *architecture practice* criterion evaluates of the EAF promote the creation of a coherent set of services, processes, roles as well as bodies with responsibilities assigned to them and who participate in the creation, maintenance, modification and evaluation of the EA [39]. The *simple* criterion evaluates if the EAF is useable by internal resources with limited EA and IT knowledge without needing the help of external experts (adapted from) [13]. The following nine tables list the terms used in the articles identified in the literature review referencing the nine criteria we identified. In cases where the article didn't present a clear definition for a term, our comprehension of this term is listed instead and noted by (*).

TABLE I. TAXONOMY EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Taxonomy Completeness	Evaluates how well the practitioner can use the methodology to classify architectural artifacts.	[19][22]
Planner View	Classifies models based on the 'Planner' perspective of the Zachman framework.	[20]
Owner View	Classifies models based on the 'Owner' perspective of the Zachman framework.	[20]
Designer View	Classifies models based on the 'Designer' perspective of the Zachman framework.	[20]
Builder View	Classifies models based on the 'Builder' perspective of the Zachman framework.	[20]
Subcontractor View	Classifies models based on the 'Subcontractor' perspective of the Zachman framework.	[20]
User View	Classifies models based on the 'User' perspective of the Zachman framework.	[20]
What? Abstraction	Classifies models based on the 'What?' abstraction of the Zachman framework.	[20]
How? Abstraction	Classifies models based on the 'How?' abstraction of the Zachman framework.	[20]
Where? Abstraction	Classifies models based on the 'Where?' abstraction of the Zachman framework.	[20]
Who? Abstraction	Classifies models based on the 'Who?' abstraction of the Zachman framework.	[20]
When? Abstraction	Classifies models based on the 'When?' abstraction of the Zachman framework.	[20]
Why? Abstraction	Classifies models based on the 'Why?' abstraction of the Zachman framework.	[20]
Best of Breed / Best Fit	Evaluates if the framework can be identified as the best for a certain need/context/domain. (*)	[22]
Concept: Artifacts	The framework describes various components of an organization. (*)	[23]
Modeling: Different Views	The framework classifies models in different views. (*)	[23]
Modeling: Consistency	The definition, description and classification of the models is consistent. (*)	[23]
Modeling: Dynamic	Models describe the dynamic nature of an organization. (*)	[23]
Model Taxonomy	Defines, describes and classifies all models that compose the enterprise architecture.	[24]
From Biz to Technology	Evaluates how well the framework describes and classifies various components of the enterprise based on the 'User' perspective of the Zachman framework.	[25]
Integration in Function	Evaluates how well the framework describes and classifies various components of the enterprise based on viewpoints related to interoperability, flexibility, reusability, scalability, portability, standardization, communication and complexity reduction.	[25]
Layer Decoupling (Clear description)	Evaluates how well the framework classifies models based on the Zachman framework perspectives 'Planer', 'Owner', 'Designer', 'Builder' and 'Sub-contractor'.	[25]
From Business Driver to Model	Evaluates how well the framework describes and defines information related to business drivers.	[25]
Architecture Analysis	Describes a set of viewpoints to guide the collection and analysis of information for making architecture choices.	[27]
System Model	Describes major components of the system.	[27]
Information Model	Describes data models, data transformation and data interfaces.	[27]
Computational Model	Describes the functional aspects of the system, system process flow as well as system operations, software components and interactions.	[27]
Software Configuration Model	Describes how software is packaged, stored, configured, managed and shared.	[27]

Software Processing Model	Describes how software processes, software threads and run-time environment are structured.	[27]
Implementation Model	Describes physical system structures such as operating environments, hardware components and networking components of the system.	[27]
Platforms	Describe platform software such as operating systems, hardware and networking components, protocols and standards.	[27]
Business Model	Describes business models, business requirements, business process, system roles, policy statements.	[27] [33]
Blueprint	Defines the current and future environment of an organization.	[39]
Modeling	Describes the components of an EA to facilitate its understanding by various stakeholders.	[40]

TABLE II. META-MODEL EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Meta-model	Describes the EA artifacts and their relationships. (*)	[14]
Metamodel	Formally defines the allowed contents of the architectural models, providing semantic rigor.	[24]
Metamodel	Describes the design rules and the structure of the system by using a common language for all models.	[26]
Metamodel	Specifies the consistency and the relationships of the various architecture artifacts that are on different layers and different views of the EA.	[34]

TABLE III. ACCELERATORS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Reference Model	Used as templates or blueprints for EA design and evolution.	[14]
Reference Model Guidance	Evaluates how useful the methodology is in helping the practitioner build a relevant set of reference models.	[19][22]
Prescriptive Catalog	Refers to how well the framework guides the practitioner in classifying and setting up a database of reference models.	[19][22]
Interoperability / Flexibility	Framework offers procedures or tools to allow interoperability with other frameworks. (*)	[22]
Concept: Repository	Evaluates how well the framework helps practitioners by supporting a repository of various EA artifacts. (*)	[23]
Reference Model	Evaluates how well the framework supports capturing knowledge from previous modeling tasks.	[24]
Patterns	Evaluates how well the framework supports practitioners by supplying patterns.	[24]
Building Blocks	Evaluates how well the framework provides building blocks to facilitate the task of practitioners.	[24]
Reference Model / Standard	Evaluates how well the framework helps practitioners by supplying a list of reference models and standards to follow. (*)	[25]
Technique	Evaluates if the framework supplies techniques (Techniques are procedures required to accomplish a task during the development of an EA) to aid practitioners.	[26]
Architecture Models	Provide consistent patterns and standards to document architecture specifications for the planning, management, communication and execution of activities related to system development.	[27]
Architecture Knowledge Base	Evaluates how well the framework helps practitioners by providing a consistent representation and a repository of design and architecture design rationale.	[27]
Visualization tool	Evaluates how well the framework is supported by specialized tools helping the practitioners visualize various parts of the EA.	[33]

TABLE IV. DEVELOPMENT PROCESS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Design Method	Step-by-step process describing the development of the EA creation. (*)	[14]
Partitioning Guidance	Evaluates how well the development process will guide the practitioner into effective autonomous partitions of the enterprise.	[19]
Business focus	Evaluates how well the methodology will focus on using technology to drive business value.	[19]
Process Completeness	Evaluates how well the development process guides the practitioner through a step-by-step process for creating an enterprise architecture.	[19][22]
Planning Phase	The steps of the development process have the equivalent of the SDLC Planning phase.	[20]
Analysis Phase	The steps of the development process have the equivalent of the SDLC Analysis phase.	[20]
Design Phase	The steps of the development process have the equivalent of the SDLC Design phase.	[20]
Implementation Phase	The steps of the development process have the equivalent of the SDLC Implementation phase.	[20]

