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Risks Affecting ERP Viability: Insights from a Very Large Chinese Manufacturing Group

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Abstract

Purpose – The purpose of the study reported in this paper is to identify, assess and explore potential risks that can affect long-term viability of Enterprise Resource Planning (ERP) systems in the post-implementation and exploitation phase.

Design/methodology/approach – The research took a large Chinese private group as a case study. A theoretical ERP risk ontology, which was adopted from the literature, was used to frame the study and generate data collection tools. Two questionnaires were thus designed and used to explore ERP post-implementation risks in the case company.

Findings – The study identified 37 risk events, of which seven were identified as the most critical for ERP exploitation in the case company. The findings show that organisational and human-related risks are the crucial factors for potential ERP failure and not the usually suspect technical risks.

Research limitations/implications – This study contributes to the knowledge of ERP in general, and provides valuable insights into ERP post-implementation risks in large companies in particular.

Practical implications – The findings will not just be useful in supporting ERP risk identification and management in the large Chinese companies, but will also be beneficial to other large companies in general, which may be confronted with similar ERP exploitation challenges.

Originality/value – The majority of large companies in China and in the West have implemented ERP systems and engaged in the system post-implementation phase. Most of the existing literature in the field focuses on the process of implementation. This paper looks forward to the risks involved in the post-implementation phase. Understanding potential risks that may occur during ERP exploitation is vital for these large firms to achieve and sustain business success though their ERP systems.

Keywords - ERP, ERP Post-implementation, ERP exploitation, Risks, Large companies, China.

Paper type - Research paper.

1. INTRODUCTION

It is widely recognised that China has experienced remarkable economic growth during the last three decades (Keng, 2006), and has now become the world's third-largest economy behind the US and Japan. In fact, China's large-sized corporations have been playing an extremely crucial role in sustaining this continuous national economic development. Specifically, and according to the National Bureau of Statistics of China, the country had 2,387 large-sized companies in total by 2006. However, this represents only 0.9% of all industrial enterprises in China. Nonetheless, these large companies contributed to 41.2% of total sales revenue of the industry in 2006, and continue to hold more than 42% of the total industrial assets of the country (National Bureau of Statistics of China, 2007).

In order to improve business competitiveness and retain leading market positions, China's large corporations have consistently invested heavily in information technologies (IT) and information systems (IS). Supporting this view, a prominent Chinese consulting firm, CCW Research (2005), reports that IT/IS investments of large Chinese firms exceeded RMB 12 billion in 2004. Moreover, a substantial amount of this IS investment has been spent on the adoption of Enterprise Resource Planning (ERP) systems (Wang, 2006).

ERPs are enterprise-wide IS packages that consist of a number of software modules aimed at supporting and integrating all business processes across functional divisions of an organisation. Traditionally, ERP systems attempt to help user companies to achieve seamless data and process integration in their back offices (Kumar and Hillegersberg, 2000). Nowadays, ERP systems can also act as platforms or backbone systems to link the company's back office with its front office, by integrating with other enterprise applications, e.g. supply chain management (SCM) and customer relationship management (CRM) systems (Kalakota and Robinson, 2000; Peng and Nunes, 2008). Due to these potential benefits, large Chinese companies commonly set ERP at the centre of their IS development strategy, and perceive successful ERP implementation as a prerequisite for future adoption of SCMs and CRMs (Wang, 2006; CCW Research, 2008). Consequently, under such business and organisational context, the majority of large companies in China have already implemented ERP systems by 2007 (CCW Research, 2008). The large enterprise market for ERP has thus become saturated in China in recent years.

However, as pointed out by Willis and Willis-Brown (2002), even if the ERP system is successfully implemented, the 'go-live' point of the system is not the end of the ERP journey. Very often, the system post-implementation or exploitation stage is where the real challenges begin (Willis and Willis-Brown, 2002). In a related study on the electronic and telecommunication sector in the Guangdong region, Peng and Nunes (2008) confirmed that user companies will often encounter a wide range of risks when using, maintaining and enhancing ERP systems at the post-implementation phase. These risks are not only localised around technical aspects, but more importantly can also be found in diverse operational, management and strategic thinking areas (Peng and Nunes, 2009). The occurrence of undesirable risk events in ERP exploitation may not just affect ERP viability, but may also lead to significant decreases in business efficiency. Therefore, ERP post-implementation emerges as an increasingly important research topic, and is adequately considered by IS researchers (e.g. Yu, 2005) as the direction of the second wave ERP research. However, despite the need for research in this area, current studies on ERPs focus mainly on system preparation (e.g. Baki and Cakar, 2005; Deep et al., 2008) and implementation phase (e.g. Gupta et al., 2004; Ehie and Madsen, 2005; Kim et al., 2005; Woo, 2007). In contrast, studies addressing the organisational exploitation of ERPs after the implementation stage have been very limited (e.g. Peng and Nunes, 2008).

Therefore, the research reported in this paper aimed at contributing to this research gap, by investigating ERP post-implementation risks in the context of large companies in China. In order to achieve this research aim, a case study approach was adopted. In order to provide a first theoretical frame for the study, a ERP risk ontology was used, which was established and proposed by previous research by the same research group (Peng and Nunes, 2008; Peng and Nunes, 2009). Two questionnaires, which were constructed based on this theoretical risk ontology, were administered to seek managers' and ICT experts' perceptions of ERP exploitation risks in the selected case company. The remainder of this paper presents and discusses the research question, research design and findings of the study.

2. RESEARCH METHODOLOGY

2.1 Research question

This study was driven by the general aim of identifying, assessing and exploring potential risks that Chinese large companies may encounter during ERP exploitation after technical implementation is concluded. In attempting to address this research aim, the following research question was formulated:

"What risks will Chinese large firms experience when exploiting their ERP systems?"

As part of the process of risk assessment, the research aimed to explore the impacts, probability of occurrence and frequency of occurrence of identified risk events, as well as to prioritise these risks. Consequently, this research attempted to identify a list of critical ERP exploitation risks that can be used by large Chinese firms as an important tool for risk prevention, management and control, as well as, for strategic planning and decision making.

2.2 Case study approach

ERP post-implementation, which is a long-term endeavour, involves inevitable interactions between ERP systems and organisational contexts. In particular, the success of ERP innovation is heavily dependent on the context of application (Newell et al, 2000; Xue et al, 2005). On the other hand, the adoption and use of ERPs can reshape an organisation's culture, structure and processes, as well as change the distributions of power, autonomy, rights and obligations of people inside the organisation (O'Brien, 2004:52-53; Laudon and Laudon, 2004:146; Alter, 2002:275). Consequently, it is impossible to delineate an explicit line to separate ERP from its application context (Xue et al, 2005). Bearing these arguments in mind, it is clear that the above research question cannot be easily responded by using traditional survey tools. Cross-sectional questionnaires, which are very often used in IS research, would help find commonalities between the different companies that compose the Chinese industrial tissue, but would not allow to explore the ERP risks in the specific context that characterises the different large companies, in very different sectors and facing very challenges. Therefore, the study research team decided to take an in-depth case-study approach that would allow to take into account aspects such as organisational culture, sector culture and ultimately national culture as well.

