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IT CAPABILITIES IN ERP MAINTENANCE – A REVIEW OF THE ERP POST-IMPLEMENTATION LITERATURE

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Abstract

With the maturing use of ERP systems, the management of their post-implementation phase is receiving increased attention. There is a need to understand how to manage post-implementation activities like ERP maintenance. ERP maintenance is a critical IT service provided by IT organizations in the ERP post-implementation phase, including activities to support and extend existing ERP systems. The extant research has focused on tasks related to ERP maintenance, but it lacks studies that provide insights into capabilities required to perform ERP maintenance successfully. This paper aims to reduce this gap, reviewing IT-related tasks, success and risk factors in the ERP post-implementation literature. Based on this review, eight IT capabilities on the functional level of ERP maintenance are proposed. Integrating these findings with previous IT capability research, the link between the identified ERP maintenance capabilities and firm-wide IT capabilities is examined.

Keywords: ERP, enterprise resource planning, IT capabilities, maintenance, post-implementation.

1 Introduction

Implementation of ERP systems received significant attention in the 1990s, and ERP systems are now frequently used in organizations. With the maturing use of ERP systems, there is an increasing need to understand the phase after the initial go-live of an ERP system. This is referred to as the ERP post-implementation phase. Recent literature reviews on ERP systems show that studies on the ERP post-implementation phase are still underrepresented (Esteves and Bohórquez, 2007; Grabski et al., 2011). There are calls for future research to investigate how to manage post-implementation activities, including, for example, ERP maintenance (Grabski et al., 2011; Law et al., 2010).

ERP maintenance is a critical IT service provided by IT organizations in the ERP post-implementation phase. This maintenance covers the various activities to support and extend existing systems. It includes the handling of user requests and user training, the implementation of changes to the existing functionality of the system, and the implementation of patches and software updates provided by the ERP vendor (Ng et al., 2002).

Existing research focuses on the characteristics and IT tasks in ERP maintenance (e.g. Hirt and Swanson, 2001; Nah et al., 2001; Ng and Gable, 2010; Ng et al., 2002), but it lacks studies that provide insights into IT capabilities required to perform ERP maintenance successfully. IT capabilities are more comprehensive than IT tasks. They represent complex bundles of skills and knowledge that are deployed using organizational processes, and that add value to a firm (Day, 1994; Sambamurthy and Zmud, 2000). The importance of IT capabilities in the ERP post-implementation phase is supported by research on how IT capabilities affect ERP value (e.g. Grant and Chen, 2005; Jain, 2010). However, currently, there is no common understanding about which IT capabilities are required in the context of ERP maintenance.

This paper attempts to reduce this gap, deriving a series of propositions relating to IT capabilities in ERP maintenance. The research is exploratory in nature, deriving these propositions from a review of the ERP post-implementation literature.

The research questions guiding this exploratory research are:

1. What IT-related tasks are required to maintain ERP systems in the post-implementation phase?
2. What are the critical factors that influence the success or failure of ERP maintenance?
3. What are the IT capabilities that influence ERP maintenance performance in the post-implementation phase?

The rest of this paper is structured as follows. In section two, the major characteristics of the ERP post-implementation phase are outlined. Then, a short overview on the extant IT capability research is provided in section three. Section four describes the methodology used for the literature review. A set of propositions relating to IT capabilities for ERP maintenance are derived from the literature in section five. To link these findings with previous IT capability research, the identified IT capabilities for ERP maintenance are mapped onto an existing typology of firm-wide IT capabilities in section six. Finally, a discussion of the findings and the conclusions are presented in section seven.

2 ERP maintenance in the post-implementation phase

The life-cycle of an ERP system can be partitioned into two major phases (Willis and Willis-Brown, 2002): The implementation phase includes the selection and implementation of an ERP system, ending with the go-live of the system. The second phase, also called the ERP post-implementation phase, covers all activities after go-live, including the stabilization, operation and extension of the ERP system. While the two phases include some similar activities and often involve the same stakeholders, previous research on ERP life-cycle phases (Bajwa et al., 2004; Somers and Nelson, 2004) shows that the importance of activities and success factors, as well as the involvement of various stakeholders, differ across the different phases of the life-cycle.