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Business-IT alignment / Business focus	Evaluates if the framework mandates the alignment of business and technology with a focus on business. (*)	[22]
Process: Requirement	Evaluates how well the development process supports stakeholder requirements. (*)	[23]
Process: Step by Step	Evaluates how well the development process is detailed. (*)	[23]
Concept: Alignment	Evaluates if the framework mandates the alignment of business and technology. (*)	[23]
Concept: Strategy	Evaluates how well the framework considers the strategy of an organization as development process inputs. (*)	[23]
Process: Detailed Design	Evaluates how well the development process produces detailed outputs. (*)	[23]
Process: Implementation	Evaluates how well the development process supports the implementation of the EA. (*)	[23]
Architecture Development Process	Step-by-step process describing the development of the EA creation.	[24]
Integration Method	Evaluates how well the development process guides the practitioner in integrating the EA into the organization's structure. (*)	[25]
Enterprise Status and Transitional Plan	Evaluates how well the development process guides the practitioner in creating a transitional plan. (*)	[25]
Linkage Model with SDLC	EA models have to be linked with various SDLC methodology phases.	[25]
From Enterprise to Component	Evaluates if the framework mandates the alignment of business and technology. (*)	[25]
Procedure Model	Describes a set of directives that define the order in which architecture descriptions are derived and transformed.	[26]
Specification Document	Describes the outputs generated during the creation of the EA.	[26]
Business Requirements	Evaluates how well the framework considers users' requirements, functional requirements, data requirements and other business system related requirements as development process inputs.	[27]
Non-functional Requirements	Evaluates how well the framework considers non-functional requirements like availability, reliability, scalability, security, performance, inter-operability, modifiability, maintainability, usability and manageability as development process inputs.	[27]
Information System Environment	Evaluates how well the framework considers budget, schedule, technical constraints, resources and expertise, organisation structure, other constraints and enterprise knowledge base as development process inputs.	[27]
Design Trade-offs	The development process allows for more than one design choice by resolving multidimensional conflicting requirements.	[27]
Design Rationale	The development process documents reasons behind design decisions for future verification.	[27]
Architecture Verifiability	The development process provides sufficient information or explanation in the architecture design for review and verification.	[27]
Architecture Process	Evaluates if the framework has a well-defined process to guide the construction of the EA.	[27][33]
Business Drivers	Evaluates how well the framework considers business goals, direction, principles, strategies and priorities as development process inputs.	[27][33]
Technology Inputs	Evaluates how well the framework considers strategic architecture direction including technology platforms, future architecture, systems interoperability and emerging technology standards as development process inputs.	[27][33]
Development Process	Step-by-step process describing the development of the EA creation. (*)	[39]

TABLE V. MAINTENANCE AND EVOLUTION PROCESS EAF SELECTION CRITERION

Term used within the literature	**Definition of the term used by the authors**	**References**
Evolution Method	Step-by-step process describing the maintenance of the EA. (*)	[14]
Maintenance Phase	Evaluates how well the framework supports the equivalent of the SDLC Maintenance phase. (*)	[20]
Process: Continual	Evaluates if the framework has a well-defined process to guide the continual change of the EA to support the changing landscape of the organization. (*)	[23]
Process: Maintenance	Evaluates if the framework has a well-defined process to guide the maintenance of the EA. (*)	[23]
Architecture Maintenance Process	Step-by-step process describing the maintenance of the EA.	[24]
Architecture Evolution Support	Evaluates if the framework has a well-defined process to guide the evolution of the EA.	[27][33]
Transitional Design	The development process provides designs and plans to support system transition and evolution.	[27][33]
Maintenance Process	Step-by-step process describing the maintenance of the EA. (*)	[39]

TABLE VI. PRINCIPLES EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Standardisation	The organization should prioritize the use of development and architectural standards.	[22][33][37]
Process: Guidelines	Evaluates if the framework defines a list of guidelines and principles to adhere to. (*)	[23]
Architecture Guidelines and Principles	Describes the principles and guidelines to which the EA has to adhere to.	[24]
Scope Integration	The use of the EA has to be efficient and based on the following quality attributes: interoperability, flexibility, reusability, scalability and portability.	[25]
Architecture Definition and Understanding	Mandates the use of standard terms, principles and guidelines for consistent application of the framework.	[27][33]
EA Principles	EA principles give advice on how to design the target architecture by restricting the design freedom of EA transformation projects.	[37][41]

TABLE VII. GOVERNANCE PROCESS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Governance Guidance	Evaluates how much help the methodology will be in understanding and creating an effective governance model for EA.	[19][22]
Concept: Governance	Evaluates how well the framework supports a step by step governance process. (*)	[23]
Modeling: Traceability	Evaluates if the modeling changes can be traced back to the resources who modified a model.	[23]
Architecture Compliance Guideline and Review Process	Step by step process that is instrumental in keeping the construction of an organization's architecture aligned with stakeholder's requirements and can be seen as a support when making architectural decisions.	[24]
Conformance	Evaluates how well the framework supports the verification of the conformance to the EA of various project implementations.	[33]
Clinger-Cohen act Compliance (CCA)	Evaluates how well the framework complies with the Clinger-Cohen law of the USA.	[33]
Governance	Assures the consistency and timeliness of enterprise architecture process outputs using various control mechanisms.	[36]
EA Governance	Mechanism that (1) defines key architecture roles, (2) involves key stakeholders, (3) monitors the application of EA standards and (4) centralizes IT decision making.	[38]

TABLE VIII. ARCHITECTURE PRACTICE EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Architecture Practice	Coherent set of services, processes, roles and bodies with responsibilities assigned to them who participate in the creation, maintenance, modification and evaluation of the EA.	[15]
Practice guidance	Evaluates how much the methodology helps practitioners assimilate the mindset of EA into an organization and develop a culture in which it is valued.	[19]
Maturity model	Evaluates how much guidance the framework gives the practitioner in evaluating and assessing the effectiveness and maturity of different organizations within your enterprise in using EA.	[19][22][24]
Architecture Roles/Skills	Describes the roles and skills required for the development and maintenance of the EA.	[24]
Roles	Describes the required roles to participate in EA activities.	[26]

TABLE IX. SIMPLICITY EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Simplicity	To be considered simple, an EAF has to be useable by internal resources with limited EA and IT knowledge without needing the help of external experts.	[13]
Vendor neutrality	Evaluates how likely the organization is to get locked into a specific consulting organization by adopting this methodology.	[19]
Information availability	Evaluates the amount and quality of free or inexpensive information about this methodology.	[19][22]
Modeling: Easy to use	Evaluates if modeling outputs are easy to use. (*)	[23]
Modeling: Easy to learn	Evaluates if modeling tasks are easy to learn. (*)	[23]
Modeling: Complexity	Evaluates if modeling outputs are complex. (*)	[23]

B. Operationalization of EAF Selection Criteria in the Literature

Amongst the eighteen articles that identified EAF selection criteria and/or proposed EAF comparison matrices, only nine of them provided the operationalizations of their criteria [19][20][22]-[27][33]. While these operationalizations represent a step in the right direction, the scales proposed to evaluate each criterion are very simplistic. Indeed, most of the scale proposed (7 articles out of 9) only measured if a specific criterion is supported, partially supported or not supported by the EAF [20][23]-[27][33]. In this list of nine articles, only the ones from [19] and [22] contain scales that properly operationalizes the selection criteria. Indeed, using a range of 1 to 4 (1 being very poor to 4 being excellent), [22] polled managers from various companies about their satisfaction level of the EAF being used in their organization while [19] used a very similar scale to evaluate various EAFs. Yet, the operationalization of the selection criteria in these two articles are based on subjective assessment and not on an objective instantiation or threshold.

In sum, the shortcomings in the operationalization of the EAF selection criteria in articles comparing these frameworks hinders the selection process of organizations [4][22].

IV. Conclusion

This research has enabled us to identify the nine criteria commonly used to compare/select EA frameworks: *taxonomy, meta-model, accelerators, development process, maintenance process, principles, governance process, architecture practice* and *simplicity*. This research has also shown that the operationalization of these criteria remains elementary.

Findings of this research will be used as inputs to the following phases of our research program. The next phase of our research program will aim to use the criteria identified in this research to compare the most popular EAF available today in order to validate the pertinence and quality of these criteria. The objective of the following and last phase of our research program will then be to develop and test a complete artifact comprised of the complete set of criteria, as well as their operationalization (metric) to help organizations big and small to choose the EAF that best suits their needs. Ultimately, we hope that findings from our research program will help organizations succeed in their information technology-enabled organizational transformation.

