
Proceedings Paper:
Peng, G.C. and Nunes, J.M.B. (2010) Interrelated Barriers and Risks Affecting ERP Post-Implementation in China. In: 43rd Hawaii International Conference on System Sciences (HICSS). 43rd Hawaii International Conference on System Sciences, 05-08 Jan 2010, Honolulu, HI. IEEE, 4219 - 4228. ISSN: 1060-3425.

https://doi.org/10.1109/HICSS.2010.240

Interrelated Barriers and Risks Affecting ERP Post-Implementation in China

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Abstract

The research reported in this paper aimed to identify and explore potential barriers and risks that can affect successful exploitation of Enterprise Resource Planning (ERP) systems in Chinese companies. A barrier and risk ontology was established from a critical literature review process. In order to examine this theoretical model, the study employed a deductive research design based on a cross-sectional questionnaire survey. The survey received 84 responses from 42 Chinese firms. The findings identified that organizational barriers are often the main triggers of other ERP barriers and risks, including the system ones. The study thus concluded and suggested that Chinese companies need to pay substantial attention to the organizational barriers identified, since properly managing this type of obstacle may potentially help them to mitigate and remove other ERP challenges and risks and thus ensuring long-term success in ERP post-adoption.

1. Introduction

Enterprise Resource Planning (ERP) systems, which are widely perceived as the most important development in the corporate use of information technology (IT) in the 1990s [1], have nowadays been adopted by thousands of modern companies worldwide. However, it is commonly perceived in the information systems (IS) community [2, 3, 4, 5] that, successful implementation of the system is only an important first step toward achieving ERP success. In truth, long-term viability and success of ERP depend on its continued operation, usage, maintenance and enhancement during the system post-implementation or exploitation phase [3, 4, 6, 7].

Nevertheless, it is expected that a wide range of barriers embedded in the organizational context (e.g. lack of top management support) and the system itself (e.g. deficient system design) may affect long-term success in ERP utilization. Moreover, the existence of these barriers may in turn lead to the occurrence of a variety of risks (e.g. staff are resistant to use the implemented system) during ERP post-implementation. Disregarding these barriers and risks may turn initial ERP success into a failure, and thus contributing to critical business disasters.

Although many researchers recognize the importance of ERP post-adoption and even stress it is the direction of the second wave ERP research [2], current studies on ERPs focused mostly on system implementation and project management aspects [8, 9, 10]. In contrast, research studies on ERP post-implementation have only begun to appear in mainstream IS journals until recently. One of the significant examples, Gattiker and Goodhue's study [11] about how interdependence and differentiation among sub-units of an organization can affect ERP post-implementation performance, appeared in MIS Quarterly in 2005. Later on, Chou and Chang [12] drew upon this study of Gattiker and Goodhue to explore further how customization and organizational mechanism can affect ERP benefits and performance in the post-adoption phase. Nevertheless, as recognized by Chou and Chang [12], these prior studies emphasized on a very limited number of variables and factors to study ERP exploitation. In truth, no intensive and comprehensive studies or model on ERP post-implementation barriers and/or risks were identified from the literature reviewed.

The empirical study presented in this paper thus contributed to this significant research gap. This study aimed to investigate barriers and risks associated with the post-adoption of ERP systems in China, and more importantly to explore potential causal relationships between the identified barrier and risk items. In order to frame the study, the researchers conducted a critical literature review at the early stage of the research. This extensive review resulted in the establishment of a theoretical ontology which consisted of a wide range of barriers and risks that companies may encounter during ERP exploitation. A questionnaire was used to seek Chinese managers' and IT experts' perceptions of the established ERP barriers and risks. This paper is

organised as follows. The next section presents the theoretical ERP barrier and risk ontology. This is followed by a discussion of the research methodology. Finally, the results of the study are interpreted and the implications of these findings are discussed, with conclusions drawn.

2. Theoretical foundation

In order to construct adequate theoretical foundation to base the study on, a critical literature review was conducted. This section presents the results of this extensive review.

2.1. Potential barriers to ERP exploitation

The concept of barrier is defined differently in the literature as shown in the two examples below:

> "A barrier is, generally speaking, an obstacle, an obstruction, or a hindrance that may…prevent an event from taking place …" [13].

> "[From the business perspective,] barrier is an obstacle within the business context that prevents business objectives from being realized" [14].