In addition, ERP maintenance differs not only from ERP implementation activities but also from traditional maintenance functions due to two characteristics of ERP systems: First, ERP systems are integrated systems, supporting various functions and subunits of an enterprise, and frequently reach beyond enterprise boundaries (Klaus et al., 2000; Markus and Tanis, 2000). Due to this wide span of influence, the maintenance of ERP systems involves a large number of different stakeholders from different functions, IT personnel, customers and vendors. Second, ERP systems are standard software (Markus and Tanis, 2000; Nah et al., 2001). Therefore, the ERP vendor frequently plays a significant role in system maintenance and often controls frequency and extensiveness of software updates (Nah et al., 2001).

3 IT capabilities

Capabilities "...are complex bundles of skills and accumulated knowledge, exercised through organizational processes, that enable firms to coordinate activities and make use of their assets" (Day, 1994). IT capabilities enable IT organizations to deliver IT services to an enterprise (Ravichandran and Lertwongsatien, 2005). They include the ability to foster rich partnerships between the IT organization and IT users, the ability to continually improve existing business and IT processes, and the ability to manage the IT organization effectively (Bharadwaj et al., 1999). Strong IT capabilities enable enterprises to leverage their IT to enhance their competitive position (Ravichandran and Lertwongsatien, 2005).

IT capabilities are defined on two different levels of analysis. These are the functional/technical and strategic levels (Lee and Lim, 2005; Ravichandran and Lertwongsatien, 2005). IT functional capabilities are related to a specific IT function including, for example, planning, system development, IT support and operation, and they are described by the quality and sophistication of the underlying IT processes (Ravichandran and Lertwongsatien, 2005). Although it is likely that IT functional capabilities correlate with firm performance, the link between capabilities and performance is not necessary for the definition of these capabilities (Ravichandran and Lertwongsatien, 2005). Capabilities on the strategic level on the other hand describe IT capabilities according to their strategic value and their ability to support the business goals of a company (Lee and Lim, 2005).

Extant research has proposed various typologies for IT capabilities on different levels of analysis. One frequently used and cited typology is the typology proposed by Bharadwaj et al. (1999). They develop and test a multidimensional construct of IT capabilities that covers 23 IT capabilities organized in six categories.

There have been some attempts to identify capabilities that are related specifically to ERP systems. For example, Luo and Strong (2004) propose that customizing ERP systems requires technical change capabilities and process changes capabilities. However, the focus of their contribution is not on the ERP post-implementation phase. Instead, they focus exclusively on the task of ERP customization. Other studies examine the effect of knowledge, relationships and infrastructure (Karimi et al., 2007) and upgrade decisions (Ng, 2006; Ng and Chang, 2009) on the capabilities of the ERP application. However, the focus of these studies is on capabilities of the ERP system rather than capabilities to maintain the system.

4 Research methodology

Guided by our research questions, the literature review and analysis aims to identify typical IT-related tasks in ERP maintenance and factors that are critical to perform these tasks successfully. Methods used for data collection and data analysis are described in this section.

4.1 Data collection

In order to find answers for our research questions, we focus on literature related to the ERP post-implementation phase. We assume that most of the ERP-related literature is published in IS journals or

conference papers. Therefore, we investigated the following sources for papers on ERP post-implementation:

- Conference papers in leading IS conferences including AMCIS, ECIS, ICIS and WI
- The top 50 IS journals in the journal ranking provided by Levy and Ellis (2006).

In a second step, we also included academic literature database into our search to avoid missing any relevant documents. These include:

- The ACM Digital Library (<http://portal.acm.org>)
- Business Source Premier (EBSCO) (<http://search.ebscohost.com>)
- Elsevier ScienceDirect (<http://www.sciencedirect.com>)
- Emerald (<http://www.emeraldinsight.com/>)
- IEEE Xplore (<http://ieeexplore.ieee.org>)
- Google Scholar (<http://scholar.google.de/>).

We performed forward- and backward search for selected articles as recommended by Webster and Watson (2002) to identify additional articles. As the interest in the ERP post-implementation grew after many organizations have implemented ERP systems in the 90ties, we expected that most research on the ERP post-implementation phase is published after 2000. Therefore, the literature selection process was restricted on articles that have been published between 2000 and 2010.