According to Yin (2003:13), a case study is an adequate approach to investigate "a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". Moreover, as highlighted by Saunders et al. (2000: 94), case study is particularly capable of generating answers to the "why", "how" and "what" questions. Thus, these facts led the researchers to select and adopt a case study approach for this research. However, the results of the case-study will not be easily generalisable to all large companies in China, and the above research question can only be partially addressed by this paper. Nevertheless, it is hoped that the study will raise awareness and interest on the area of ERP post-implementation risks and will be followed other studies that will help shed light on the research question.

2.3 Case study description

The Chinese company involved in this case study is Shagang Group (known in the West as the Sha Steel Group - http://www.sha-steel.com/eng/index.html), which is located in the Jiangsu province in China. Sha Steel Group is a privately owned enterprise group. At the time of the data collection process for this research, Sha Steel Group consists of the main company and 13 subsidiary companies, which in turn had their own subsidiary companies, numbering more than 80. It was established in 1975 with self-financing of only 450,000 RMB. The group however has achieved remarkable development during the last three decades. It currently possesses total assets of over 43.7 billion RMB and employs about 26,700 staff. It also ranks 2nd in China's private enterprise groups after Lenovo, and is one of the ten largest steel producers in the world.

In 1997, Sha Steel Group purchased its first ERP solution from Oracle (Wang, 2003). However, after using Oracle's ERP package for five years, the group experienced a number of crucial ERP exploitation problems, e.g. the system failed to satisfy the group's rapid expansion, and could not be integrated with other IS applications being used, etc (Wang, 2003). These ERP problems eventually led the group to shift its ERP vendor from Oracle to SAP in 2003 (Wang, 2003). Nevertheless, SAP's ERP solution still cannot satisfy all their business requirements. Consequently, Sha Steel Group currently adopts and uses diverse ERP modules provided by SAP, Oracle and Ufida (a Chinese ERP vendor) to support its daily operation (Yu, 2006). Based on these facts, Sha Steel Group presents itself as a meaningful context for a study of ERP post-implementation. In truth, it was deemed that ERP exploitation experience and lessons learnt by this enterprise group would be of interest and importance, and may even be transferable, to other large corporations.

2.4 Data collection

In order to frame the study and generate the data collection tools, a theoretical risk ontology was adopted (Figure 1). This ontology was established and proposed by previous investigation projects within the same research group (Peng and Nunes, 2008; Peng and Nunes 2009):

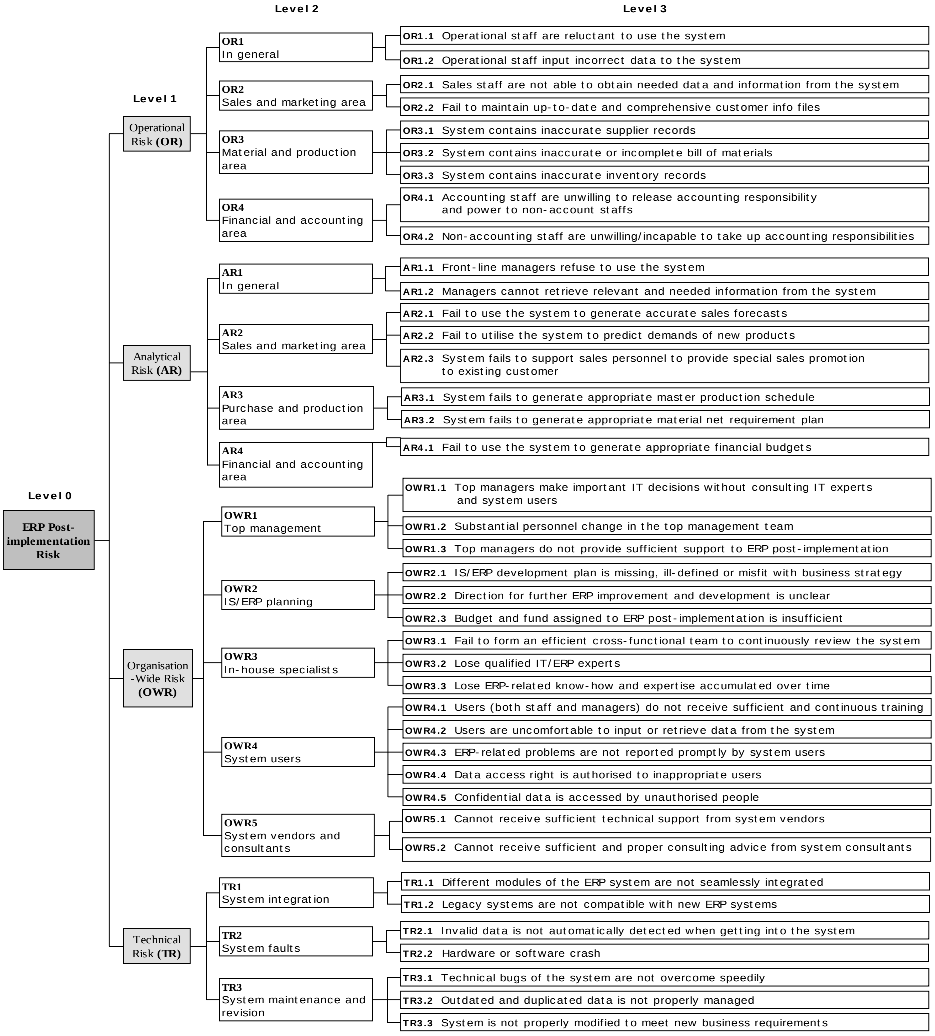

Figure 1. Potential risks to ERP exploitation (Source: Peng and Nunes, 2008; 2009)

An exhaustive review of the literature has shown that this risk ontology is the only comprehensive model available in its area. As shown in Figure 2, this comprehensive risk ontology contains 40 potential ERP risks that user companies may encounter during ERP exploitation, including:

– *9 operational risks*. Operational staff are daily users of ERP systems. Operational risks refer to risks that may occur as operational staff use ERP systems to perform daily business activities.

– *8 analytical risks*. Front-line managers use ERP systems to generate plans and forecasts (e.g. production plan, sales forecast, etc) to predict and better manage the uncertain future. Analytical risks refer to risks that may occur as managers use ERP systems to carry out analytical tasks.