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A Goal-oriented Method for Requirements Prioritization

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***Abstract*—In today's global economy where organizations must constantly transform themselves, prioritization of information systems (IS) requirements is crucial. Different techniques have been proposed to automate the IS requirements prioritization process. Still, existing techniques suffer from a number of limitations and their implementation are mostly informal. This work aims to design a novel method for IS requirements prioritization. Our method is based on the Goal-oriented Requirement Language (GRL), which links requirements to the business objectives/goals of the organizations. Our method allows stakeholders, such as business analysts to model requirements and objectives using GRL and then evaluate the impact of requirements choices on organizations' objectives. In this paper, we present the principles underlying our method for automating the prioritization of IS requirements and discuss issues for future research.**

Keywords—Requirements Prioritization; Requirements Engineering; Goal-oriented Requirement Language.

I. INTRODUCTION

The success of transformation projects is conditional to the proper management of the requirements of Information Systems (IS) [1]. Indeed, with organizations often facing time, resource and budget constraints, IS projects are more often than not delivered late and over budget since they have to implement a large number of requirements [1]. Furthermore, since enterprise resources are limited, it is becoming increasingly difficult to implement all the elicited requirements [2] [3]. Thus, to help stakeholders improve IS projects performance, organizations must select the most critical requirements to implement [1]. Requirements prioritization helps to overcome this challenge by classifying requirements according to their relative importance [1][3][4]. According to Mulla and Girase [1], requirements prioritization optimizes Information Technology (IT) investments by targeting the most important functionalities. In addition, conflict situations are often raised during the elicitation process because of stakeholders diverse interests, needs and priorities. Stakeholders go through negotiations in order to select the most important business needs to be addressed, which implies that requirements need to be prioritized [5]. According to [4], requirements prioritization gives the right tools to decision makers to solve conflicts, take strategic decisions in order to control IT project costs, deliver value and optimize the return on invested resources.

The importance of requirements prioritization has motivated research initiatives and many approaches were proposed including [3][4][6][7]. This research main objective is to propose a unified IS requirements prioritization method. A prioritization approach is unified when it meets quality attributes, such as usability, transparency, efficiency, adaptability, flexibility and genericity. Our approach is based on a goal-oriented method that allows to model and evaluate the impact of requirements choices on the organization objectives. The proposed method is generic since it can be used by organizations regardless of their activity sector, their specific structure or the nature of their IS projects.

A. The Methodological Approach

We used the Design Science Approach (DSA) to conduct our research project. Hevner and Chatterjee [8] presented design science as a research approach that aims to answer questions related to relevant issues through the creation of innovative artifacts. The design science methodology is articulated around five main activities, namely: Problem identification and motivation, Definition of the artifact objectives, Design and development of the artifact, Demonstration, and Evaluation of the artifact [9].

B. Theoretical and Practical Contributions

This research aims to provide both a theoretical and a practical contribution. From a theoretical perspective, the research will proposes a unified method for prioritizing requirements based on the use of the Goal-oriented Requirement Language (GRL), which is part of the URN (User Requirements Notation) standard [10]. GRL enables the explicit modeling of objectives, requirements, alternatives and their relationships. This is why we chose to use GRL to design and develop a unified method for requirements prioritization. We mean by unified method that it can be applied in different types of IS projects and by different types of organizations, regardless of their size, activity sector, or the technical skill level of the project stakeholders. Hence, the unified method we propose can be adapted to the particular context of any organization without any dependency on situational elements.

The unified method addresses the limits of previously proposed approaches. In [4], Wohlin compared five prioritization techniques on the basis of their measurement scales, the granularity of the analysis they provide, and their level of sophistication. The granularity of the analysis represents

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the level of accuracy of the prioritization results that are presented in the measurement scale. The level of sophistication represents the level of complexity of the assessment on priority of components. The results of this comparison are shown in Table I. According to the author, a value scale is strong when it allows the results to be measured and presented with high accuracy. In other words, the higher the value scale, the more refined is the granularity of the analysis and therefore the more sophisticated the technique (see Table I). As a result, the unified method tends to find a balance between granularity and sophistication.

TABLE I: SUMMARY OF THE PRIORITIZATION TECHNIQUES [4].

Technique	Scale	Granularity	Sophistication
AHP	Ratio	Fine	Very Complex
Hundred-dollar test	Ratio	Fine	Complex
Ranking	Ordinal	Medium	Easy
Numerical Assignment	Ordinal	Coarse	Very Easy
Top-ten	-	Extremely Coarse	Extremely Easy

From a practical perspective, the proposed method helps IS practitioners to improve the quality of their requirements prioritization activity. Today, practitioners use different approaches to prioritize requirements that produce inconsistent results. They cannot simply choose the most sophisticated prioritization techniques since, according to Wohlin [4], the more sophisticated the technique, the more difficult and time consuming is its usage. For Wohlin [4], the solution is to make a compromise between the level of precision in the analysis of the prioritization and the time needed to perform the prioritization. The proposed method offers a good compromise between accuracy and ease of use. Therefore, we believe that by addressing the limits of other methods, we will increase the adoption of the proposed method by IT practitioners.

II. Literature Review

Several scientific papers have proposed approaches to help prioritize IS requirements. The Must, Should, Could and Would (MoSCoW) prioritization technique classifies requirements into four broad categories that designate the overall level of priority of requirements [6]. Some researchers, such as Achimugu *et al.* [2] and Hatton [11] have criticized the MoSCoW technique for its inability to identify the relative importance of one requirement over another. This is an important limit, since the identification of the relative importance provides access to a more detailed level of information on the requirements, which will make it possible to better prioritize and consequently deliver the best system value to the customer [11]. As a result, MoSCoW does not effectively prioritize requirements.

The prioritization process proposed by Kaymaz [7] prioritizes business and IT change requests based on three types of priorities: general, business and IT priorities. In order to establish the business priority, Kaymaz's [7] process uses the FMEA (Failure Mode and Effect Analysis) quantitative tool of the Six Sigma methodology. According to Ashley and Armitage [12], Franklin *et al.* [13], and Shebl *et al.* [14], the results originating from the FMEA tool show a large variance, indicating a lack of reliability and efficiency.

Rahmouni *et al.* [3] proposed a method that prioritizes IS requirements by grouping them according to their similarities, commonalities, synergies, and their technical dependency relationships. According to these authors, their method has limitations because it does not take into account the business objectives.

Despite the number of works proposed to prioritize IS requirements, existing approaches have several shortcomings e.g., the MoSCoW technique [6] is not effective, FMEA-based approaches [7], the method proposed by Rahmouni *et al.* [3], and those presented in Table I lack of usability, reliability and efficiency. In addition, to date and to the best of our knowledge, there is no unified method that prioritizes requirements based on their contribution on business objectives. The contribution of this work is twofold: 1) from a structural perspective, it proposes a novel method for IS requirements prioritization that takes into account business objectives as well as technical and business dependencies; 2) from a usability point of view, this research aims to address the limits of the approaches presented in Table I by proposing a method that is generic, adaptable and easy to use.

III. A Prioritization Approach by Modeling Objectives

To design our method, we had to look for an easy and practical tool, which enables us to both link requirements with business objectives and evaluate the impact of the choice of requirements on objectives. We found that GRL [10] would support the achievement of these research objectives. GRL is standard for goal-oriented modeling. It is part of the URN (User Requirements Notation) standard, a Recommendation of the International Telecommunications Union [15]. GRL makes it possible to model explicitly the objectives, the requirements, the alternatives and their relations. GRL can also model and evaluate the impact of requirements on objectives, allowing stakeholders to observe and understand why some requirements should be prioritized. The explicit modeling makes GRL a tool that supports the evaluation and the analysis of the best compromises between different objectives of stakeholders in a manner to avoid conflict situations. As a result, GRL can help IT managers' decision-making by empowering them to identify the best alternative.

