Towards Green ERP Systems: The selection driven perspective

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Abstract

Enterprise Resource Planning (ERP) system has become a vital strategic tool in today's competitive business environment. Recently, a high demand is emerging for computer-based information systems that better support corporate sustainability management. In this regard ERP systems are supposed to contribute for these demands such that they can be considered under the categories of Corporate Environmental Management Information Systems (CEMIS). Such ERP systems are considered as Green ERP systems and there are several efforts towards such systems. These efforts also contribute to the realization of the concepts behind the project IT-for-Green, which is running at University of Oldenburg. One of the modules in this project, which is named Green IT, emphasis on effective system utilization under efficient power consumption. Therefore the effort towards Green ERP systems will also add up to the efforts of the project IT-for-Green. For the instrumentation of this concept, companies should be aware of Green ERP systems and should also consider and emphasis on dimensions in evaluating the greenness of ERP systems. At this junction, one of the major issues to be addressed is the determination of the dimensions to evaluate the greenness of ERP systems. This study is, therefore, motivated to determine the dimensions in evaluating the greenness of ERP systems. In determining these dimensions the study first identified general ERP selection criteria and further refined them and come up with suitable criteria for the assessment of the greenness of ERP solutions. Based on this result, companies are expected to emphasis on such criteria to identify a Green ERP alternative and this will also enforce vendors towards the manufacturing of Green ERP systems.

Keywords: Green ERP Systems, ERP selection criteria, Dimensions for Green ERP systems, Sustainability, CEMIS, IT-for-Green

1. Introduction

Enterprise Resource Planning (ERP) system has become a vital strategic tool in today's competitive business environment [1]. It facilitates the smooth flow of common functional information and practices across the entire organization. In addition, it also improves the performance of the supply chain and reduces cycle times. In general, an ERP system is expected to improve both backbone and front-end functions, simultaneously resulting in to low operating cost and improved customer service. Accordingly, organizations are choosing and deploying ERP systems for such and many other tangible and intangible benefits and strategic reasons. However, recently, a high demand is emerging for computer-based information systems that better support corporate sustainability management and this initiate the need for special type of information systems called Corporate Environmental Management Information Systems (CEMIS) [2]. These systems are supposed to fit for new administrative approaches, e.g. in the field of emission trading, and recommendations, for instance regarding carbon footprints of products [3].

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In this regard, an ERP system is supposed to provide the required information for environmental or sustainability management such that it can be considered under the categories of CEMIS systems. This leads to the realization of the concepts behind the project IT-for Green, which is running at University of Oldenburg. The project has several modules and one of them, which is named Green IT, emphasis on effective system utilization under efficient power consumption. Therefore, since the motive behind Green ERP system is also energy efficiency, the effort towards Green ERP systems adds up to the efforts of the project IT-for-Green.

In order to get the best out of ERP systems, companies should be aware of Green ERP concepts and should also consider and emphasis on dimensions in evaluating the greenness of ERP systems, such that, vendors will gear towards manufacturing of such systems. At this junction, one of the major issues to be addressed is the determination of the dimensions to evaluate the greenness of ERP systems. This study, therefore, determined the dimensions in evaluating the greenness of ERP systems. In reporting the works carried out when determining the dimensions, the paper is organised in to five parts. The second part addressed how Green ERP can contribute for the efforts in IT-for-Green project. The extraction of general ERP selection criteria to evaluate ERP alternatives is addressed in the third section. Having the identified criteria list, the fourth part discussed the determination of the criteria for the evaluation of the greenness of ERP systems. Finally summary and conclusion of the study is provided in the last section.

2. Green ERP as an Enabler in IT-for-Green

2.1. IT-for-Green

IT-for-Green aims at increasing the environmental friendliness of companies and their processes by means of ICT. In this context, ERP systems can play a significance role if they are designed to address the requirement sets for CEMIS. Such ERP systems can be considered as Green ERP systems and their role is discussed in the next section.