These two definitions point out that a barrier is an existing obstacle that prevents an action or event from being carried out successfully. For the purpose of this paper, a barrier to ERP exploitation is defined as follows:

> "Any obstacle or factor that is inherent to the business context or the system itself; and can prevent companies from efficiently using, maintaining and improving the implemented ERP system."

It was identified from the critical review that, IS researchers have continued to stress a variety of organizational and system factors and barriers that can prevent user companies from achieving long-term IS success.

For instance, Rucks and Ginter [15] and Reich and Benbasat [16] argue that potential benefits associated with the use of MIS may not be achieved, due to issues such as inappropriate organizational structure, poor internal communication, and inefficient strategic planning. Other IS researchers [17, 18, 19, 20] reinforce that user satisfaction and acceptance toward the implemented system can be reduced, owing to barriers including insufficient user training, deficient system design, lack of top management commitment, low data quality, and poor integration of systems. Moreover, the studies of Boyton et al. [21], Raymond et al. [22] and Desai et al. [23] identified a further set of organizational and technical barriers to successful IS innovation, such as lack of efficient IS planning, inappropriate system upgrade, high ERP enhancement cost, etc.

Apart from organizational and technical barriers, the Chinese culture can also raise additional obstacles for IS usage and exploitation, e.g. power centralization of Chinese managers, lack of trust in system data, and unwilling to disclose problems in order to preserve personal image, etc [24, 25, 26, 27].

Consequently, by systematically reviewing and synthesizing these prior IS studies, the researchers established and proposed a set of 25 barriers that may affect successful exploitation of ERP systems in the Chinese context. These ERP barriers consisted of seven cultural barriers, nine organizational barriers and nine system barriers. Subsequently, a barrier ontology was developed to highlight the established ERP exploitation barriers, as presented in Figure 1

This ontology consists of two hierarchical levels ranging from general barrier categories (e.g. organizational barrier) to specific barrier items (e.g. power centralization of top managers). Moreover, it emerged from the critical review that, an ERP barrier may often be the cause or consequence of other barriers. For instance, "lack of ERP exploitation plan", which can be a result of "short-term thinking of top managers", may lead to "insufficient ERP fund". The barrier ontology thus also highlights a number of potential ERP barrier relationships emerged from the literature review. Detailed discussion of each barrier item and relationship involved in this ontology can be seen in our forthcoming journal article [6].

2.2. Potential risks to ERP exploitation

On the other hand, a risk is defined by Kleim and Ludin [28] as "the occurrence of an event that has consequences for, or impacts on" a particular business process. In fact, the terms 'barrier' and 'risk' were often misused by authors. In particular, some non-scientists [29] and less careful researchers [30] may use these two terms interchangeably. Nevertheless, these two concepts are in reality substantially different. Specifically, a risk is associated with uncertainty. That is, there is a probability that the risk event may occur and thus lead to an impact on the business processes that may imply substantial losses. In contrast, a barrier is a factor that is inherent to a given context. Therefore, a barrier, unlike a risk, has no uncertainty associated to it, and has 100% probability of occurrence. Due to this characteristic, a barrier is fundamentally different from a risk. These two terms must therefore be clearly distinguished.

For the purpose of this study, the researchers slightly modified the above definition given by Kleim and Ludin, and defined an ERP post-adoption risk as:

"The occurrence of an event that has consequences or impacts on the use, maintenance and enhancement of the implemented ERP system."