– *16 organisation-wide risks*. 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 to the entire company and therefore are referred to as organisation-wide risks.

– *7 technical risks*. A set of system and technical factors may result in risk events that can hinder the implemented ERP system to meet its intended functions and performance requirements. These risk events are identified as technical risks.

Moreover, it was considered that interview, which is very often used in case study research, may not be an efficient way to seek perceptions of managers and IT experts from the 14 different companies (1+13 subsidiaries) that compose Sha Steel Group. These are geographically dispersed different cities in the Jiangsu province. Furthermore, although interviews are useful in collecting and exploring in-depth human insights about complex social phenomena, they are less efficient in examining a large number of predefined factors. Due to these reasons, the research group selected questionnaire survey as the data collection method. The questionnaire design was based on the theoretical risk ontology. For each risk event, respondents were firstly asked to indicate whether or not they perceived it as a risk to ERP exploitation (1 = yes, 0 = no). Furthermore, in order to assess the importance of these ERP risks in the case company, respondents were also asked to provide their perceptions on:

1) The probability of occurrence of each risk event (measured on a 3-point Likert scale, ranging from high [3] to low [1]);

2) The impact of each risk (measured on a 3-point Likert scale, ranging from high [3] to low [1]);

3) The frequency of occurrence of each risk event (measured on a 5-point Likert scale, ranging from very often [5] to very rarely [1]).

Furthermore, as highlighted by Peng and Nunes (2008), some of the risk items contained in the ontology were related with business aspects, while the others focused on technical issues. Therefore, two different questionnaires (please see Appendix A) were designed and used to obtain perspectives from both business managers and ICT experts of Sha Steel Group.

2.5 Survey respondents

As discussed in the literature review (Manion, 1994; Roy et al, 2001; Gamble, 2003; Alon, 2006:215; Peng and Nunes, 2008b) doing participative social science research in China raises problems that go far beyond the simple translation of data collection tools. There is the need to fully understand the social, cultural and political contexts, as well as the business culture. Failure in acquiring this understanding may result in failure of the research process altogether, by either failing to recruit participants or failure to understand their perspectives, motivations and behaviours (Peng and Nunes, 2008b). Therefore, the research team made sure to seek the explicit assistance and support from the CIO of Sha Steel Group. This CIO gave the project both written and oral unequivocal support, as well names and contact details for the respondents.

The sample for the survey was composed of two groups: managers and IT users and experts. Consequently, two sets of questionnaires were sent to each company aiming on one hand four questionnaires were to be responded by CEOs, production managers, logistics managers and accounting managers and on the other two were to be responded by IT and ERP managers and 2 by ERP users - a total of 8 (4+2+2) questionnaires per company(Table 1). A total of 112 questionnaires were sent to the 1+ 13 companies. A total of 80 valid responses were received from 10 companies. One of the companies only sent 4 (2+2), rather then the 8 questionnaires back. These however were deemed to be valid responses and added to the analysis. In sum, the survey had a 75% response rate with 11 out of 14 companies providing feedback. This very high response rate was certainly due to the support and determination of Sha Steel´s CIO.

Office		**Total** Responses
Main	4 (4 from managers + 4 from users and IT experts)	8
13 Subsidiaries		
	9 * 8 (4 from managers + 4 from users and IT experts)	72
	1 * 4 (2 from managers + 2 from users and IT experts)	4
	3 did not respond	0
Total		84

Table 1. Respondents of the survey

3. DATA ANALYSIS AND FINDINGS

3.1 General findings

As discussed above, the survey asked respondents in Sha Steel Group to assess the importance of each risk from three aspects, namely probability of occurrence, impact and frequency of occurrence. A summary of responses associated with the probability, impact and frequency of each risk event is given in Appendix B.

The need for all this information lies in the fact that from a risk management perspective, a risk event that has a high probability of occurrence may not have a high impact, and vice versa. As a typical example, system crash is a risk event that often has high impact but low probability of occurrence. Moreover, while probability refers to 'how likely' a risk event may occur, frequency refers to 'how often' this event may happen. Therefore, when evaluating the importance of risk events, it was considered necessary and vital to take into account all these three risk aspects. Consequently, the following formula was developed:

Risk score of each ERP risk = Σ *[W*(Probability + Impact + Frequency)]*

This formula allows the researchers to calculate the risk score of each identified risk event, by using its probability, impact and frequency. The formula consists of 3 components:

Component 1 - (Probability + Impact + Frequency): sum up the values given by each respondent for the three independent dimensions of a risk event, namely probability of occurrence (i.e. high = "2", medium = "1", and low = "0.5"), level of impact (i.e. high = "2", medium = "1", and low = "0.5") and frequency of occurrence (i.e. 5 values from very often to very rarely = "2", "1.5", "1", "0.75" and "0.5").

Component 2 - W(Probability + Impact + Frequency)*: 'W' refers to whether or not the respondent perceived this risk event as an ERP risk, with '1' stands for 'yes' and '0' means 'no'. In case that the respondent did not perceive the given risk event as an ERP risk, the formula will turn the value generated from Step 1 into 0: W*(Probability + Impact + Frequency) = 0*(Probability + Impact + Frequency) = 0.

Components 1 and 2 thus generate the individual score that each respondent gave for a specific risk event.

Component 3- Σ *[W*(Probability + Impact + Frequency)]*: sum up the individual score that each of the respondents of the survey gave for a particular risk event, and thus generate the total risk score that this risk event received.

By using this formula, the researchers calculated the risk scores for all of the 40 risk events examined, and then prioritised these risks based on their risk scores, as shown in table 2.

Moreover, as shown in the same table, three ERP events have a risk score that is lower than 70, namely 'System fails to support sales staff to tailor special offers to existing customers', 'Front-line managers refuse to use the ERP system', and 'ERP-related problems are not reported promptly by system user'. In fact, more than 43% of respondents did not perceive these events as ERP risks to the case company. Therefore, these 3 events were removed from the risk list.

