# IDENTIFICATION AND ASSESSMENT OF RISKS TO SUCCESSFUL EXPLOITATION OF ERP SYSTEMS IN CHINA

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Abstract

*The research presented in this paper aims at identifying, assessing and discussing potential risks that Chinese State Owned Enterprises (SOE) may encounter when using, maintaining and enhancing their Enterprise Resource Planning (ERP) systems in the post-implementation phase. The need for the research emerged from the growing awareness in the filed that there is a lack of studies addressing the organisational exploitation of ERPs after the implementation stage.*

*The study adopted a deductive research design based on a cross-sectional questionnaire survey. This survey was preceded by a Political, Economic, Social and Technological (PEST) analysis and a set of Strength, Weakness, Opportunity and Threat (SWOT) analyses. The PEST and SWOT analyses enabled the researchers to narrow the scope of the study and identify an appropriate industry sector and region to base the study on, namely the Electronic and Telecommunication Manufacturing Sector in Guangdong province. The questionnaire design was based on a theoretical risk ontology drawn from a systematic literature review process, which consisted of 40 predefined ERP risks. The questionnaire was sent to the operational managers and the information technology (IT) managers of 118 SOEs in Guangdong in China, from which 42 (84 questionnaires) valid and usable responses were received and analysed.*

*The findings identified a set of 16 top prioritised ERP exploitation risks, which concentrate around operational, analytical, organisation-wide and technical issues. The study also explored and identified 10 correlations between the risks identified.*

*Keywords: Enterprise Resource Planning, Risks, Post-Implementation, China.*

## 1 INTRODUCTION AND BACKGROUND OF STUDY

Since 1978, China has gradually reformed its economic system from the traditional planning economy to a more competitive market-oriented economy. After an effort of three decades, China has now become the world's fourth-largest economy behind the US, Japan and Germany (Reuters, 2006), the world's third-largest trading nation (Yusuf et al., 2006:3), and the world's second-largest recipient of foreign direct investment (FDI) (Yusuf et al., 2006:3). With its rapid and continuous economic development, China has attracted substantial attention from businessmen, investors and academics across the world. Nevertheless, continuous national economic reform and participation of foreign companies have significantly changed China's business environment, and resulted in increasingly drastic market competition in the domestic market.

Faced with this competitive environment and economic pressure, thousands of Chinese companies have implemented ERP systems in order to improve operational efficiency and enhance core

competencies. However, the adoption of ERP is not an easy task. It often represents a business dilemma to user companies. Specifically, Liu Chuanzhi, former chairman and president of Lenovo, states that

> "Not implementing ERP means inevitable failure, while implementation could possibly contribute to one's demise." (SAP, 2005)

In reality, a review of previous literature identifies that the implementation of ERP is often fraught with risks, difficulties and problems (Loh and Koh, 2004). However, even if the system is successfully implemented, the 'go-live' point of the system is not the end of the ERP journey, the system post-implementation is where the real challenges begin (Willis and Willis-Brown, 2002; Buonanno et al, 2005). It is expected that user companies will inevitably encounter a wide range of risks when using, maintaining and enhancing ERP in the post-implementation stage.

This is particularly true if we consider three apparent facts. First, some failures of ERP implementation are prevail across the literature (e.g. insufficient user training), even when the implementation project itself is considered a successful one. Such early failures can cause severe problems in ERP post-implementation. Second, undesirable internal and external changes (e.g. loss of in-house IT experts, bankruptcy of system vendor, etc) may arise over time, and can directly impact the use of ERP. Third, internal and external barriers (e.g. inefficient communication between functional divisions) that are inherent to the business context may prevent companies from achieving long-term ERP success. The occurrence of undesirable risk events in the ERP post-implementation stage can turn initial ERP success into a failure and may lead to system and business collapses. Although many researchers recognize the importance of ERP post-implementation and even state that ERP post-implementation is the direction of the second wave ERP research (Yu, 2005), current research which focuses on ERP post-implementation is still extremely limited. No study in ERP post-implementation risks was identified in the literature reviewed.