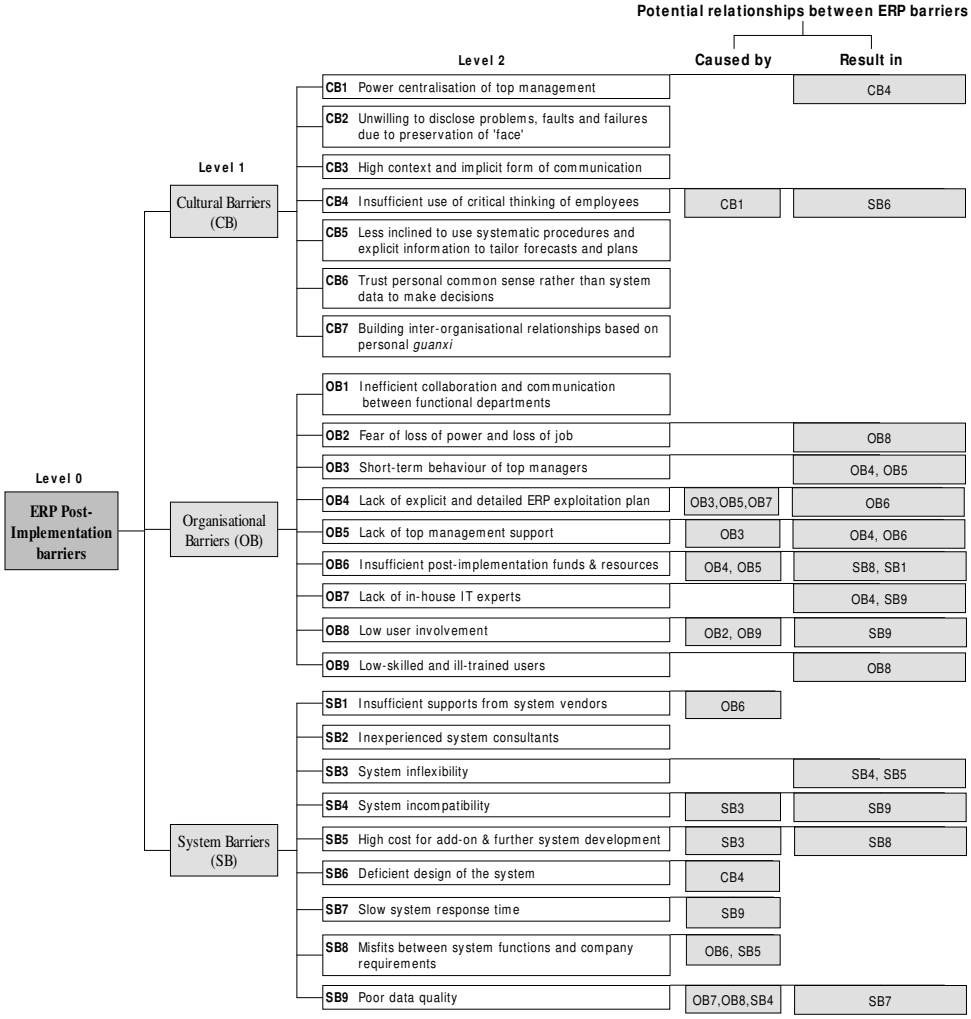

Figure 1. Theoretical ontology of the 25 established ERP barriers

Given the size and complexity of an ERP system, identification of risk in ERP post-implementation was a very time-consuming and complicated task. In order to frame the study and generate meaningful outcomes, the researchers particularly looked at ERP risks in four main categories:

- Operational risk (OR). ERP systems are mainly designed to integrate and automate transaction processing activities of companies [31, 32]. Operational risks refer to risks that may occur as operational staff use ERP systems to perform daily business activities.
- Analytical risk (AR). ERP systems are also embedded with a set of analytical tools to facilitate planning and forecasting (e.g. production plans, sales forecasts, financial budgets, etc) [33, 34]. Analytical risks refer to risks that may occur as managers and business analysts use ERPs to carry out analytical tasks.
- Organization-wide risk (OWR). When using and maintaining ERPs in the post-implementation stage, companies may encounter a set of risk events in relation to various internal (e.g. system users, in-house IT experts) and external factors (e.g. system vendor, system consultants). Such risks may have impact on the entire company [35], and thus are referred to as organization-wide risks.
- Technical risk (TR). A set of technical (e.g. hardware and software) issues may result in risk events that can hinder the implemented system

from meeting its intended functions and performance requirements [36]. These risk events are identified as technical risks.

Furthermore, it was considered that operational and analytical risks occur in different functional areas and processes in a company, and are therefore very different in nature [37, 38]. Their study needs to take into account diverse aspects and sometimes very disparate triggers. Therefore, apart from general operational and analytical risks, the researchers specifically selected and focused on three essential business areas for identification of operational and analytical risks, namely sales and marketing area, production and purchasing area, and financial and accounting area. Subsequently, a large amount of studies regarding IS and ERP usage in these specific business areas [32, 39, 40, 41] were reviewed and analyzed in order to identify possible ERP risks.