The basic elements of the GRL language are shown in Figure 1. Section (a) of the figure presents the intentional elements of GRL, such as the goals, soft-goals, tasks, and resources. A goal is quantifiable while a soft goal refers to qualitative aspects that cannot be measured directly (e.g., customer satisfaction) [10]. Soft-goals are usually related to *Non-Functional Requirements* (NFR), while goals are related to *Functional Requirements* (FR). Tasks are solutions to goals or soft-goals [10]. The section (b) presents the GRL links, such as the decomposition, contribution, correlation or dependency links [10]. These links are used to connect elements (e.g., NFR, FR, Solutions, etc.,) in the requirement model. An intentional element can be decomposed into sub-elements

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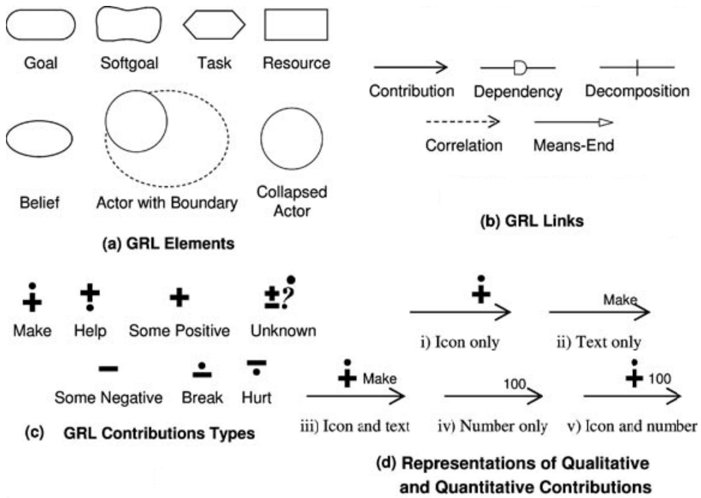

Figure 1: Basic GRL elements [10].

using decomposition links. The correlation links show side effects between the intentional elements. The relationships between the actors are illustrated using dependency links. The section (c) of the figure presents the contribution types used to model qualitative or quantitative impacts of an element on another. These impacts are propagated through the contribution links presented in section (d). In the next sections, we present our method as proposed by Peffers *et al.* [16] for design science works.

IV. The Problem

The starting point for initiating research activities in design science is a specific field problem that emerges from an external environment. In the context of our research, based on our literature review, we noted the importance of prioritizing requirements in organizations. However, despite the many advantages of prioritizing requirements, there are no unified methods for prioritizing requirements. Therefore, we formulated our research problem based on this finding. Although several requirements prioritization approaches exist, they have not been standardized in a manner that the IT community can use them (see Section II).

V. The Artifact: The Prioritization Method

The second step consists of defining the artifact whose purpose is to solve the problem. The artifact that was designed and evaluated in our research project is a method. In order to make our method unified, we made sure that it meets quality criteria, such as usability, transparency, efficiency, adaptability and genericity. By usability, we mean that the method is easy to use by a stakeholder who does not have the technical skills to design or develop IS solutions. The method is also transparent, so that all stakeholders can see and understand the selection of the requirements to be prioritized and implemented. In addition, the method is effective in a sense that it achieves its original purpose, which is the prioritization of the requirements in a simple and fast manner, while producing a result deemed acceptable for an experienced business analyst. The proposed method is also generic as it can be applied to prioritize IS solutions from different business domains. Finally, the method is adaptable, meaning that its use can be adapted to fit specific organizations needs.

VI. Design and Development of the Prioritization Method

The design of the method was based on the following four main functions: grouping, explicit modeling, evaluation and prioritization (see Figure 2). The grouping function is used to group requirements that share different categories of relationships. This function consists of identifying and grouping requirements that share relationships of similarity, commonality, synergy, technical and business dependency [3]. The grouping function is important since it optimizes the requirements prioritization process while facilitating and reducing inefficiencies [3].

The explicit modeling function allows a clear and accurate representation of the requirements, objectives and relationships that exist between them. In this fashion, all the stakeholders involved will be able to better see and understand, in a transparent way, the requirements to be prioritized. The modeling function allows reaching a common understanding. On the one hand, explicit modeling will be easy to use so that a stakeholder without technical skills can work with it, thus meeting the usability requirement. On the other hand, using explicit modeling enables the method to clearly evaluate the choice of requirements through their interrelationships and their impacts on the organizations objectives. This requirement evaluation function, combined with the modeling function, allows to assess the impact of the requirements choice on the objectives.

We have integrated and adapted the GRL language to build our method. GRL provides the means to perform all the functions and to achieve the quality attributes that make our artifact a *unified method* for requirements prioritization. By incorporating the GRL language into our method, it is possible to explicitly model requirements, business objectives and their interrelated links. By being able to show impacts of the requirements on the objectives through GRL, it is now possible for stakeholders to have both qualitative and quantitative evaluations of their requirements choice. The last function prioritizes the requirements. It is based on the results of the evaluation function. More precisely, this function consists of comparing the results of the GRL evaluation performed in the previous step in order to prioritize the requirements.

VII. Example : Library Loan Management Case

We applied our approach to prioritize the requirements of a library loan management IS. To illustrate our approach, we limit the prioritization to two groups of requirements: the automated invoice emailing and the automated invoice printing for postal mailing. The product owner wants to establish an order of priority to address these functional requirements. The process starts with the requirement grouping function to identify the GRL elements that share the relationships of

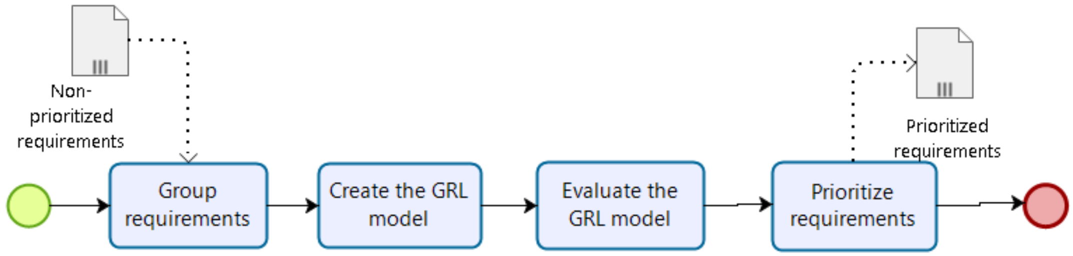

Figure 2: The functions of the proposed method.

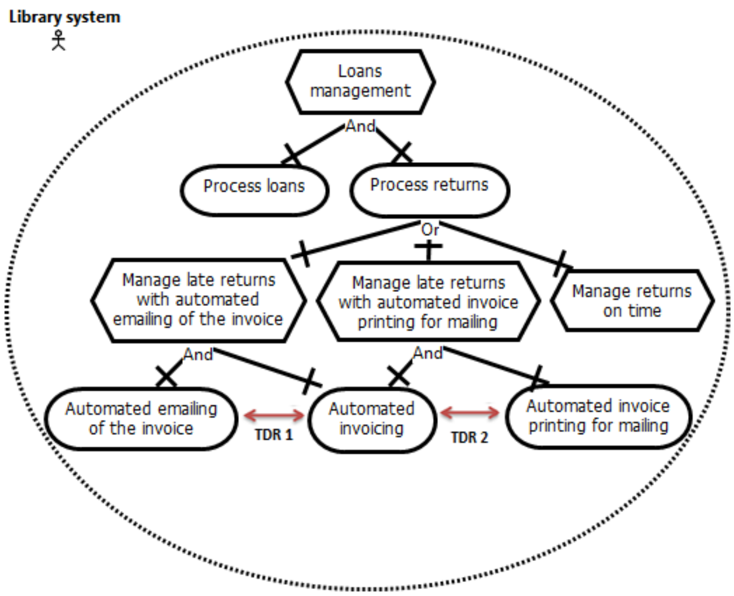

Figure 3: GRL model of the library loan management system.

similarities, commonalities, synergies, technical dependencies and business dependencies.