2.2. Green ERP in IT-for-Green

ERP systems, which are environmentally friendly and allow organizations to cut costs while benefitting the planet, are termed as Green ERP systems [4]. The concept Green ERP system is a more environmentally responsible initiative to reduce carbon emissions and concerned with people and the planet in addition to profit [5]. This philosophy has been dubbed the "triple bottom line", which is an expanded version of the business concept of the bottom line that includes social, environmental and financial results [6]. As Green ERP systems are concerned with addressing the" triple bottom lines" (social, economic, and environmental dimensions), this coincides with the objectives and concerns of the project IT-for-Green. Therefore such ERP systems that can provide the required information for environmental or sustainability management can be considered as enablers of IT-for-Green as they can lead to the realization of the concepts behind the project. The corresponding benefit can also extend to companies adopting ERP systems.

In this regard companies should be aware of Green ERP concepts and should also consider and emphasis on dimensions in evaluating the greenness of ERP systems, such that, vendors will gear towards manufacturing of Green ERP systems. At this junction, one of the major issues to be addressed is the determination of the dimensions to evaluate the greenness of ERP systems. However, a depth evaluation on existing ERP selection trends revealed that there is lack of research in determining ERP selection dimensions even for the evaluation of common ERP systems [7]. As an emerging concept, the lack of dimensions in determining the greenness of ERP systems is also quite expected. Therefore the general ERP selection criteria, which are the basis for the criteria to evaluate the greenness of ERP systems, are first determined in the next section.

3. Criteria for ERP Evaluation

The implementation of an ERP system is an important investment for an organization and for a successful implementation of such systems selecting the most appropriate software is a necessary condition [8, 9]. In selecting the most appropriate solution, the available alternatives should be evaluated against standard criteria such that the new software capabilities and needs should not be mismatched with organization's business process and procedures [10]. Although a considerable amount of articles contribute towards analyzing the value of information systems, packaged software solutions or commercial off the shelf (COTS) products in general, only a few have focused on the special case of ERP systems [11, 12].

This study, therefore, combines the theoretical approach to ERP selection with ERP practical recommendations to determine the dominant set of criteria that would provide maximum support for ERP implementation. The process encompasses several activities starting from extraction of the criteria from journal articles and then matching the criteria based on their similarity. The unified criteria are then ranked based on their frequency of occurrence and the most frequent ones formulate the suitable criteria list. Finally standardization has been made through ISO9126 software quality model to determine the categorical representation of the criteria.

3.1. Extracting

The extraction of ERP selection criteria has been made from journal articles covered in Web of Science. Articles which were considered as the most relevant are those which topics include strings "enterprise resource planning" and "selection" or "selecting". Similar strings were also used in the study of [7]. 25 articles, which fulfil the criteria, out of 2971 articles on enterprise resource planning were found on web of science. Only 16 out of these 25 articles mention selection criteria. The remaining 9 articles discussed ERP system selection in general or as a part of implementation process or terms selection and ERP were not related.

3.2. Matching

Although the total list indicate as there are 226 criteria, it is not to mean that all of them are unique, rather the counting considered redundancies and this should be managed to get the real figure. In addition to this, there are also criteria, which seem unique but similar in their effect with some other criteria. Therefore, the matching process addressed synonymy and also similarity in effect. In managing this process the matching has been made first within an article and then followed by the matching between articles. The matching with in an article has been made for synonymy and effect as illustrated in Table 1 below.

Criteria	Terms	Article
Cost	Software Costs	[13]
	Consultation Costs	
	Maintenance Costs	
	Price	[14]
	Value (Total implementation cost versus total value tithe company)	
	Average cost of packages	[15]
	Support fees	
	Training fees	
Reliability	Trust in the ERP System	[13]
	Credibility of the System	

Table 1: Matching ERP Selection Criteria
Source: [16]

The table gives two exemplar criteria which are redundantly expressed and represented in different terms in a given article. “Price” and “Value” in Umbel et al. [14] are cost aspects represented by synonymous terms and have similar effect. “Trust in the ERP system” and “Credibility of the system” in Bueno and Salmeron [13] are other dimensions expressing the reliability of the software but represented redundantly in a given article. The matching has been made within all articles and the total criteria list shrinks to 81 based on this intra article matching process.