Level 1 category	Level 2 category	Level 3 Risk item	N = 42	Risk Score	Rank
Operational Risk (OR)	Generic risk (OR1)	OR1.1	Operational staff are unwilling to use the ERP system	129.5	3
		OR1.2	Operational staff input incorrect data into the system	107.7	15
	Sales and marketing risk (OR2)	OR2.1	Sales staff are not able to obtain data and information they need from the system	93.4	29
		OR2.2	Customer info files contained in the ERP system are out-of-date or incomplete	96.8	28
	Production and purchasing risk (OR3)	OR3.1	ERP system contains inaccurate supplier records	[illegible]	[illegible]
		OR3.2	ERP system contains inaccurate or incomplete bill of materials	106.1	17
		OR3.3	ERP system contains inaccurate inventory records	101.1	21
	Fin. & acc. risk (OR4)	OR4.1	Account staff are unwilling to release accounting responsibility and power to non-account staff	116.4	[illegible]
		OR4.2	Non-account staff are unwilling and incapable to take up accounting responsibilities	77.9	[illegible]
Analytical Risk (AR)	Generic risk (AR1)	AR1.1	Front line managers refuse to use the ERP system	[illegible]	[illegible]
		AR1.2	Managers cannot retrieve relevant and needed information from the system	108.2	14
	Sales and marketing risk (AR2)	AR2.1	Sales forecast is inaccurate and inappropriate	[illegible]	[illegible]
		AR2.2	Fail to predict actual demands of new products	[illegible]	[illegible]
		AR2.3	Fail to provide special sales offers and promotion to existing customers	67.9	[illegible]
	Production and purchasing risk (AR3)	AR3.1	Master production schedule generated by the ERP system is inappropriate	132.3	2
		AR3.2	System fails to generate appropriate material net requirement plan	127.2	6
	Fin. & acc. risk (OR4)	AR4.1	Fail to use the system to generate appropriate financial budgets	91.4	[illegible]
Organisation Wide Risk (OWR)	Top management risk (OWR1)	OWR1.1	Top managers make important IT decisions without consulting IT experts or system users	104.7	18
		OWR1.2	Substantial personnel changes in the top management team	[illegible]	[illegible]
		OWR1.3	Support from top managers for ERP post-implementation is insufficient	117.0	9
	IS/ERP planning risk (OWR2)	OWR2.1	IS/ERP development plan is missing, ill-defined or misfit with business strategy	91.7	[illegible]
		OWR2.2	Direction for ERP improvement and further development is unclear	109.1	12
		OWR2.3	Insufficient resources and funds are assigned to ERP training, maintenance and enhancement	[illegible]	[illegible]
	In-house IT experts risk (OWR3)	OWR3.1	Fail to form an efficient cross functional team to continuously review and revise the ERP system	[illegible]	[illegible]
		OWR3.2	Lose qualified IT/ERP experts	164.4	1
		OWR3.3	Lose ERP-related know-how accumulated over time	127.8	4
	System users risk (OWR4)	OWR4.1	ERP users (both staffs and managers) do not receive sufficient and continuous training	[illegible]	[illegible]
		OWR4.2	Users are uncomfortable to use the ERP system in their daily jobs	[illegible]	27
		OWR4.3	ERP-related problems are not reported promptly by system users	91.1	[illegible]
		OWR4.4	Data access right to ERP is authorised to inappropriate users	[illegible]	[illegible]
		OWR4.5	Confidential data of the system is accessed by unauthorised people	101.4	19
	System vendors and consultant risk (OWR5)	OWR5.1	Cannot receive enough technical support from system vendors	127.3	5
		OWR5.2	Cannot receive sufficient and proper consulting advice from system consultants	118.8	[illegible]
Technical Risk (TR)	System integration risk (TR1)	TR1.1	Seamless integration is not achieved between modules of the ERP system	123.8	7
		TR1.2	ERP system is not able to seamlessly integrate with other information systems	117.5	10
	System failure risk (TR2)	TR2.1	Invalid data is not automatically detected when getting into the ERP system	[illegible]	[illegible]
		TR2.2	Hardware or software failures	108.4	13
	System maintenance and revision risk (TR3)	TR3.1	Technical bugs of our ERP system is not speedily overcome	94.0	[illegible]
		TR3.2	Outdated and duplicated data of our ERP system is not properly discarded	[illegible]	[illegible]
		TR3.3	ERP is not properly modified to meet new business requirements	[illegible]	16

Table 2: Risk scores and ranking of the 40 examined ERP risks in Sha Steel Group

On the other hand, the findings of the study showed that the remainder 37 ERP risks examined were important to the case company. Particularly, the top seven ERP risks, of which the risk scores were all above 120, were identified as the most crucial to Sha Steel Group, as shown in table 3.

Rank	Critical ERP Exploitation Risks	Risk Score
1	Lose qualified in-house IT/ERP experts	164.4
2	Master production schedule generated by the ERP system is inappropriate	132.3
3	Operational staff are unwilling to use the ERP system	129.5
4	Lose ERP-related know-how accumulated over time	127.8
4	Cannot receive enough technical support from system vendors	127.3
6	ERP system fails to generate appropriate material net requirement plan	127.2
7	Seamless integration is not achieved between modules of the ERP system	123.8

Table 3: Critical ERP exploitation risks in Sha Steel Group

In relation to previous IS and ERP literature, the next section further discusses and interprets these seven critical ERP risks and their causes and consequences in the context of Sha Steel Group.

3.2 Discussion of critical ERP risks

Lose qualified in-house IT/ERP experts

As presented in table 3, loss of qualified IT experts ranked 1st in critical ERP exploitation risks in Sha Steel Group. Findings of the study showed that 90% of the respondents perceived the probability of occurrence of this risk event as high to medium, and 63% stated this risk event had a high frequency of occurrence (Figure 3).

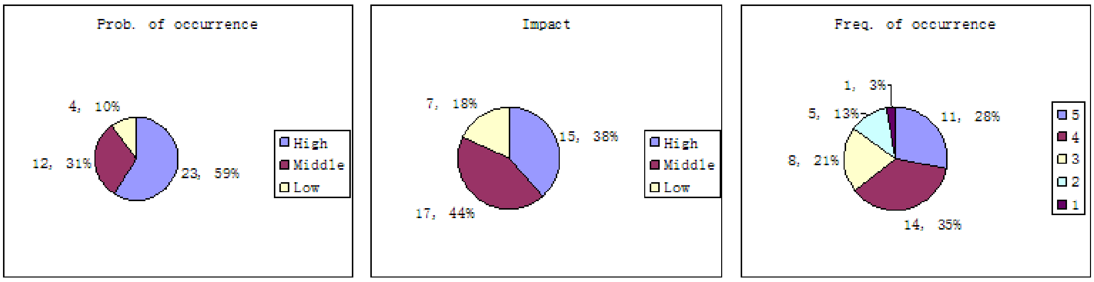

Figure 3. Lose qualified in-house IT/ERP experts

In truth, a review of the literature identified that the occurrence of this risk event may be attributed to two substantial reasons. On the one hand, the process of ERP implementation and maintenance actually represents valuable learning opportunities for all in-house staff (Scott and Vessey, 2000; Pentland, 1995). For IT staff in particular, they can often develop a wide range of skills and expertise (e.g. project management, system requirement analysis, business process redesign, etc) through ERP adoption and exploitation (Scott and Vessey, 2000). Consequently, the better the skills in-house IT staff acquire, the higher the probability that they may seek a better job. On the other hand, since China is currently at a rapid development stage, market demands for various types of highly qualified experts have been extremely high in the country (Zhao, 2001; Zhang et al, 2005). This certainly provides the perfect conditions for highly skilled IT experts to hunt for better careers. As a result, turnover rate of qualified IT people seems to have been very high in Sha Steel Group up to the moment of data collection.