On the other hand, there is a very rich amount of literature on risks associated with IS and ERP implementation. As some of the significant examples, the studies of Huang et al. [42], Scott and Vessey [43], Sumner [44] and Barki et al. [45] identify a wide range of organization-wide risks that can affect ERP adoption, e.g. top managers do not provide sufficient support to ERP, lose qualified IT experts, and cannot receive sufficient support from system vendors, etc. It was expected that such organization-wide risks might also occur during ERP post-implementation. Moreover, IS researchers [46, 47] also point out a number of common technical risks that can occur during the use of IT systems, e.g. hardware and software crash, invalid data of the system is not properly managed, and system is not continually modified to meet new business requirements, etc.

Consequently, by critically analyzing and synthesizing these IS and ERP studies, the researchers identified a comprehensive set of 40 risk events that may occur during ERP exploitation, including nine operational risks, eight analytical risks, sixteen organization-wide risks and seven technical risks. Subsequently, a risk ontology (Figure 2) was developed to highlight these 40 established ERP risks.

As shown in Figure 2, this risk ontology consists of three hierarchical levels ranging from general risk categories (e.g. operational risks) to specific risk items (e.g. ERP contains incomplete bills of materials). In addition, the critical literature review also pinpointed a number of potential relationships between the established ERP risk events. For instance, it was identified that ERP systems need to use three types of inputs (i.e. bill of materials, inventory records and master production schedule) to calculate net requirement plans of materials as outputs [34, 48]. Therefore, if ERP contains "incomplete bills of materials", "inaccurate inventory record" or "inappropriate master production schedule", the system may also "fail to generate proper material net requirement plans". These potential causal relationships between the proposed ERP risks were also highlighted in the risk ontology. Further discussion of this risk ontology can be found in our other publications [49].

2.3. Potential correlations between ERP barriers and risks

Finally, it emerged from the above definitions that a barrier existing in the organizational context may lead to the occurrence of a set of undesirable risk events. Our review and synthesis of prior IS and ERP literature suggested that this would be particularly true for ERP post-implementation. For instance, power centralization of top managers, which is a prevalent phenomenon in the Chinese context, is a barrier to MIS adoption and usage in China's companies [24]. This barrier may result in the risk that Chinese leaders may make centralized decisions on important IS issues without collecting and considering alternative ideas from a wider group of people, e.g. IT experts and/or system users [24, 26]. Therefore, based on results of the critical review, Figure 3 summaries and highlights a set of potential causal relationships between the identified ERP barriers and risks.

3. Research methodology

This study adopted a cross-sectional questionnaire survey to examine the theoretical barrier and risk ontologies. In the questionnaire, each proposed ERP barrier was measured by using a 5-point Likert scale ranging from "strongly disagree (1)" to "strongly agree (5)". On the other hand, in order to assess how likely each established risk event may occur in the firm, the study employed a 3-point Likert scale from "high probability of occurrence (3)" to "low probability (1)". Additionally, it emerged from the theoretical ontologies that, some of the predefined ERP barriers and risks are related with business aspects, while the rest focus on technical dimensions. This fact led to the development of two different questionnaires to obtain perspectives respectively from business managers and IT experts. Moreover, both questionnaires were pilot tested with a group of Chinese postgraduate students and researchers in the authors' department as well as 4 Chinese managers. A number of corrections to the questionnaires were made according to the feedback received from the pilot test.