The matching process has then further applied for criteria in different articles and as depicted in table 1 different articles represent the criteria “cost” in synonymous terms and also with terms having similar effects. This process has been applied to all criteria between articles and when accounted for synonyms in a wide sense of the word, it was possible to identify 30 uniquely expressible criteria out of the eighty one criteria. Therefore this inter-article matching process concludes the matching phase and the 30 criteria are taken to the ranking phase to determine the most important and suitable criteria.

3.3. Ranking

The identified 30 criteria are ranked based on their frequency of occurrence in different articles. The occurrence of the criteria ranges between a maximum of 10 articles and minimum of a single article. This study, therefore, considered those criteria which occurred in 3 and more articles and the rarely occurred criteria are rejected from the list. Accordingly the top 21 criteria are considered as important ones and the criteria together with the corresponding articles are depicted in Table 3 below.

Criteria	Articles
Vendor Support	[14, 15, 17–24]
Administration Cost	[7, 13–15, 17, 20, 25]
System Cost	[7, 13-15, 17, 20- 22]
Vendor Reputation	[7, 23,19, 21, 24, 25, 17, 20]
Ease/Speed of Implementation	[7, 13-15, 17, 21-22, 25]
Time to go live	[7, 14-15, 17, 21-22, 25]
Training	[15, 22, 25]
Organizational fit	[14, 19, 21, 23, 24, 26, 27]
Customization/Parameterization	[7, 13, 19, 22, 23, 25, 28]
Accuracy	[7, 17-19, 23-24]
Recoverability	[18, 13, 7, 25, 17, 22]
Compatibility	[7, 13, 17-19, 23]
Ease of use	[7, 13, 17-18, 22, 25]
Latest Technology	[18-20, 23, 27]
Flexibility	[14, 17-18, 27]
Upgrades	[14, 19, 20, 23]
Modularity	[13, 19, 23]
Information Needs	[13, 27-28]
Scalability	[19-20, 23]
Security	[14, 17-18]
High Performance	[13, 27-28]

Table 3: Important ERP Selection Criteria List
Source: [16]

Representative terms are selected out of existing criteria list and domain experts are also consulted for expert based consensus on the naming of the 21 criteria. Accordingly “Ease/ speed of

Implementation" is represented by "Implementation" and in the definition of the criterion the intention of the term is further explained. In a similar way "Time to go live" is also tuned as "preparation", "organizational fit" as "Suitability"; "Customization/ Parameterization" as "Customization" , "latest technology" as "technology", and "High performance" is represented as "Performance". Based on this labelling, the most important criteria are depicted in Figure 3 below.

3.4. Standardization

The standardization process is mainly concerned with the comparison of the identified ERP selection criteria with the criteria in ISO9126 software quality model to check whether all the dimensions in the software quality model are also reflected in the identified criteria list. In addition, the process is also concerned with the categorical representation of the criteria. In doing so ISO9126 software quality model, which is depicted in Figure 1 below, is employed in the process through its 22 software quality sub-criteria and 6 criteria categories