It is obvious that efficient ERP maintenance, review and enhancement are dependent on continuous effort and contribution of a large amount of IT experts. Therefore, 82% of the respondents perceived that this loss of highly skilled and experienced IT experts could lead to significant impact on long-term ERP exploitation in their company. Moreover, losing qualified IT experts may also often lead to the loss of valuable ERP know-how and expertise, as further discussed below.

Lose ERP-related know-how accumulated over time

In-house IT experts will be able to accumulate a large amount of know-how and expertise, both on the specificities of the company and the system their using, through the process of ERP implementation and exploitation (Scott and Vessey, 2000). It is therefore essential and important for user companies to capture such implicit knowledge and expertise from their IT experts, in order for such knowledge to be shared effectively across the firm and with fellow IT staff.

This however may often not be the case in Chinese firms. Specifically, as stated by Burrows et al (2005), Chinese companies may often fail to adopt systematic knowledge management practices to capture valuable knowledge from in-house experts. On the other hand, Martinsons and Westwood (1997) argue that information and knowledge in Chinese firms are normally held by senior managers and trusted supervisory staff, but would rarely be shared freely across the company. As a consequence, when highly skilled IT experts leave the company, valuable ERP knowledge and expertise may be lost.

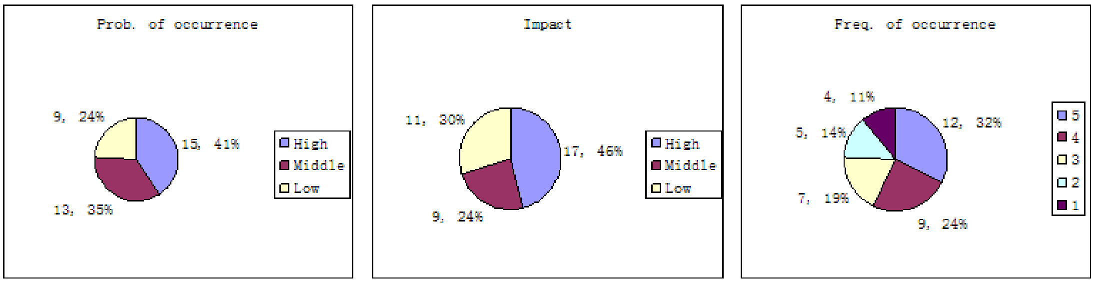

Figure 4. Lose ERP-related know-how accumulated over time

As shown in Figure 4, 76% of the respondents considered this risk event had a high to medium probability of occurrence in Sha Steel Group, and 56% perceived its frequency of occurrence was also high. The majority (70%) of the respondents also said the occurrence of this risk event could lead to a significant impact. Therefore, there seemed to be a need for Sha Steel Group to make an effort to reduce the probability and frequency of this critical risk, in order to ensure long-term ERP success.

Master production schedule generated by the ERP system is inappropriate

Master production schedule (MPS) is one of "the most important planning and control schedule[s]" generated by ERPs (Slack, 2005:489). It specifies "the quantity of each finished product required in each planning period; it is a set of time-phased requirements for end items" (Chen, 2001).

The appropriateness of master production schedules may be largely dependent on the accuracy of sales forecasts, which are the main input used to generate such production plans (Zhou et al, 2005:101). In fact and in the same survey, more than 57% of the respondents stated that the probability for them to have inaccurate sales forecasts was high to medium. If sales forecasts are inaccurate, then there is also a relatively high probability and frequency for this company to have inappropriate MPSs (Figure 5).

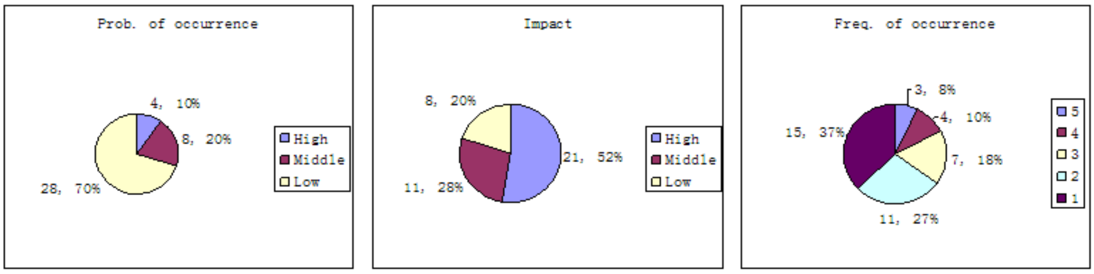

Figure 5. Master production schedule generated by the ERP system is inappropriate

Moreover, the occurrence of this risk event may result in product shortages and/or overages (Chen, 2001), which may directly influence costs and normal production. Therefore, 80% of the respondents perceived this risk can lead to a high to medium impact in Sha Steel Group. Furthermore, inappropriate MPS can also lead to inadequate material requirement plans, which is another critical ERP exploitation risk as discussed below.

ERP system fails to generate appropriate material requirement plan

ERP applications in material and production area typically follow the same logic as that of Material Requirements Planning (MRP) systems (Klaus et al, 2000). MRP is the former generation of ERP, and now forms the core of most ERP applications (Klaus et al, 2000). It tends to use three types of inputs, namely Bill of materials, Inventory records, and MPS, to calculate the net requirement plan (NRP) of materials as outputs (Koh et al, 2000). User companies can then launch material production and procurement orders based on their NRPs.

However, it can be expected that, if any of the three required inputs are inappropriate or inaccurate, the generated NRP will also be problematic. In Sha Steel Group, a significant amount of respondents perceived that there was a high to medium probability for them to have inaccurate bill of materials (77%), inaccurate inventory records (51%), and inappropriate MPS (30%). Consequently, it is not surprising that 68% of the respondents stated that the probability for their firm to have inappropriate NRP was medium to high (Figure 6). Koh et al (2000) state that inappropriate NRP can result in material shortage or over-ordering/producing, which may lead to delay/cease of production and directly impact costs, customer delivery lead time and customer satisfaction. The occurrence of this risk event can thus result in extremely critical impacts to user companies, as confirmed by 59% of the respondents.