The search process was performed as follows: Within the relevant sources, we did a key word search using the terms 'ERP' or 'Enterprise Resource Planning' or 'enterprise system' in conjunction with the key words 'post-implementation', 'maintenance', 'support' or 'upgrade'. From this result, we identified relevant articles for further analysis by scanning titles and available abstracts to determine if these articles can support us in answering the research questions. In a second step, we identified additional articles from other peer-reviewed journals and conferences by backward search based on the identified articles. In a third step, we searched articles citing previously identified articles using forward search supported by Google Scholar. In total, we identified 34 articles satisfying our criteria.

4.2 Data analysis

The study focuses on the functional level of ERP maintenance. To guide the analysis of the identified articles, ERP maintenance is partitioned into three functional categories based on the ERP maintenance taxonomy proposed by Ng et al. (2002). These categories are (1) *ERP user support* including the handling of user requests and user training, (2) *ERP changes* induced by the client organization including changes to the existing functionality of the ERP system, or enhancements that provide new functionality, and (3) *ERP software updates* including the implementation of patches, technical upgrades and functional upgrades. Each category comprises distinct tasks and characteristics. Therefore, we also expect that they relate to different success and risk factors, and different IT capabilities. The relevant literature is, therefore, analyzed, structured and discussed within these categories. The data analysis is performed as follows:

1. First we identified sections within the selected articles that refer to ERP maintenance in general or to one of the three maintenance categories listed above.
2. To gain a deeper understanding of each maintenance category, we analyzed typical activities and characteristics for each maintenance category, using information provided in the article sections identified in step 1.
3. In a third step we identified factors that are proposed to influence success or failure within each maintenance category, using information provided in the article sections identified in step 1.
4. In a further step, the frequency of occurrence for each factor had been counted to determine critical factors. A factor is identified as critical in this study if at least three references are found to support the inclusion of the factor.

In the following section the reviewed literature and the results of the data analysis are discussed.

5 Development of propositions

Here, typical IT-tasks and characteristics of ERP maintenance are summarized in response to research question 1. Furthermore, critical factors in ERP maintenance identified in the literature are discussed in response to research question 2. Based on these findings, a set of propositions relating to IT capabilities in ERP maintenance is derived, in response to research question 3. As mentioned above, all results are discussed along the three maintenance categories ERP user support, ERP changes and ERP updates, which guided our research.

5.1 ERP user support

IT-tasks and characteristics

ERP user support involves a wide range of tasks. These include answering how-to questions, consulting users in the use of the system, solving user problems and analysing errors in the application, serving as first contact for change requests, searching for ERP vendor bug fixes, bug reporting to the ERP vendor, and preparing and performing user trainings (Ahituv et al., 2002; Nah and Delgado, 2006; Ng et al., 2002; Ng et al., 2003b). ERP user support requires not only technical system knowledge but also knowledge about work processes in the ERP system in order to address user requests adequately (Ahituv et al., 2002; Bajwa et al., 2004; Wenrich and Ahmad, 2009). Business knowledge is often provided by functional subject matter experts who act as key users between the ERP support organization and the business unit (Volkoff et al., 2004; Worrell, 2007; Worrell et al., 2006). Key users are not part of the IT organization, but they provide ERP support to a certain extent. Key users can, for example, serve as first level support for end users, assist in the solution of user problems, provide trainings, serve as central contact for the IT support personnel and assist in the specification, implementation and test of new ERP functionality (Volkoff et al., 2004; Zwicker and de Souza, 2006).

Critical factor 1: Integration of key users

Missing involvement of users is a major risk factor in ERP maintenance (Salmeron and Lopez, 2010). Key users play a vital role to ensure the involvement of users in ERP maintenance, as they can act as broker between ERP support staff and the end user community and enable knowledge transfer between the ERP support staff and end users (Gallagher and Gallagher, 2010; Häkkinen and Hilmola, 2008; Volkoff et al., 2004; Worrell, 2007). Key users do not only contribute to an efficient support of end users, but they also provide valuable knowledge of business practices and system processes that are critical for adapting and extending ERP systems (Gallagher and Gallagher, 2010; Haines, 2009; Hirt and Swanson, 2001; Worrell, 2007).