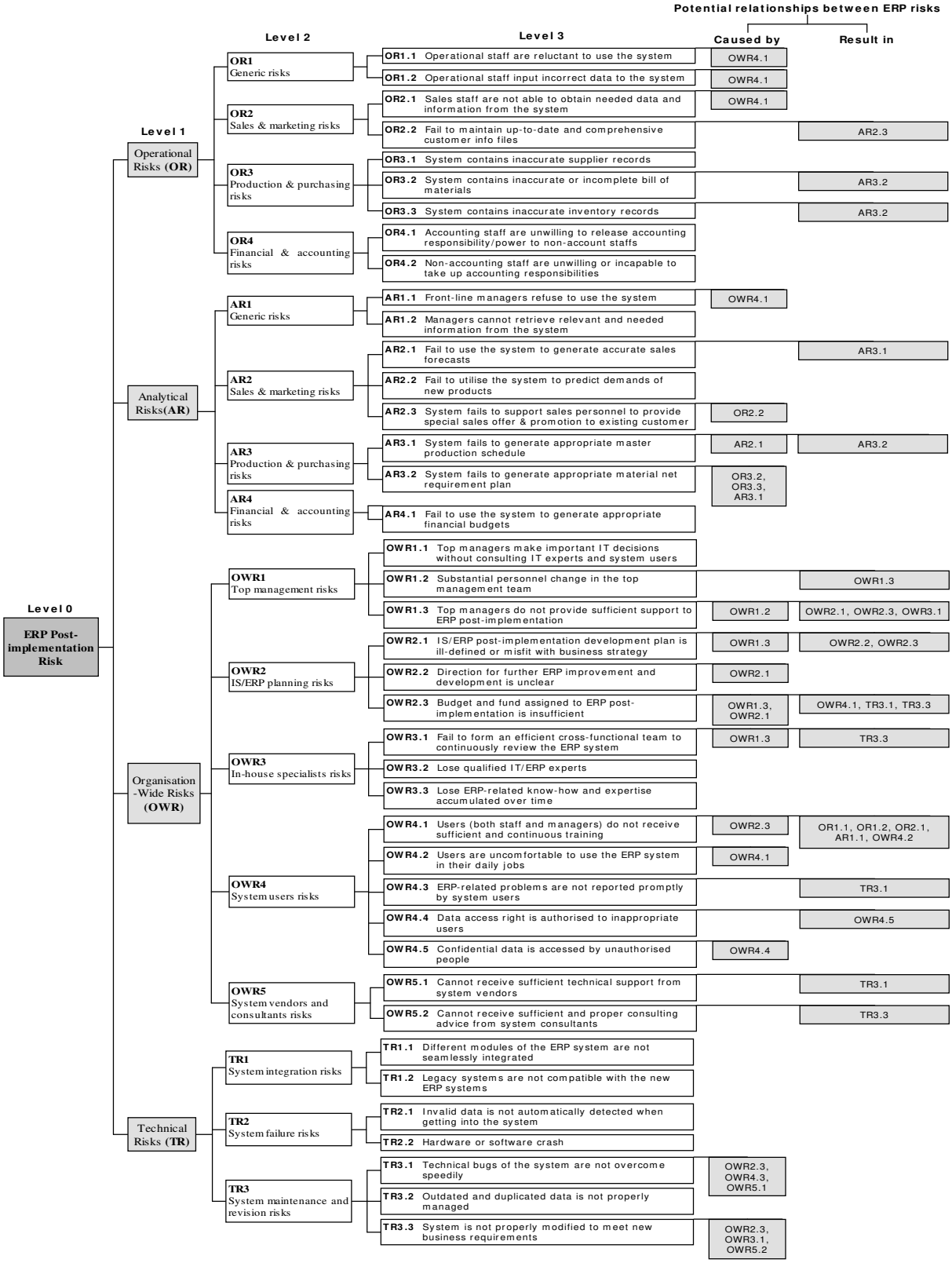

Figure 2. Theoretical ontology of the 40 established ERP risks

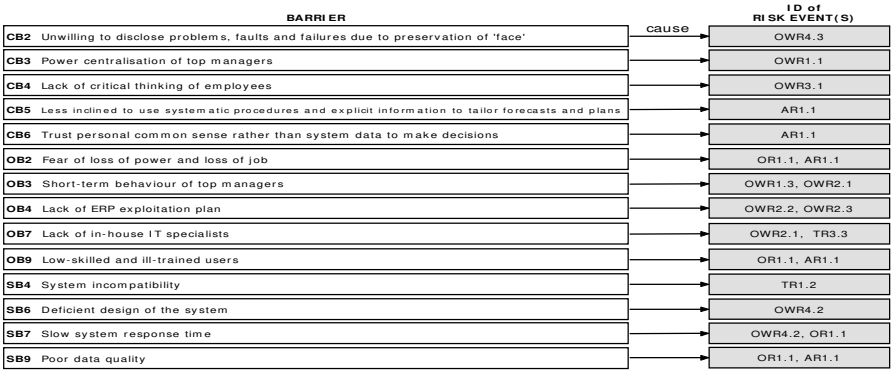

Figure 3. Potential relationships between ERP barriers and risks

Furthermore, the initial temptation of the researchers was to conduct a national survey of the whole of China. This however soon proved to be very difficult and virtually impossible. This difficulty does not only follow from China's large size and number of potential respondents [50], but more importantly is attributed to the fact that IT and IS utilization in China vary significantly between different regions, types of companies, and industrial sectors [51, 52]. It is therefore infeasible for a single study to cover all these variances and complexities [51]. Faced with the need of focusing the research, the researchers adopted a Political, Economic, Social and Technological (PEST) analysis, to narrow the scope of the study, as well as to identify a type of firm, an industry sector, and a region in China to base the study on [51].