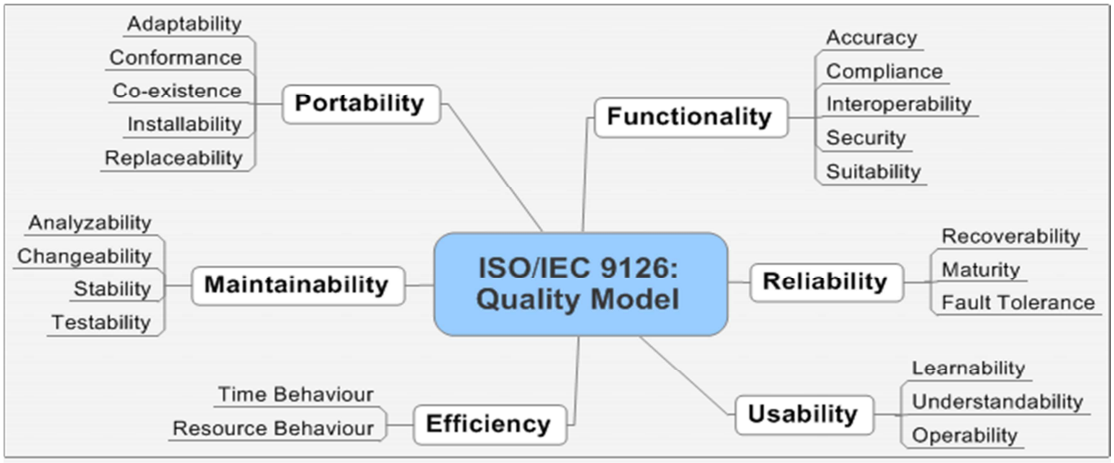

Figure 1: ISO9126 Software Quality Model
Source: [29]

The result of the comparison revealed that the identified ERP selection criteria are matching with the sub-criteria in ISO9126 software quality model. But, since the identified ERP selection criteria have no categorical representation, the representation inISO9126 software quality model is adopted to the identified ERP selection criteria. Categorical representation of the criteria is quite important to simplify the management of the criteria [30]. However the categorical representation in ISO9126 software quality model can only address 14 of the identified ERP selection criteria and the remaining criteria are not stated in ISO9126 software quality model. This initiates the need for further assessment on the categorical representation of ERP selection criteria.

According to Ayaug and Özdemir [18], ERP selection criteria can be classified in three dimensions: competitive advantage, productivity, and profitability. Bueno and Salmeron [13] identified six ERP selection criteria and stated that four of them involve criteria related to ERP software, whereas the last two are related to the organization. Wei et al. [17] draws a clear boundary between ERP selection factors related to ERP system itself and factors related to ERP vendors. From these arguments, it is evident that the diversity of ERP selection factors complicates their classification into standard groups.

However by considering the nature of the identified criteria, this study split ERP selection criteria into two groups: the first group consists of ERP software quality-related criteria and comprises those criteria related to software quality aspects. The other category comprises software cost, time factors, and vendor related criteria under the category of management aspects of ERP

implementation. The categories for quality aspect criteria are determined from ISO9126 software quality model and the management aspect categorization is customized from the work of Lien and Chan [8]. In their work, they represent the criteria related to management issues of ERP system in to three major categories: vender factors, cost factors and time factors. Accordingly, the 7 management aspect criteria have been categorized under these 3 major categories. This categorical representation of the criteria is depicted in Figure 2 below.

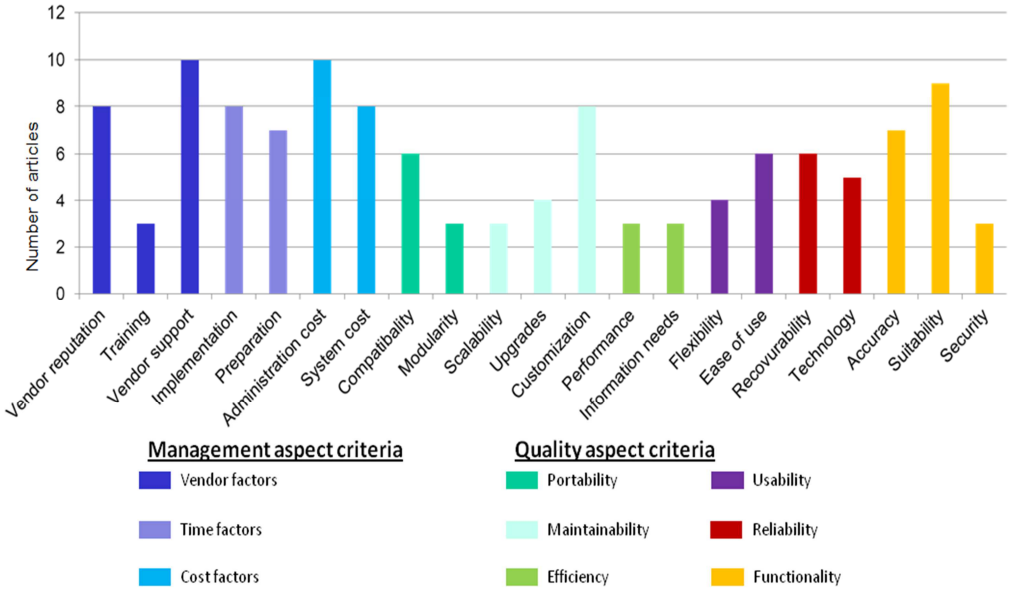

Figure 2: Categorical Representation of Important ERP Selection Criteria List
Source:[16]