A first Technical Dependency Relationship (TDR 1) exists between the two functional requirements: the automated invoicing and the automated emailing of the invoice. Indeed, emailing the invoice requires that the invoice be generated. Similarly, a second Technical Dependency (TDR 2) exists between the automated invoicing and automated invoice printing for mailing requirements. In fact, printing and sending the invoice requires that the invoice be generated first.

Once we have identified the requirements and related elements, we must establish an order of priority of the requirements having technical dependency relationships. This is the second activity of the requirements grouping function. This order can be expressed as a Technical Dependency Sequence (TDS) between requirements.

Due to TDR 1, there is a first Technical Dependency Sequence (TDS 1) between the automated invoicing requirement and the automated emailing of the invoice requirement because emailing the invoice requires the invoice to be generated first. Due to TDR 2, there is a second dependency TDS 2 between the automated invoicing and the automated invoice printing for mailing requirements because printing and sending the invoice also require the invoice be generated.

Before starting the prioritization process, and to avoid inefficiency, we must consider all existing technical dependencies between requirements and establish the relations or sequences between them. The requirements that share these technical dependencies are interdependent. Inspired by the work of Rahmouni *et al.* [3], we grouped interdependent requirements both when they share technical dependencies, and when they share relationships of similarity, synergy, commonality, and business dependency. Using relationships that exist between requirements optimizes the prioritization and reduces inefficiencies [3]. In addition, a product owner (e.g., business analyst) can more easily prioritize inter-related and interdependent requirements per group than if he prioritizes each requirement individually.

There is no relationship between the automated invoice emailing and the automated printing for postal mailing functional requirements. Therefore, these two requirements are independent. Consequently, we can place them in two distinct groups.

After grouping the requirements, we need to create the GRL model that links the requirements, tasks/solutions and business objectives. The resulting GRL model is presented in Figure 3.

Once the GRL elements and links were represented, the evaluation criteria must be defined. In our case, the require-

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ments were evaluated on the basis of their contribution to the business objectives, such as reduction of costs and payment delays. Quantitative contributions of functional requirements to business objectives are values within the range of -100 to +100. The main business goal is cost reduction; we gave it a value of 100. As for the goal of reducing payment delays, we gave it a value of 75. Note that the GRL modeler (e.g., business analyst) can use other values that best reflect the practices or needs of their organizations.

We then assessed the impact of the requirements on business objectives by analyzing the requirements to determine their types of quantitative contribution on the objectives. Each type of qualitative contribution generally leads to a marginal quantitative value of 25 or –25, depending on the level of positive or negative impact of the functional requirement on the business objective (see Table II).

TABLE II: QUANTITATIVE CONTRIBUTION VALUES FOR QUALITATIVE CONTRIBUTIONS [10].

Qualitative contribution	Quantitative contribution
Make	100
Some Positive	75
Help	25
Unknown	0
Hurt	-25
Some Negative	-75
Break	-100

After analysis, it was established that the automated invoice emailing did not generate any costs. Therefore, this requirement makes a positive contribution to the cost reduction objective, which represents a quantitative value of 100 (see Table II). Also notice that sending and receiving the invoice by email is instantaneous, therefore it helps to reach the goal of reducing payment delays, which represents a value of 25 as the subscribers are more likely to pay invoices upon faster reception. We then modeled the first set of requirements with TDR 1, TDS 1 and their quantitative contributions to the objectives. The resulting model is shown in Figure 4.

In Figure 4, the TDR 1 relationship is represented by the *brown double arrow*, and the TDS 1 sequence is indicated by the *brown arrow* that starts from the automated invoicing and ends at the automated emailing of the invoice requirement. The idea that sending and receiving the invoice by email are done faster is shown by the belief link in Figure 4. Since the cost reduction objective has a value of 100, we multiplied the value of the contribution by the value of the business objective and divided the total by 100, because the contribution of the functional requirement is between -100 and 100. The calculation is as follows: (100 x 100) / 100 = 100.

Similarly, we multiplied the value of the second contribution by the value of the reduction of payment delays objective and we divided it by 100, that is: (25 x 75) / 100 = 18.75.

The functional requirement of automated printing for mailing brings recurrent costs since printing generates costs associated to paper and ink use. In addition, there are other recurring costs related to postal mailing, such as envelopes and stamps. As a result, this requirement is harmful (Hurts) to the cost reduction business objective, which represents a value of -25. Furthermore, the invoice reception by mail requires a certain number of working days, which extends the payment period. As a result, this requirement is detrimental to the goal of reducing payment delays, which represents a value of -25. The modeling of this group of requirements is presented in Figure 5.

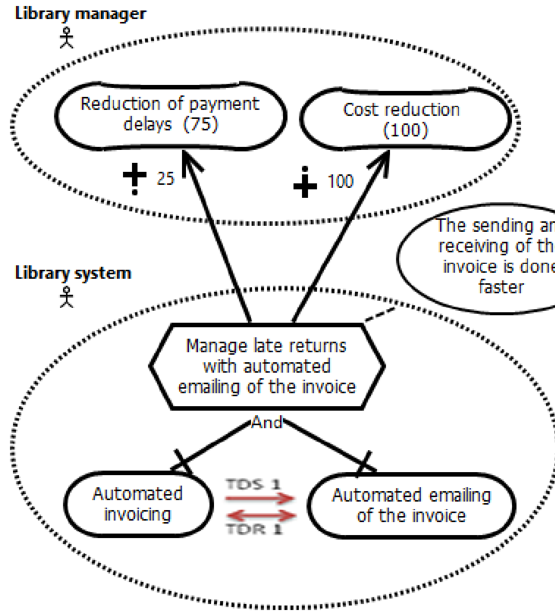

Figure 4: Group 1 of the library system requirements.

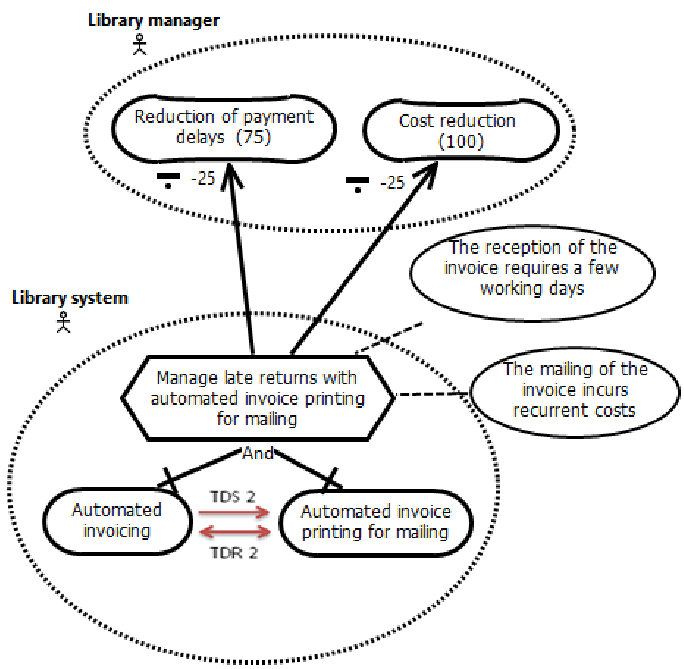

Figure 5: Group 2 of the library system requirements.

With respect to the evaluation score of this requirement on the cost reduction business objective, the calculation is as follows: (-25 x 100) / 100 = -25.

With regards to the evaluation score of the requirement on the payment delays reduction business objective, the calculation is as follows: (-25 x 75) / 100 = -18.75.

After the requirements assessment, the prioritization function is performed. To do so, the method computes the total evaluation score of each requirement group of all business objectives. The higher the score of the evaluation, the higher the priority of the group. Table III shows that the total score of the evaluation for group 1 (118.75) is higher than the one for group 2 (-43.75). The implementation of Group 1 is therefore prioritized because its contributions to the business objectives are greater than those of Group 2.