This PEST analysis resulted in three major conclusions. First, it was identified that Guangdong is one of the most important and representative economic regions in China. Its local GDP has always been the highest among the 31 regions in mainland China. Second, it was realized that China's stated-owned enterprises (SOEs) currently hold more than 50% of the country's total industrial assets. This type of company thus proves to be extremely crucial to the national economy. Third, it was found that China's electronic and telecommunication manufacturing sector is a core segment of the country's industry. More importantly, companies in this sector generally have achieved high level of IS and ERP utilisation. Based on these conclusions of the PEST analysis, the researchers selected SOEs in the electronic and telecommunication manufacturing sector in the Guangdong region, as a suitable set of Chinese companies to conduct the survey.

According to statistics provided by the Guangdong Statistical Bureau, there are 118 SOEs operating in the local electronic and telecommunication sector. The two designed questionnaires were thus mailed to the operational managers and IT managers of these 118 Chinese firms. In order to increase the response rate, a web-based version of the questionnaires was also developed. Respondents could thus either fill in the questionnaire and return it by using the pre-paid envelope, or complete the online version and submit it electronically.

4. Data analysis

84 respondents from 42 companies completed and returned the questionnaire, which representing a response rate of 35.6%. As shown in Figure 4, the majority of the 42 respondents of Questionnaire A (which covered business-related barriers and risks) held managerial positions in the company. On the other side, most respondents of Questionnaire B (which contained technical items) held IT-related positions in the firm. These respondents thus prove to be suitable stakeholders to participate in the survey. Moreover, 73.8% of the respondent companies have been using ERP for 2 to 6 years. This result further confirms that, a research on ERP exploitation risk in China is not just timely but also highly meaningful.

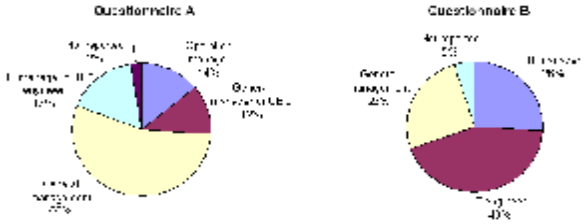

Figure 4. Positions of respondents

As highlighted by Bryman and Cramer [53], the mean is often considered the most efficient method for summarising a distribution of values. Therefore, the mean was used to provide a summary of responses for each barrier and risk item. Table 1 shows the top ten ERP barriers ranked by their means. Furthermore, the

top ten risk events, which were found to be most likely to occur in Chinese firms, are given in Table 2.

Table 1. Top ten ERP barriers

Rank	*Barrier*		*N = 42*	*Mean*
1	SB1	Insufficient vendor support		2.95
2	SB4	System incompatibility		2.86
3	SB7	Slow system response time		2.81
3	SB3	System inflexibility		2.81
5	SB6	Deficient design of the system		2.76
6	SB2	Inexperienced system consultants		2.69
7	CB1	Power centralisation of top managers		2.55
8	OB7	Lack of in-house specialists		2.50
8	SB5	High cost for ERP add-ons		2.50
10	SB8	Misfits between ERP and user needs		2.36

CB = Cultural Barriers; OB = Organizational Barriers; SB = System Barriers

Table 1. Ten frequent ERP risk events

Rank	**Risk item**		**N = 42**	**Mean of probability**
1	OWR5.1	Cannot receive enough support from ERP vendors		2.00
2	TR1.2	ERP cannot be seamlessly integrate with other IS		1.98
3	AR1.2	Managers cannot retrieve needed information from ERP		1.95
3	TR3.2	Outdated data of ERP is not properly discarded		1.95
3	OWR5.2	Cannot receive proper advice from system consultants		1.95
6	OR3.3	ERP contains inaccurate inventory records		1.93
6	AR2.2	Fail to use ERP to predict demands of new products		1.93
6	AR4.1	Fail to use ERP to generate appropriate financial budgets		1.93
6	TR1.1	Integration is not achieved between modules of ERP		1.93
6	TR3.3	ERP is not properly modified to meet new business needs		1.93