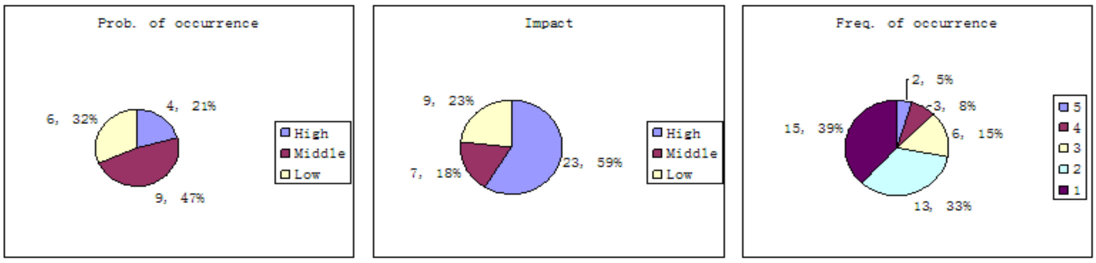

Figure 6. ERP system fails to generate appropriate material net requirement plan

Operational staff are unwilling to use the ERP system

ERP systems are mainly designed to integrate and automate transaction processing activities of companies (Chou et al, 2005). Consequently, operational staff in the shop floor are the main users of ERP, and they do so extensively in their daily work (Scapens and Jazayeri, 2003). If operational staff are reluctant to use the implemented ERP system the company's operational efficiency can be significantly reduced. More than 40% of the respondents considered that this event was both a frequent and critical risk event in Sha Steel Group (Figure 7).

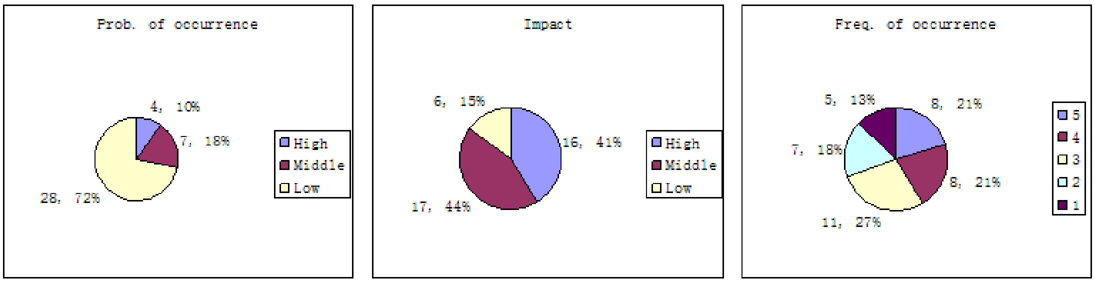

Figure 7. Operational staff are unwilling to use the ERP system

This risk event may be caused by various factors, including psychological anxieties of staff (e.g. unwillingness to change, unwillingness to learn a new system, lack of trust in the system and even fear of loss of job), initial failures in system implementation (e.g. insufficient training), and system pitfalls (e.g. poor user interface and system design). Moreover, as discussed above, Sha Steel Group purchased its first ERP package from Oracle in 1997. Ever since then, system users and internal IT people have been suffering from a set of ERP customisation, upgrading and maintenance problems (Wang, 2003). Despite the firm having shifted its ERP vendor from Oracle to SAP in 2003 (Wang, 2003), findings of this study showed that the company is still confronted with many ERP issues, which may actually increase the probability of occurrence of a variety of potential ERP risks as discussed in this paper. It is apparent that these ERP problems and risks may inevitably have an impact on daily work and performance of operational staff in the company. Consequently, system users may lose confidence in the system and thus become reluctant to use it. Overall, it seemed that managers and IT experts of Sha Steel Group may need to make a further effort to improve user satisfaction and acceptance towards the current ERP system.

Cannot receive enough technical support from system vendors

Effective and cooperative technical support from system vendors is crucial for companies to efficiently maintain and upgrade their ERP system in the post-implementation phase. However, due to various issues (e.g. user company fails to pay maintenance fees, conflicts with vendor, vendor company is short of IT people, vendor withdraws from the market for commercial reasons, vendor is acquired by another company etc), user companies may not always be able to receive sufficient and continuous technical support from their system vendors (Lientz and Larssen, 2006). Additionally, in the case of Sha Steel Group, the current ERP system consists of modules provided by multiple vendors (i.e. SAP, Oracle and Ufida) (Yu, 2005). Therefore, it may be difficult for this firm to manage the very complex relationships with different vendors and receive sufficient support from them.

Consequently, 49% of the respondents stated that the probability for them to receive insufficient vendor support was high to medium (Figure 8). The occurrence of this risk event may inevitably result in delay in identifying and resolving technical pitfalls of the implemented ERP system. Thus, the majority of the respondents perceived the impact of this risk as medium (54%) or high (33%).

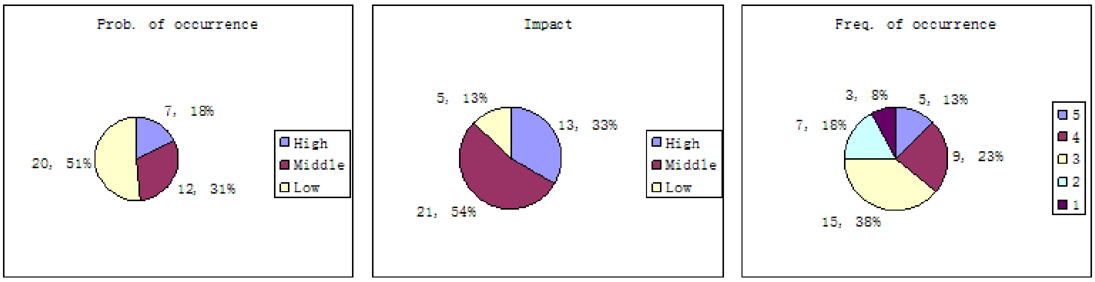

Figure 8. Cannot receive enough technical support from system vendors

Seamless integration is not achieved between modules of ERP

Very often an integrated solution from one single ERP vendor may not satisfy all business needs of the company. Therefore, it is increasingly common for large companies to procure suitable software modules from different system vendors to form their own ERP package (Currie, 2003). This is exactly the situation in Sha Steel Group, as mentioned before. However, this approach may increase complexity and difficulty in harmonizing data integration, synchronisation and redundancy issues. In other words, the firm may face a risk that seamless integration may not be achieved between current modules or between current and new modules of the ERP system. 64% of the respondents stated this risk event has a high to medium probability to occur (Figure 9).