Proposition 1: *ERP maintenance performance is a function of the IT organization's capability to integrate key users into their support structures.*

Critical factor 2: User training

There is a shared view in the extant literature that sufficient and continuous user training is a key factor in the successful adoption of an ERP system (Bajwa et al., 2004; Calvert and Seddon, 2006; Somers and Nelson, 2001; Somers and Nelson, 2004). A lack in user training and a poor user documentation represent a risk factor in ERP maintenance, that can lead to low data reliability for the ERP system due to user mistakes, and a lack of user awareness of the system's potential (Häkkinen and Hilmola, 2008; Salmeron and Lopez, 2010; Stein et al., 2003). User training is not confined to formally organized training sessions, but includes informal trainings, documentations, and user manuals, depending on the users' situation and needs (Jones et al., 2008; Scott, 2005; Shang and Hsu, 2007; Stratman and Roth, 2002; Wenrich and Ahmad, 2009).

Proposition 2: *ERP maintenance performance is a function of the IT organization's capability to provide trainings contingent on the users' specific situation.*

5.2 ERP changes

IT-tasks and characteristics

ERP systems are continuously improved and extended after go-live. Changes to the ERP system that are induced by the client organization can result from changes in the business strategy, organization, environment or due to technological changes (Ahituv et al., 2002; Ross and Vitale, 2000). In this way, a change in the ERP system can be triggered by a business-related event such as the change of a business process supported by the ERP system, or by a technology-related event, such as a change in other applications that are connected with the ERP system through interfaces that have to be maintained. ERP changes are implemented using various methods, including the selection of new modules, the configuration of the software using parameters, the modification of the ERP system's source code, and the development of add-ons within the ERP system's development environment (Luo and Strong, 2004; Ng et al., 2002; Rothenberger and Srite, 2009).

Critical factor 3: Selection of change requests

It is not cost-effective to implement all change requests. Therefore, IT organizations require mechanisms to prioritize change requests to deliver optimal support to all involved parties (Haines, 2009; Law et al., 2010; Wenrich and Ahmad, 2009). If too many changes are accepted at the same time, their proper implementation may be hindered due to a tight schedule of changes (Salmeron and Lopez, 2010). Therefore, prioritization of change requests should be performed carefully, as requests that are inadequately prioritized have a strong impact on the performance of all ERP change processes (Salmeron and Lopez, 2010). Generally, a lack of good change management practices is a major barrier to realizing potential ERP system benefits (Stein et al., 2003).

Proposition 3: *ERP maintenance performance is a function of the IT organization's capability to assess and select ERP change requests.*

Critical factor 4: Implementation method for ERP changes

There is a shared view in the extant literature that the chosen implementation method for ERP changes (e.g. the configuration of the software, the modification source code, the development of add-ons) has to be selected with great care because path dependences influence subsequent maintenance efforts, including subsequent upgrades of the ERP system (Brehm et al., 2001; Law et al., 2010; Light, 2001; Ng, 2001; Rothenberger and Srite, 2009; Salmeron and Lopez, 2010; Wenrich and Ahmad, 2009).

Proposition 4: *ERP maintenance performance is a function of the IT organization's capability to make informed decisions about the implementation method for ERP changes.*

Critical factor 5: Procedures for testing

Any change to the system has an impact on existing business processes and, therefore, should be performed and tested according to a defined procedure before it is moved to the productive system (Law et al., 2010; Stratman and Roth, 2002). Testing should take place on different levels, and should include a comparison of initial requirements and final results from the changes as well as a check whether or not the development meets defined quality requirements (Salmeron and Lopez, 2010; Wenrich and Ahmad, 2009). If testing is not done properly, users might accept changes that do not work properly (Salmeron and Lopez, 2010).