OR = Operational Risk; AR = Analytical Risk; OWR = Organization-Wide Risk; TR = Technical Risk

Subsequently, in order to explore potential correlations between the identified ERP barriers and risks, a bivariate analysis was conducted. The use of Likert scales in the survey means that data variables generated were ordinal in nature. Therefore, Spearman's rho (r^s) was adopted as the most appropriate technique for measuring bivariate correlations between these ordinal variables [54, 53]. Moreover, one-tailed test was used to test the statistical significance (P value) of each directional correlation proposed in the theoretical ontologies [54]. By following this approach, the researchers identified 19 statistically significant correlations between the ERP barriers and risks. Figure 5 presents a conceptual map to summarise and represent these correlations. A full description of each of these correlations is presented in Table 3.

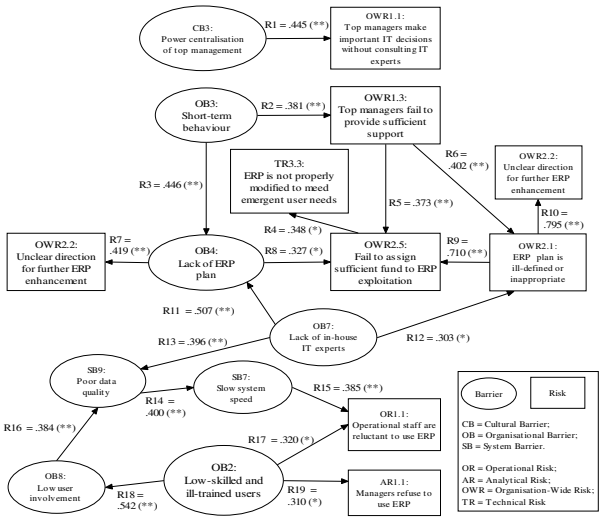

Figure 5. Conceptual map of correlations

Table 3: Description of correlations identified

Correlation		r_s
R1	Higher extent of power centralization can lead to higher chance for top managers to make centralized IS decisions	.445 (**)
R2	The greater the extent of short-term thinking, the higher the probability to lack top management support for ERP	.381 (**)
R3	Short-term behaviour of top managers can have negative effect on the establishment of long-term ERP plan	.446 (**)
R4	The higher the possibility to have insufficient ERP fund, the greater the chance for ERP to be poorly enhanced	.348 (*)
R5	The higher the chance to lack top management support, the higher the chance to have insufficient ERP fund.	.373 (**)
R6	The higher the chance to lack top management support, the higher the chance to have ill-defined ERP plan	.402 (**)
R7	Lack of ERP exploitation plan can result in unclear direction for long-term ERP development	.419 (**)
R8	Lack of ERP plan can increase the probability for the firm to assign insufficient fund to ERP exploitation	.327 (*)
R9	The higher the chance to have ill-defined ERP plan, the greater the possibility to have insufficient ERP fund	.710 (**)
R10	A firm that is likely to have an ill-defined ERP plan, will also be likely to have unclear ERP exploitation direction	.795 (**)
R11	Lack of IT experts can have negative impact on the establishment of ERP plan	.507 (**)
R12	Lack of IT experts can increase the probability for the firm to have inappropriate ERP plan	.303 (*)
R13	Lack of in-house IT experts can negatively affect the quality of system data`	.396 (**)
R14	When data quality of ERP is poor, speed of the ERP system will be correspondingly slow	.400 (**)
R15	Slow system speed can increase the probability for having user resistance	.385 (**)
R16	Low user involvement can negatively affect the quality of system data	.384 (**)
R17	Staff are more likely to be resistant to use ERP, when they have low skill levels and insufficient training	.320 (*)
R18	Users with low skill levels and insufficient training will have low involvement in ERP-related activities	.542 (**)
R19	Managers, who have lower skill levels and insufficient training, are more likely to be reluctant to use ERP	.310 (*)

* Correlation is significant at the 0.05 level (1-tailed);
** Correlation is significant at the 0.01 level (1-tailed).