TABLE III: PRIORITIZATION OF REQUIREMENT GROUPS.

Group	Business Objective		Total	Priority
	Cost reduction	Payment delays reduction		
Group 1	100	18.75	118.75	1
Group 2	-25	-18.75	-43.75	2

VIII. Preliminary Validation

We conducted a preliminary evaluation of the proposed prioritization method through the library loan management system presented in Section VII. We presented the results of our approach to a group of twelve graduate students from an internationally renowned management school known for its in-depth business analysis skills. All students had a good knowledge of the GRL language. We asked them to evaluate the approach through a questionnaire on the effectiveness and usability of the method. The other quality attributes of the method presented in Section V were not evaluated in this preliminary experiment.

As shown in Figure 6, 10 of the 12 students (83.33%) found that the method is effective and usable in the context of the library loan management system. Two students (16.67%) found that the GRL notation and the evaluation process are complex and made the method less useful for stakeholders such as business analysts.

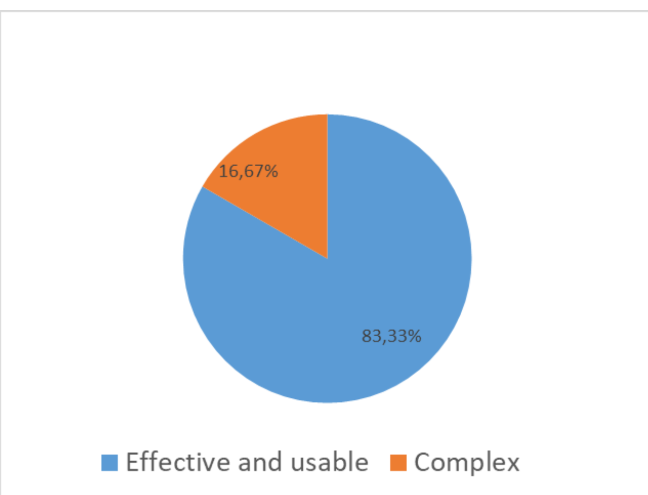

Figure 6: Evaluation of the effectiveness and usability of the method.

IX. Conclusion and Future Works

This research demonstrates that it is possible to prioritize IS requirements with a business objectives driven approach. We used the GRL language to link IS requirements to business objectives. We conducted a preliminary evaluation of our method with a dozen graduate students to validate the soundness of the conceptual ingredients that underlie our approach in the context of a library loan management system.

Although this work is still at an early stage, this paper establishes guidelines to advance our long-term research project. In future research, we plan to: i) conduct experiments to validate the proposed method in a larger experimental data set, ii) support other types of dependencies between requirements in addition to technical dependencies, and iii) design and develop a comprehensive framework for automating the prioritization of IS requirements.

Acknowledgments

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Critical Success Factors in the Implementation of ERP Systems in Public Sector Organizations in African Developing Countries

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***Abstract*—In the wake of budget restriction and increased pressure for transparency and accountability, more and more Public Sector Organizations (PSO) have opted to implement Enterprise Resource Planning (ERP) systems. PSO of developing countries have also followed this trend, pressured not only by the demands of accountability and efficiency from their own citizens but also from the multinational and binational development agencies that fund a majority of the development projects and programs that they deliver. ERP is also seen as a way to foster organizational transformation, though best practices adoption and process harmonization. Yet, success rate of ERP systems implementation, adoption, as well as their perceived results are less then optimal. This paper aims to explore the Critical Success Factors (CSF) in the implementation of an ERP system in PSO in African developing countries, in hope to give practitioners and decision-makers tools to increase the chances of success of these initiatives.**

Keywords-Enterprise Resource Planning – ERP; public sector organizations; Critical Success Factors – CSF; developing countries.

I. INTRODUCTION

An increasing number of Public Sector Organizations (PSO) has opted to implement Enterprise Resource Planning (ERP) systems. This trend is also followed by developing countries, pressured not only by the same demands from their own citizens but also from the multinational and binational funding development agencies.

ERP system implementation is still in its early stages in developing countries, with Asia-Pacific and Latin America accounting for most of its expansion, and Africa trailing behind [1]. Yet, today it is estimated that developing countries account for 10% of all ERP sales [2]. In North America and Europe, the private sector is the main client of ERP systems. In developing countries, ERP are mainly deployed in large organizations, rather than in SMEs. The public sector being the largest employer in developing countries [3], the main proportion of ERP systems is implemented in PSO. This specificity adds an additional level of complexity to an already complex project, since funding usually comes in part from external single or multiple donors, with their own interests in the project, and their own procurement, management and monitoring processes. Success rate of ERP systems implementation, adoption, as well as their perceived results in PSO in developing countries are less then optimal. Yet, little research has been undertaken to understand the specific Critical Success Factors (CSF) of the implementation process of ERP in PSO in developing countries.

Based on secondary data analysis of CSF collected through four professional workshops with key stakeholders, this paper aims to explore this gap. Section 2 presents a state of the art on ERP systems. Section 3 presents the Methodology of this paper, while section 4 presents the main Results. Section 5 reviews the Conclusion and before the discussion in section 6.

II. CONTEXT

In this section, we will define the main terms used in this paper such as ERP, PSO and developped/developping countries; describe the reasons why PSO would implement ERP systems; and explore main CSF in ERP systems implementation, both in general and specific to PSO in developping countries.

A. What is an ERP?

An ERP system is an "adaptable and evolutive software system that supports real-time and integrated management of a majority – if not all – processes of an organization" [4, p. 70]. ERP systems are an integrated, modular, customizable and uniform (database, management and interface) software [5][6].

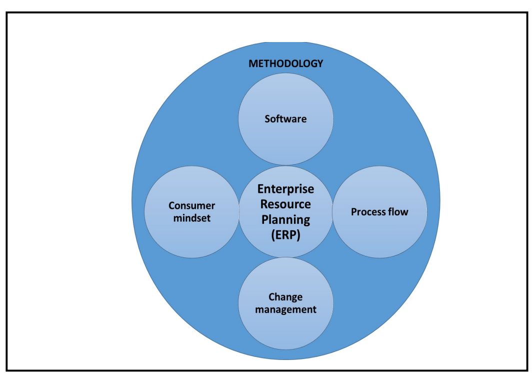

Figure 1. Conceptual model for Enterprise Resource Planning (ERP), Marnewick and Labuschagne [24].

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ERP systems are highly complex [24]. Marnewick and Labuschagne [24] postulate that ERP systems can be conceptualize as a combination of four main components: Software (Product), Process Flow (Performance), Change Management (Process) and Consumer Mindset (People; Figure 1 below). All four components are implemented through a Methodology, which underlines each ERP life-cycle phases (pre-implementation, implementation and post-implementation phases [7]).

Conceptual model components: The Software component refers to the ERP product itself, such as its main features, choice of interface, and other technical aspects, as well as its development, testing and troubleshooting. The Process flow component refers to the way the different ERP modules flow within and between them. This includes both the processes themselves and the data they store and process. The Consumer mindset component refers to the need for stakeholder management at the user, team and organizational levels. Lastly, the change management component covers all factors pertaining to the planning, managing and controlling of changes. Change management is divided in four subcomponents, namely: user attitudes changes, project changes, business process changes, and system changes. Methodology refers to the “systematic approach to implement an ERP system” [24, p.153]. All together, these components help better approach ERP system’s complexity.

B. *Why would PSO want to implement an ERP system?*

PSO consists of “governments and all publicly controlled or publicly funded agencies, enterprises, and other entities that deliver public programs, goods, or services”, and exists at any level – international, national/federal, regional or local) [3].