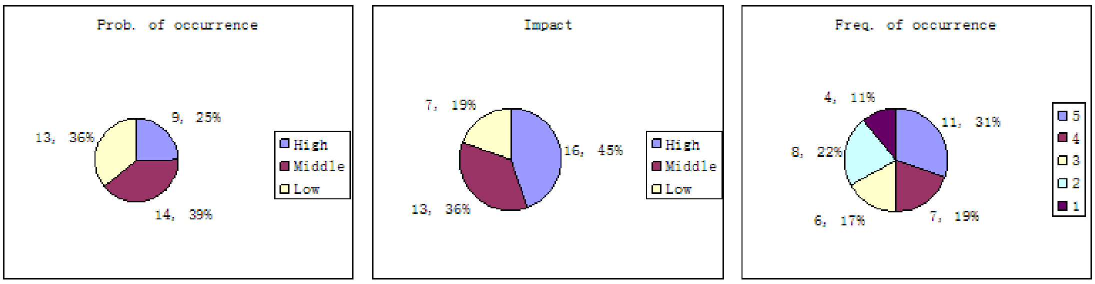

Figure 9. Seamless integration is not achieved between modules of ERP

Moreover, the occurrence of this risk event may lead to system fragmentation in the company, through the creation of technological islands which are very often isolated and non-communicant. Therefore, 45% of the respondents perceived this risk as extremely critical and dangerous.

3.3 Further discussion and conclusions of critical risks

From the above discussion, it can be inferred that the critical ERP risks identified have elements of Chinese business characteristics and organisational culture features. However, further analysis of the findings identified that these risk events may also be found in Western firms. For instance, losing highly qualified IT specialists has been frequently reported as a problem in Western companies (Wright and Donaldson, 2002; Scott and Vessey, 2000). Moreover, many large companies in the West, such as General Electric Co., have also purchased and attempted to integrate ERP modules from diverse system vendors (http://www. informationweek.com/news/global-cio/outsourcing/ showArticle.jhtml?articleID=160500765). These companies thus may face similar system integration difficulties as discussed above. Therefore, it is expected that the findings of this study may have transferability beyond the Chinese context.

On the other hand, by investigating the list of critical risks, it became apparent that, among the seven critical ERP risks, only one (i.e. seamless integration that may not be achieved between ERP modules) was related to technical aspects. The other six critical risks, faced by Sha Steel Group, were actually rooted in organisational and human related areas. Moreover, it also emerged from the above discussion that the occurrence of the identified critical risks seemed to be mainly attributed to a variety of organisational and business reasons, e.g. loss of IT experts might be caused by current high market demand of skilled labour in China, loss of ERP know-how seemed to be a result of inappropriate knowledge management practice and knowledge sharing behaviour, etc.

Therefroe this study seems to confirm the findings of a different recent study by this research group (Peng and Nunes, 2008), which stated that the "potential failure of ERP systems cannot be conveniently attributed to technical aspects, such as the software package and the ICT infrastructure…it is in organisation processes and procedures that the more dangerous and difficult-to-manage risks can be found [in the Chinese context]". Specifically, the findings of this study indicate that, in the context of Sha Steel Group, organisational culture and behaviour related risks and problems proved to be more critical to long-term ERP success than the technical ones.

4. CONCLUSIONS

This paper reported on an exploratory study, which investigated potential ERP exploitation risks in a large corporation in China at the post-implementation phase. The study used a deductive questionnaire survey approach developed from an existing theoretical risk ontology. The study identified 37 ERP exploitation risks, of which seven were identified as extremely critical to the case company. These critical ERP risks for Sha Steel Group have elements of Chinese business culture and management style, but also some others that have been reported in Western literature. Finally, the findings of the study showed that the majority of the critical ERP risks identified (6 out of 7) were rooted in organisational culture and business aspects of the corporation, rather than on the technical areas. This suggests that, like in many other large corporations, investing further millions of RMB in further technological solutions, may not be the solutions for Sha's current problems with their ERP system. In fact, the study suggests that Sha Steel Group needs to invest in organisational changes and human resource policies that enable the mitigation of the critical risks identified.

The results of this study have important practical and research implications. Specifically, the identified ERP risk ontology in general and the seven critical risks in particular, should be used immediately by managers and IT experts of the case company, as a checklist for managing and preventing potential ERP post-implementation risks and associated causes and consequences. In addition, the findings of this study may also be useful and transferable to other Chinese and Western large companies, which may currently be confronted with similar ERP exploitation challenges. It however should be acknowledged that as a single-case study, the ability to generalise the findings is limited. Nevertheless, this study will contribute to the knowledge of ERP in general, and is expected to provide valuable insights into ERP exploitation issues in large companies. Further research studies in this field are strongly recommended in order to further explore the findings derived from this case study, as well as to establish strategies to address and mitigate the critical risks identified.

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(Appendix follows overleaf)

APPENDIX

Risk items involved in *Questionnaire A* for business managers

1. Operational staff are unwilling to use the ERP system
2. Operational staff input incorrect data into the system
3. Sales staff are not able to obtain data and information they need from the system
4. Customer info files contained in the ERP system are out-of-date or incomplete
5. ERP system contains inaccurate supplier records
6. ERP system contains inaccurate or incomplete bill of materials
7. ERP system contains inaccurate inventory records
8. Account staff are unwilling to release accounting responsibility and power to non-account staff
9. Non-account staff are unwilling and incapable to take up accounting responsibilities
10. Front-line managers refuse to use the ERP system
11. Managers cannot retrieve relevant and needed information from the system
12. Sales forecast generated by ERP is inaccurate and inappropriate
13. Fail to use ERP in predicting actual demands of new products
14. System fails to support sales staff to tailor special offers to existing customers
15. Master production schedule generated by the ERP system is inappropriate
16. System fails to generate appropriate material net requirement plan
17. Fail to use the system to generate appropriate financial budgets

Risk items involved in *Questionnaire B* for IT managers

1. Top managers make important IT decisions without consulting IT experts or system users
2. Substantial personnel changes in the top management team
3. Support from top managers to ERP post-implementation is insufficient
4. IS/ERP development plan is missing, ill-defined or misfit with business strategy
5. Direction for ERP improvement and further development is unclear
6. Insufficient resources and funds are assigned to ERP training, maintenance and enhancement
7. Fail to form an efficient cross-functional team to continuously review and revise the ERP system
8. Lose qualified IT/ERP experts
9. Lose ERP-related know-how accumulated over time
10. ERP users (both staff and managers) are not receiving sufficient and continuous training
11. Users are uncomfortable to use the ERP system (e.g. input or retrieve data) in their daily jobs
12. ERP-related problems are not reported promptly by system users
13. Data access right to the ERP system is authorised to inappropriate users
14. Confidential data of the system is accessed by unauthorised people
15. We cannot receive enough technical support from system vendors
16. We cannot receive sufficient and proper consulting advice from system consultants
17. Seamless integration is not achieved between current modules or between current and new modules of our ERP system
18. ERP system is not able to seamlessly integrate with legacy or new information systems in my company
19. Invalid data is not automatically detected when getting into the ERP system
20. Hardware or software crashes
21. Technical bugs of our ERP system is not speedily overcome
22. Outdated and duplicated data of our ERP system is not properly discarded
23. ERP is not properly modified to meet new business requirements