5. Discussion

It emerged from Table 1 that eight of the top ten ERP barriers are related to system aspects. Therefore, the respondents seemed to perceive system barriers to be particularly crucial to their firms, when organizational and cultural issues were considered to be less important. However, the results of the bivariate analysis proved that these respondents had in fact underestimated the critical impacts associated with organizational barriers and problems.

In particular, the above conceptual map clearly shows that many identified ERP barriers and risks are interwoven and closely correlated with each other. Further investigation of this conceptual map and the list of significant correlations identified that, organizational barriers (e.g. lack of in-house IT experts), which are mainly located at the center of the map, can originate a number of other ERP barriers, including the system ones (e.g. poor data quality). Moreover, the existence of these organizational obstacles can also increase the probability of occurrence of a wide range of ERP risks (e.g. ERP plan is ill-defined or inadequately developed). In contrast, system barriers, which were perceived as crucial by the respondents, do not prove to be the main triggers of other ERP barriers and risks. As a consequence, it became apparent that organizational barriers should in reality be more dangerous than system ones, although the significance of these organizational issues seems to be overlooked by the Chinese respondents.

In truth, despite their importance, organizational factors and issues have traditionally been understated by practitioners, probably due to a lack of understanding and awareness of the existence and influence of these barriers [54]. In China, this underestimation may also be caused by an unwillingness of Chinese managers to talk about their organizational and management shortcomings. Specifically, many researchers [6, 27, 55] stress that, Chinese managers are traditionally less willing to disclose problems and failures to external bodies, in order to preserve their own and/or their firms' images. In addition, under the hitherto bureaucratic environment in the firm, Chinese managers may often be reluctant to address problems embedded in their organizational and management mechanism in order to avoid potential personal risks (e.g. job loss). These attitudes however may blind Chinese practitioners to the complexity and importance of organizational barriers, which might be less obvious but proved in this study to be more difficult to resolve and more critical to long-term ERP success in the Chinese context.

6. Implications

The results of this study have important implications for both practice and research. In terms of practice, the barrier and risk ontologies are useful checklists to help Chinese practitioners to identify, prevent and manage ERP post-implementation barriers and risks in their workplaces. The exploration and identification of a set of barrier and risk correlations also allow Chinese managers to gain deeper insights into possible triggers of the ERP problems that they are facing. More importantly, it is hoped that the findings of this study can make practitioners in Chinese firms become more aware of the importance and critical impacts of organizational barriers, and thus preventing them from potential ERP failure. In addition, it is important to note that, our findings may also be applicable to Western companies, considering that many ERP barriers and risks were initially grounded from Western IS literature as discussed above.

On the other hand, and in terms of research, the study added to the knowledge of ERP in general, and contributed to the research gap of ERP post-implementation barriers and risks in the Chinese context in particular. It represented a first attempt in producing a comprehensive study in its research area. The process of literature search could not return any other such studies. Therefore, the established barrier and risk ontologies can also be used as a starting point for researchers to carry out further research in this increasingly important research area.

7. Conclusions

This study identified and explored empirically a wide range of ERP exploitation barriers and risks in the Chinese context. Our findings have led to three major conclusions. Firstly, it was confirmed that successful implementation of the ERP system is not the end of the story. In fact, user companies can often experience a large number of barriers and risks during organizational exploitation of ERPs. Secondly, it was found that many ERP barriers and risks are interrelated with each other. These ERP issues thus prove to be very difficult to manage and mitigate. Thirdly, and most importantly, the findings identified that the complicated network of ERP barriers and risks is actually originated by organizational barriers. However, this type of ERP obstacle currently seemed to be underestimated by Chinese practitioners. Therefore, in order to ensure long-term ERP success, Chinese practitioners need to become aware of the significance and networked nature of organizational

issues, as well as to take proper actions to address these critical ERP obstacles.

A noticeable limitation of this study is related to the small sample size. Indeed, the use of the PEST analysis to narrow the research context and select a specific set of Chinese company to base the study on, can limit the generalizability of the findings [52]. This limitation is attempted to be addressed in the next phase survey, in which a larger sample (e.g. involving Chinese SOEs and private companies in selected inland and coastal regions in diverse industrial sectors) will be used.

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