The study further refined the above listed criteria through literature and consultation with CEMIS experts, and accordingly determined the criteria for the evaluation of the greenness of ERP systems as discussed in the next section.

4. Determining the greenness of ERP systems

4.1. The general dimensions in IT-for-Green

IT-for-Green project basis on the three pillars of sustainability (social, economic and environmental), which are currently unequally addressed by the project. The three modules Green IT (focusing on energy efficiency in data centre), Green Production & Logistics (aiming on life-cycle assessment over a product life cycle including production and transportation), and Sustainability Reporting and Dialogue (focusing on reporting the activities and impacts towards the three sustainability dimensions) are currently focussing to determine and optimize material and energy flows and to point out possible improvements. Therefore, energy optimization from the first module together with measuring energy and material flows are mainly addressing the environmental part and should be extended in further modules towards improving social aspects. Economic benefits will arise by reducing energy consumption in data centre but aren't calculated yet. In general the "triple bottom lines" formulate the dimensions in IT-for Green project.

4.2. Dimensions for the Evaluation of the Greenness of ERP Systems

The dimensions for the evaluation of the greenness of ERP systems emanate from the "triple bottom lines" considered as dimensions in IT- for-Green project. In this regard they are supposed to assess the expected requirements out of ERP systems such that the greenness of optimal ERP

solutions can be secured. In this regard the determination of the criteria for the evaluation of the greenness of ERP systems has been carried out based on the general ERP selection criteria in a pair wise comparison matrix and the Fuzzy Analytical Network Process (FANP) method has been applied to facilitate the comparison process. Based on the mathematical computation in the comparison matrix: Modularity, Scalability, Customization, Flexibility, and Technology have been determined as suitable criteria for the assessment of the greenness of ERP solutions.

A modular ERP system gives the possibility for an on-demand utilization of its functionalities such that the energy to run the temporary ideal modules can be saved. An ERP system should also be scalable in a way to bolt-in other systems. This enables to get the benefit of multiple systems with efficient energy consumption. The system should also be customizable to the critical requirements of adopting organizations such that the business can sustain their competitive edge and also manage processes effectively. This by in-turn contributes for efficient energy utilization. The system should also be flexible to adapt to possible or future changes when required. This can be assured by the upgradeability of the ERP system, and simplicity of integration and internal programming work. On the top of that the latest the ERP technology is, the longer its usage to the adopting company and also possible to have speedy execution of transactions. In general, an ERP system, which satisfied these requirements, can be considered as a Green ERP System.

Therefore, companies are expected to emphasis on such criteria when selection ERP systems, such that they will determine a Green ERP solution. This can be assured by providing more weights for these dimensions. The more weights are assigned for these criteria imply the more emphasis is provided to determine such systems and this by in turn will enforce vendors towards the manufacturing of Green ERP systems.

5. Summary and Conclusion

The study determined the important dimensions to be considered in evaluating the greenness of ERP systems. Companies can sustain the competitive advantages out of ERP systems by providing the required emphasis for the identified dimensions. In general the expected economic, social and environmental requirements can be confirmed by adopting Green ERP systems. For more comprehensive discussion on the determined dimensions, a meta-analysis study will be conducted in further studies of extending the dimensions. The study can also be extended to the broader field of “Software selection” and the dimensions can also be tested for suitability to evaluate other systems. The study will further report the determination process made to identify the dimensions for the greenness of ERP systems and will also address the structural and network representation of the criteria, which is important to facilitate the pairwise comparison process in evaluating ERP systems. It would be better, if a meta-analysis study on these dimensions is given.

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