Table I: Summary of responses for probability, impact and frequency

Level 1 category	Level 2 category	Level 3 Risk item	N = 42	Probability		Impact		Frequency	
				M.	S.D.	M.	S.D.	M.	S.D.
Operational Risk (OR)	Generic risk (OR1)	OR1.1	Operational staff are unwilling to use the ERP system	0.74	0.47	1.33	0.58	1.09	0.52
		OR1.2	Operational staff input incorrect data into the system	1.13	0.69	1.22	0.63	1.21	0.54
	Sales & marketing risk (OR2)	OR2.1	Sales staff are not able to obtain needed data and information from ERP	0.98	0.48	1.00	0.21	0.88	0.42
		OR2.2	Customer info files contained in the ERP system are out-of-date or incomplete	1.12	0.57	0.84	0.48	0.71	0.47
	Prod. & purchasing risk (OR3)	OR3.1	ERP system contains inaccurate supplier records	1.14	0.57	1.12	0.58	1.03	0.48
		OR3.2	ERP system contains inaccurate or incomplete bill of materials	1.23	0.59	1.30	0.52	0.71	0.41
		OR3.3	ERP system contains inaccurate inventory records	1.00	0.60	1.06	0.49	1.00	0.46
	Fin. & acc. risk (OR4)	OR4.1	Account staff are unwilling to release accounting power to non-account staff	1.05	0.64	1.16	0.57	0.95	0.50
		OR4.2	Non-account staff are unwilling/incapable to take up accounting responsibilities	1.09	0.67	1.00	0.53	1.20	0.56
Analytical Risk (AR)	Generic risk (AR1)	AR1.1	Front-line managers refuse to use the ERP system	0.93	0.58	1.58	0.60	1.08	0.50
		AR1.2	Managers cannot retrieve relevant and needed information from the system	0.82	0.47	1.38	0.61	1.00	0.46
	Sales & marketing risk (AR2)	AR2.1	Sales forecast is inaccurate and inappropriate	1.03	0.59	1.20	0.60	1.04	0.46
		AR2.2	Fail to predict actual demands of new products	1.21	0.59	1.23	0.52	1.13	0.54
		AR2.3	Fail to provide special sales offers and promotion to existing customers	0.98	0.47	1.19	0.55	0.88	0.49
	Prod. & purchasing risk (AR3)	AR3.1	Master production schedule generated by the ERP system is inappropriate	0.75	0.46	1.43	0.63	0.96	0.45
		AR3.2	System fails to generate appropriate material net requirement plan	1.02	0.58	1.47	0.65	0.91	0.40
	Fin. & acc. risk (OR4)	AR4.1	Fail to use the system to generate appropriate financial budgets	1.05	0.46	1.34	0.63	0.93	0.45
Organisation-Wide Risk (OWR)	Top management risk (OWR1)	OWR1.1	Top managers make centralised IT decisions	1.09	0.59	1.46	0.60	0.83	0.44
		OWR1.2	Substantial personnel changes in the top management team	1.08	0.61	1.22	0.62	1.00	0.47
		OWR1.3	Support from top managers to ERP post-implementation is insufficient	1.5	0.56	1.41	0.61	1.00	0.48
	IS/ERP planning risk (OWR2)	OWR2.1	IS/ERP development plan is missing, ill-defined or misfit with business strategy	1.13	0.60	1.39	0.61	1.14	0.55
		OWR2.2	Direction for ERP improvement and further development is unclear	1.09	0.52	1.23	0.66	0.97	0.49
		OWR2.3	Insufficient funds are assigned to ERP exploitation	1.11	0.56	1.39	0.63	1.10	0.50
	In-house IT experts risk (OWR3)	OWR3.1	Fail to form an efficient cross-functional team to review and revise the system	1.30	0.64	1.26	0.57	1.19	0.52
		OWR3.2	Lose qualified IT/ERP experts	1.54	0.57	1.29	0.58	1.21	0.50
		OWR3.3	Lose ERP-related know-how accumulated over time	1.28	0.62	1.31	0.66	1.30	0.54
	System users risk (OWR4)	OWR4.1	ERP users do not receive sufficient and continuous training	1.17	0.59	1.02	0.58	1.06	0.50
		OWR4.2	Users are uncomfortable to use the ERP system in their daily jobs	1.33	0.59	1.03	0.54	1.14	0.51
		OWR4.3	ERP-related problems are not reported promptly by system users	1.14	0.49	1.14	0.64	1.13	0.50
		OWR4.4	Data access right to ERP is authorised to inappropriate users	1.00	0.60	1.26	0.58	1.29	0.55
		OWR4.5	Confidential data of the system is accessed by unauthorised people	1.05	0.60	1.35	0.61	1.07	0.52
	System vendors and consultant risk (OWR5)	OWR5.1	Cannot receive enough technical support from system vendors	0.92	0.55	1.27	0.54	0.91	0.50
		OWR5.2	Cannot receive sufficient/proper consulting advice from system consultants	0.97	0.58	1.30	0.52	1.03	0.47
Technical Risk (TR)	System integration risk (TR1)	TR1.1	Seamless integration is not achieved between modules of the ERP system	1.07	0.58	1.35	0.61	1.33	0.56
		TR1.2	ERP system is not able to seamlessly integrate with other information systems	1.31	0.63	1.17	0.57	1.19	0.53
	System failure risk (TR2)	TR2.1	Invalid data is not automatically detected when getting into the ERP system	1.20	0.64	1.02	0.57	0.89	0.45
		TR2.2	Hardware or software crashes	0.81	0.48	1.46	0.49	1.05	0.49
	System maintenance and revision risk (TR3)	TR3.1	Technical bugs of our ERP system is not speedily overcome	0.79	0.49	1.18	0.53	0.79	0.46
		TR3.2	Outdated and duplicated data of our ERP system is not properly discarded	0.96	0.59	0.96	0.53	1.11	0.53
		TR3.3	ERP is not properly modified to meet new business requirements	1.37	0.64	1.23	0.66	0.95	0.47

M = Mean; S.D. = Standard Deviation

Probability: High =2, Medium = 1, Low = 0.5; Impact: High =2, Medium = 1, Low = 0.5; Frequency: from Very Often (2) to Very Rarely (0.5)