Proposition 5: *ERP maintenance performance is a function of the IT organization's capability to apply defined procedures for testing ERP changes that involve both users and IT personnel.*

Critical factor 6: Management of modifications and extensions

Typically, a substantial part of the modifications and extension becomes obsolete sometime in the ERP system lifetime. This is due to changing business requirements or the fact that functionality is provided as standard functionality in later software releases (Sekatzek and Krcmar, 2009). This obsolete program code causes unnecessary costs as it needs to be tested after each update to the system. To keep an overview on existing modifications or extensions of the ERP system, each change

to the system has to be documented and tracked across its life cycle (Ng et al., 2003a; Salmeron and Lopez, 2010; Wenrich and Ahmad, 2009).

Proposition 6: *ERP maintenance performance is a function of the IT organization's capability to manage an existing modification or extension to an ERP system across its life cycle.*

5.3 ERP software updates

IT-tasks and characteristics

Standard ERP software packages are usually updated on a regular basis by the software vendor who provides patches or upgrades for the software. Patches are used to fix bugs in the ERP standard programs, to adapt the system to changes in the external environment, including, for example, changes in government regulations, and to keep a system up-to date (Ng et al., 2002). Compared to patches, software upgrades are more extensive changes to the ERP system, that include functional as well as technical enhancements of the software (Ng et al., 2002; Ng et al., 2003b).

Critical factor 7: Identification and evaluation of software updates

The identification and evaluation of relevant software updates is vital in ERP maintenance to ensure that benefits provided by them are available to the organization (Beatty and Williams, 2006; Haines, 2009; Ng, 2001, 2006; Ng et al., 2002). Business benefits can e.g. be achieved by new or improved functionality that covers business requirements, or compliance to new legal regulations that are considered in the software update (Haines, 2009; Ng, 2006; Ng et al., 2002). Technical benefits on the other hand include a better system performance, and ongoing vendor support of the software (Beatty and Williams, 2006; Haines, 2009; Ng, 2001, 2006; Ng et al., 2002).

Proposition 7: *ERP maintenance performance is a function of the IT organization's capability to identify and evaluate relevant software updates.*

Critical factor 8: IT project management for ERP upgrades

Upgrades represent the most complex form of software updates, as they usually provide a wide range of additional functionalities. These upgrades are not routine work and, therefore, should be handled as a project due to the required efforts and the complexity (Beatty and Williams, 2006; Nah and Delgado, 2006; Ng and Gable, 2010). Upgrade projects are not one-time events but recur throughout the life of an ERP implementation (Nah and Delgado, 2006). The reuse of knowledge and documentation from previous implementation and upgrade projects therefore supports organizations in performing an upgrade project successfully (Erickson and Scott, 2007; Nah and Delgado, 2006).

Proposition 8: *ERP maintenance performance is a function of the IT organization's capability to manage ERP upgrades with appropriate IT project management practices that build on experience from previous implementation and upgrade projects.*

6 ERP maintenance and firm-wide IT capabilities

Based on the literature review, eight IT capabilities on the functional level of ERP maintenance are proposed that are labelled as *ERP maintenance capabilities*. In the second step, the link between the proposed ERP maintenance capabilities and an existing typology of firm-wide IT capabilities (Bharadwaj et al., 1999) is examined. This typology covers six IT capability categories that are *business partnership, external IT linkages, business IT strategic thinking, IT business process integration, IT management, and IT infrastructure*, whereas each category includes a set of IT capabilities. The typology had been selected as it provides a comprehensive view on IT capabilities and is frequently used and cited in subsequent research on IT capabilities, e.g. in (Ray et al., 2005; Santhanam and Hartono, 2003). Linking these capabilities with the proposed ERP maintenance capabilities provides insights on how firm-wide IT capabilities can be operationalized with respect to the specific area of ERP maintenance. In the following, each IT capability category proposed by Bharadwaj et al. (1999) is examined regarding its links to ERP maintenance capabilities proposed in this paper.

Business Partnership

The previously proposed capabilities *to integrate key users* (P1) and *to provide trainings* (P2), can be linked to the business partnership capability category. The integration of key users into ERP support structures builds multi-disciplinary teams with business and technology expertise. These teams are one capability identified by Bharadwaj et al. (1999) in the business partnership category. Appropriate ERP training increases users' self-confidence with the system and encourages them to experiment with the ERP functionality. Experimentation with IT is another IT capability identified by Bharadwaj et al. (1999) in the business partnership category.