Public and private sectors have “different goals and motives and are governed by somewhat different principles, with unique groups overseeing their actions and procedures”. Organizations in the private sector have “more freedom to operate, while public organizations are governed by laws, rules, traditions, and structural bureaucratic checks and balances”[8].

Although very different, benefits sought during ERP system implementation seem consistent among public- and private-sector organizations [9]. These benefits include improvements in:

Financial performance: improves financial management; creates value; maximizes investments; and reduces costs;

Functional performance: increases productivity, quality of services, and functional efficiency; improves management of resources; enables automation of operational procedures; eliminates redundant data and operations; and reduces cycle times;

Organizational performance: increases organizational performance; enables the centralization and delocalization of maintenance services; increases adaptability; facilitates harmonization around best practices; enhances support to organizational activities; and changes nature of work in various units and departments;

Communication management: centralises and harmonizes information; improves management and organization of internal and external information flux, and improves security and information access management;

Internal audit, monitoring and control: improves controls and institutional accountability; enhances organizations regulatory compliance; achieves accuracy in management information system; enables real-time access to performance information, which in turn fosters better strategic analysis and decision [5][10][11].

Furthermore, a study on the impact of ERP systems in small and midsized PSO suggests that implementing an ERP system helped PSO improve services to customers and suppliers; enhance knowledge of primary users and increase shareholders confidence in organization [11]. With all those potential benefits, we have to ask ourselves: why are not all PSO implementing ERP systems?

C. *Is ERP implementation in PSO successful?*

As discussed below, ERP system implementation can have important benefits for PSO. Nevertheless, ERP system implementation can be cost and time consuming [12]. As example, the cost of ERP implementation in UN organizations is estimated at 712 millions United States Dollar (USD). This does not include recurring maintenance costs (at least 66 millions USD per year), nor the off-budget associated costs (between 86 and 110 millions USD per year).

Furthermore, failure rate, both in private and public organization, is high. The 2016 ERP Report [13] states that less that 10% of all ERP projects sampled in 2015 were implemented on time, within budget and in respect to the planned scope. More than a third (35%) was stopped or (indefinitely) differed. The remaining 55% were completed with an average of 178% cost and 230% schedule overruns. In fact, ERP implementation projects lasted 1 to 3 years, with an average of 21 months, while most projects had been planned around an 8-14 months timetable.

Although data on the subject is scarce, ERP systems implementation failure rate in PSO in developing countries is believes to be even higher. In his study of ERP implementation in Egyptian organizations, Abdelghaffar [14] argued that 75% of ERP implementation attempts can be classified as failures. Another study found schedule overruns in 67% and cost overruns in 33% of all ERP implementation projects in United Nations organizations [10]. Reasons frequently mentioned to explain these schedule overruns were: changes in project scope; delays in personalization of software; users resistance to change, delays in data conversion, changes in initial project strategy, and redefinition of operating procedures. As for cost overruns, they were attributable mainly to unplanned personalization costs; inadequate definition of functional needs; unforeseen delays in the implementation process, and unrealistic cost estimation planning. No data was found on ERP implementation success in African developing countries, even if failure rates are though to be higher than in developed countries [5].

D. Are all PSO the same? or How do PSO from developing countries differ from PSO from African developed countries?

United Nations divides countries into two categories: developed and developing countries. This classification is mainly based on economic indicators and indices such as Gross Domestic Product (GDP), Gross National Product (GNP), per capita income, unemployment rates, industrialization and standard of living [15]. The developing countries categories include both developing and least developed countries, most of which are in Africa.

Contrary to developed countries, most PSO in African developing countries are funded (partly of entirely) by external funding. These funds usually come from multidonors/multilateral aid agencies, and with an obligation to prove the results of PSO's initiatives (result-based management). ERP implementation projects are often imposed by the donor agencies as a way to increase transparency and guarantee accountability of PSO.

Considering the important costs – both financial, social and political – associated to ERP implementation failures in PSO in African developing countries, it is important to understand the CSF that could hinder or facilitation this process.

E. What are the CSF in ERP systems implementation in PSO in African developing countries?

In order to support organizations in their implementation efforts, practitioners and researchers have come up with CSF that facilitate or hinder implementation. CSF are defined as "factors needed to ensure a successful ERP project" [16]. This includes both factors that facilitate and hinders the implementation of an ERP system. These factors vary depending of the nature and environment of the organization [17]. Yet most research on ERP success factors have been done in developing countries, in the context of private-sector organizations.

Through their literature review of CSF in ten different countries/regions, Ngai, Law and Wat identified 18 CSF, with more than 80 subfactors for the successful implementation of an ERP. The CSF are: appropriate business and IT legacy system; business plan/vision/goals/justification; business process reengineering; change management, communication; data accuracy; ERP strategy and implementation; ERP project team; ERP vendor; monitoring and evaluation performance; organizational characteristics; project champion; project management; software development, testing, and troubleshooting; top management support; fit between ERP and business/process; national culture; and country-related functional requirements [17]. This typology has been used by many other scholars to guide their analysis of the influence of CSF in phases of an ERP implementation process.

In the last years, a few studies have tried to identify CSF specific to ERP implementation in PSO of developing countries.

In its assessment of ERP implementation projects in its organizations, the United Nations identified 11 CSF, namely: project planning and software selection; governance of the project, risk management, change management, project team, end users training and assistance; ERP system hosting and infrastructure; data conversion and systems integration, ERP upgrade, and project audit [10].

Another study from the World Bank identified eight CSF from its experience implementing ERP systems, namely: capacity building and training, close supervision and control from the donor agency, favorable political context and leadership; pre-existing favorable environment (IT, HR, Accounting); adequate preparation and clear conception; good project management and coordination, and external environment factors [18]. It also identified main failure factors, which were: inappropriate training/education of project teams; institutional/organizational resistance; inadequate project preparation and planning; complex conception/high number of procurements; organizational structure adapted to integration efforts; inadequate IT infrastructure; absence of leadership/engagement and ambiguous attitude of authorities, regarding implementation; inappropriate technology; inadequate project coordination; and external factors (political troubles, natural disasters). These failure factors are consistent with other studies on ERP implement issues in developing countries [5][12].

These studies offer some insight on perceived CSF in ERP implementation from the point of view of donor agencies. Yet, these highlight the need to further explore the Critical Success Factors (CSF) in the implementation of an ERP system in PSO in African developing countries, in hope to give practitioners and decision-makers tools to increase the chances of success of these initiatives. This paper will try to address this gap.

III. METHODOLOGY

This work uses secondary data collected through professional workshops with key stakeholders that have direct experience either in the planning, managing or implementing of an ERP in PSO in developing countries. A description of the initial data collection process and methods, as well as a overview ot the data analysis techniques and conceptual model used for secondary data analysis follows.

A. Data collection – primary data

Primary data was collected through four 1 ½- 2 hours professional workshops. In total, 140 participants took part in the workshops. The workshops took place in Abidjan (Ivory Coast), Rabat (Morocco) and Marrakech (Morocco). The following subsection offers an overview of the composition of each of the workshop groups.

- Workshop no1: 15 participants from a multilateral development bank institution working as Task team Leaders, Procurement and Monitoring and Evaluation

Specialists, and Managers. Languages: English and French.

- Workshop no2: 85 participants from public and parapublic organizations. Participants worked as directors, project or program managers, procurement or monitoring and evaluation sectors on single or multidonors initiatives. Two came from the academia. Language: French.
- Workshop no3: 26 participants from public organization sector or project and programs funded through single or multidonors development aid. Languages: French and Arabic.
- Workshop no4: 14 participants from West Africa working as either project or program managers or Monitoring and Evaluation Specialists on single donor or multidonors projects or programs. Language: French.

The diverse composition of the different groups was one of the main difficulties facing the workshop facilitators (english/french/arabic languages, professional status, type of organizations, and number of participants per session). To increase participation and create cohesion between participants of the workshops, facilitators used World Café as a data collection method.

World café is a collaborative approach that aims to "to engage [participants] in constructive dialogue around critical questions, to build personal relationships, and to foster collaborative learning [21, p.28]", helping creative new ways to address problems emerge from the initiative. Simple and flexible, the approach can be used both in small and large heterogeneous groups to foster open dialogue and collaboration [22].

World café follows seven integrated design principles, namely:

- Set the context;
- Create a hospitable space;
- Explore questions that matter;
- Encourage everyone's contribution;
- Connect diverse perspectives;
- Listen together for patterns and insights;
- Share collective discoveries [22].

At the end of each of the workshops, participants drafted a list of factors that facilitated and hindered the implementation of an ERP. All entries of the four lists were then combined by the facilitators. This final compilation was sent to all workshop participants in the conference proceedings by the event organizers. These conference proceedings are the basis of our analysis.

B. *Data analysis*

To facilitate understanding, subthemes were then organized using a modified version of Marnewick and Labuschagne [24]'s ERP Conceptual Model. This modified version includes all four main components (Software, Process Flow, Change Management, Consumer Mindset), Methodology, and adds a last component - external environment. This component was added to take into account the influence of national culture [17] and other macroeconomic factors, on the implementation of ERP systems in African developing countries. The ERP project financing will also fall under this category, as it has a major impact on ERP implementation in developing countries [10].

IV. RESULTS

The following section presents our results, namely the CSF identified and categorized, using the adapted conceptual model. In total, forty CSF were identified through this process. To facilitate understanding, results are presented per components, namely: Software, Process flow, Consumer mindset, Change management, Methodology, and External environment.

A. *Software*

In total, five CSF were identified by participants for the Software component, namely: software development, testing and troubleshooting; ERP vendors/suppliers relationships; country-related functional requirements; local infrastructure; ERP infrastructure and hosting; and IP maturity of organizations.

Software development, testing and troubleshooting: participants underlined the importance of the choices made through theses phases, and the need for user participation in the process to facilitate adoption.

ERP vendors/suppliers relationships: Participants highlighted that the lack of local vendors gives disproportionate power of international vendors, and hinders optimal selection of ERP systems by PSO.

Country-related functional requirements: Participants also discussed the fact that ERP often didn't meet their specific PSO requirements, e.g., integration of performance indicators at the result level, reporting formats that do not fit the donor requirements, etc.

Local infrastructure: Access to electricity, telecommunications and Internet remain problematic, especially when outside urban agglomerations, though significant improvements have been made in recent years. This has a major impact not only on ERP implementation but adoption by users.

ERP infrastructure and hosting: More and more ERP systems are cloud-based. Because of the lack of access to basic amenities in many parts of African countries, many ERP options are not feasible. ERP hosting is also a problem, not only because of security but also because of access to electricity.

IT maturity of organizations: Participants also underlined the low IT maturity in most African PSO, which hinders their ability to facilitate ERP implementation.

B. *Process flow*

The Process flow component includes two subcategories: Process and Data. In total, seven CSF were identified by participants for the Process flow component.

1) *Process*

In total, three CSF were identified by participants for the Process subcomponent, namely: Fit between ERP and an organization's procedures; Harmonized practices, procedures and processes; and Communication.

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Fit between ERP and an organization's procedures: PSO in developing countries, because of their funding and organizational structure, have specific procedures (e.g., burdensome administrative and procurement procedures, strict monitoring and evaluation requirements, etc.). ERP systems are created around private-sector (occidental) best practices. Therefore, the product offered is often than not difficult to adapt to African PSO's needs

Harmonized practices, procedures and processes: ERP systems aims to limit the possibility or errors by limiting the number of times a same information has to be entered in the system. Yet, because of the lack of harmonized procedures, users still have the obligation to enter information on multiple software.

Communication: participants highlighted the need for communication and information, sharing management plan, in order to maximize the probability of successful implementation.

2) Data

In total, four CSF were identified by participants for the Data subcomponent, namely: data quality control, data collection (aka presence of a Monitoring and Evaluation System), data management (including Security, Access, Traceability), and data conversion.

C. Change management

The Change management component can be divided into four subcomponents, namely: User attitude, Business process change, project change and System change management. In total, nine CSF were identified by participants in the Change management component.

1) User attitude management

Participants identified three CSF pertaining to user attitude management, namely: Need for communication, Need for training and education, and User active participation in ERP implementation.

2) Business processes change management

Participants identified two CSF pertaining to Business process change management, namely: Need for real-time information; Need for harmonization of practices and processes.

3) System change management

Participants identified three CSF pertaining to System change management, namely: Management and Corporate culture change, management of Interests, and Communication.

4) Project change management

Participants identified one CSF pertaining to Project change management, namely : Need for effective change control management processes and procedures.

D. Consumer mindset

The Consumer mindset component includes three subcategories, namely: User mindset, Team mindset, and Organizational mindset. In total, fifteen CSF were identified by participants for the Consumer mindset component.

1) User mindset

In total, five CSF were identified for the User mindset subcomponent, namely: User attitudes/Resistance to change, Technical level of competencies and knowledge of users; Qualified personnel; Stability of teams (attrition rate), and Access to training.

2) Team mindset

In total, four CSF were identified for the Team mindset subcomponent, namely: Team composition (status/treatment, multidiscipline, and employment), Collaboration, Leadership, and Competencies.

3) Organization mindset

In total, six CSF were identified for the Organization mindset subcomponent, namely: Prior experience in ERP implementation, Change management competences, Organizational commitment, Presence of a champion, Shared Vision, mission and organizational goals, Ownership of project by stakeholhers.

E. Methodology

In total, two CSF were identified by participants for the Methodology component, namely: Clear ERP implementation strategy, and Good project management.

Project management: Participants stressed the importance of good project management in ERP implementation, namely the need for clear planning, project division in multiple steps; realistic performance demands and deadlines, and collecting of lessons learned; planning of implementation costs and maintenance.

Clear ERP implementation strategy, and its communication to stakeholders, were also seen prerequisite for success.

F. External environment

In total, two CSF were identified by participants in the External environment component, namely: National culture and Donor-Recipient relations

V. CONCLUSION

Our results highlight the specific nature of ERP systems implementation in PSO in African countries. Certain CSF seem to be only found in this context, e.g., External environment CSF, such as national culture and donor-recipient relationships, ERP vendors/suppliers relationships; country-related functional requirements; local infrastructure; ERP infrastructure and hosting). But even when general categories of CSF were observed in both PSO in African countries and in developed countries (e.g., Change management, Consumer mindset), the way the materialize and that they influence the process differed. For instance, Team composition, collaboration, leadership and competencies were found to be CSF in both contexts. Yet, ERP project teams in developing countries are a combination of consultants, who are often lent by the PSO themselves (not always for their competencies), and that are paid in a day what the rest of the teammates will do in a month. This hinders the collaboration and leadership of the team leaders. Another example of CSF's specificity is the Organisational commitment, as in African PSO, high management is often the one who benefits from the lack of transparency and accountability, and therefore are the main opponents of these type of initiatives.

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VI. DISCUSSION

ERP implementation projects are often wrongly considered IT projects, when in fact they are major organizational transformation initiatives [22] that will significantly change the processes, structure, even the culture of an organization [10]. In line with current research [12], the need for training and education, top management support and multilevel change management were most cited CSF by participants.

Our results also highlights that CSF' influence vary depending of many factors, such as organizational and national culture, type of implementation process chosen (one time or gradual implementation), etc. This converge with Zouagui and Laghouag's findings [17]. Yet, these specificities are rarely taken into account in ERP implementation in PSC in African developing countries projects. Still, further research is needed to better understand and conceptualize the CSF in ERP implementation in PSO in the African developing countries.

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