External IT linkages

This capability category covers technology-based links among customers and suppliers, and IT-based entrepreneurial collaborations with external partners. There is no direct link between the ERP maintenance capabilities proposed in this study and capabilities listed in this category. This is because this category refers to capabilities on a technical level and not on a functional level. Nevertheless, it is expected that ERP maintenance capabilities related to ERP changes and updates have effects on the development of these technical capabilities.

Business IT strategic thinking

The proposed capability *to identify and evaluate relevant software updates* (P7) requires visions and knowledge on how IT can contribute to business value. The clarity of vision on how IT can contribute to business value is one of four capabilities that are identified by Bharadwaj et al. (1999) in the IT strategic thinking capability category.

IT business process integration

The proposed capability *to assess and select ERP change request* (P3) supports the alignment of IT applications with new business requirements, that is in turn one of the capabilities proposed by Bharadwaj et al. (1999) in the IT business process integration capability category.

IT management

The proposed capabilities *to make informed decisions about the implementation method for ERP changes* (P4), *to apply defined procedures for testing ERP changes* (P5), and *to manage an existing modification or extension to an ERP system across its life cycle* (P6) represent capabilities related to ERP system development practices. System development practices in turn represent one capability identified by Bharadwaj et al. (1999) in the IT management capability category. Another IT management capability in this category is IT project management, which can be linked with the proposed capability *to manage ERP upgrades with appropriate IT project management practices* (P8).

IT infrastructure

IT infrastructure capabilities comprise the appropriateness of data architectures, network architectures and the adequacy of architectural flexibility (Bharadwaj et al., 1999). Data architecture and architectural flexibility of ERP systems are influenced by characteristics of the ERP software package and, specifically, how the software had been adapted during the ERP implementation. Nevertheless it is expected that in the ERP post-implementation phase, the architectural flexibility of an ERP system is affected by the method used to implement ERP changes (e.g. customization of modification). Therefore, it is expected that there is an indirect link between the proposed *capability to make informed decisions about the implementation method for ERP changes* (P4) and IT infrastructure capabilities in this category.

As shown in table 1, the eight ERP maintenance capabilities are linked directly to a subset of the firm-wide IT capabilities identified by Bharadwaj et al. (1999). Furthermore, it is expected that a subset of the ERP maintenance capabilities, specifically, P4, P5 and P6 are indirectly linked to other IT capability categories identified by Bharadwaj et al. (1999).

	ERP maintenance capabilities							
	P1	P2	P3	P4	P5	P6	P7	P8
IT capability category (Bharadwaj et al., 1999)								
IT business partnerships	x	x						
External IT linkages				(x)	(x)	(x)		
Business IT strategic thinking							x	
IT business process integration			x					
IT management				x	x	x		x
IT infrastructure					(x)			
x= direct link; (x) = indirect link								

Table 1. Linking ERP maintenance capabilities to firm-wide IT capabilities

7 Discussion and conclusion

Above, we discussed IT-related tasks and critical factors in the maintenance of ERP systems that had been identified by a review of the ERP post-implementation literature. Based on the results of the literature analysis, we proposed eight ERP maintenance capabilities across the three maintenance categories ERP user support, ERP changes, and ERP software updates. We also showed how the proposed ERP maintenance capabilities can contribute to firm-wide IT capabilities that had been identified in previous research. Findings presented in this paper contribute to existing IT capability research by proposing a set of functional IT capabilities that are specific to the context of ERP maintenance. This study also provides avenues for future research into various directions. The study draws on existing ERP post-implementation literature. To gain a deeper understanding on ERP maintenance capabilities, expert interviews can be conducted with IT organizations that are responsible for the maintenance of ERP systems. Beyond that, the study is limited to the three maintenance categories ERP user support, ERP changes and ERP updates. The scope of the study can be extended to a more comprehensive view on ERP maintenance that also includes managerial aspects that are not related to one of the used maintenance categories. Such managerial aspects cover topics like maintenance planning, IT skill building, communications between IT and users, or ERP vendor partnership. Finally, gaining a deeper understanding about each proposed ERP maintenance capability and its antecedents is another possible avenue of research.

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