This paper presents the results of an empirical study that aimed at addressing this significant research gap. An extensive systematic review, which focused on theoretical papers and case studies, was conducted at the early stage of the research. As a result of the systematic review, the researcher developed a theoretical risk ontology which consists of 40 potential ERP risks that Chinese companies may encounter during ERP exploitation. A questionnaire, which was constructed based on the theoretical risk ontology, was used to seek Chinese managers' perceptions of the 40 pre-defined ERP risks as well as exploring the correlations between these risks. This paper is organised into three main sections. It firstly presents an overview of the literature review, followed by a description of the research methodology and design. Subsequently, results derived from the questionnaire survey are presented and discussed with conclusions drawn.

## 2 A BRIEF OVERVIEW OF ERP SYSTEMS

### 2.1 Emergence of ERP Systems

In the 1970s, Information Systems (IS), that were designed to support a singe functional area, were prevalent in the industry (Loonam and McDonagh, 2005). Organisations at that moment often used different and separated ISs to support diverse business functions, organisational levels and business processes (Laudons, 2006). However because these ISs were developed by using different hardware, software and data resources, they were not able to communicate or share data and information with each other (Alter, 2002:31). Loonam and McDonagh (2005) describe this phenomenon as "islands of automation", which means that information systems were isolated and running separately from each other. It is apparent that such isolated ISs would not bring sufficient strategic and competitive advantages to user companies. Specifically, managers had to spend a large amount of time to assemble data they needed from the isolated ISs, which led to significant reduction in efficiency and productivity (Laudons, 2006). Maintenance cost of these isolated systems could be very high whereas

companies received little benefits from their use (Kalakota and Robinson, 2000:245). Laudons (2006) thus concludes that integration issues were the major challenge faced by many user companies in that period of time.

In the 1990s, ERP emerged as a fundamental solution towards resolving these integration issues, by using a single and enterprise-wide system to replace the hitherto isolated ISs (Laudons, 2006; Alter, 2002). Nowadays, researchers in the field draw slightly different definitions of ERP systems. For example, Kumar and Hillegersberg (2000) define ERP systems as "configurable information system packages that integrate information and information-based processes within and across functional areas in an organization". Gable (1998) defines ERP systems as comprehensive packages of software solutions that seek to integrate the complete range of business processes and functions in order to present a holistic view of the business from a single information and IT architecture. Shehab et al (2004) consider ERP systems as "business management system[s] that comprise integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organization".

ERP systems tend to collect data from various key communicating and overlapping business processes, as well as storing the collected data in a single and comprehensive database where they can be used by other parts of the business. As such, ERP allows information that was previously fragmented in different systems to seamlessly flow throughout the whole organisation, and also facilitates company to integrate its discrete business processes from different functions into enterprise-wide processes (Laudons, 2006).

Furthermore, with rapid technology development, companies are now able to select, implement and integrate the most suitable modules from different ERP vendors to form their own ERP systems which best suit their business needs. Contemporary ERP systems can also act as platforms or backbone systems to integrate with new business applications, such as supply chain management (SCM) systems, customer relationship management (CRM) systems and e-business tools, and thus integrate the company's back office with its front office (Kalakota and Robinson, 2000).

### 2.2 ERP in China

The history of ERP in China started in the 1980s, when Material Resource Planning (MRP), the former generation of ERP, was introduced in the country. Accompanied with the emergence of a number of prominent foreign (e.g. SAP) and domestic (e.g. UFIDA) vendors, ERP has become increasingly prevalent in China since the late 1990s. Consequently, the ERP market has achieved rapid development in recent years. Data provided by a prominent Chinese consultancy firm (CCID Consulting), quoted by Xue et al (2005), shows that the ERP market size in Mainland China was around US$70 million in 2000 and grew to US$289.96 million in 2004. CCID Consulting (cited by Zhang et al, 2005) reports that China's ERP sales will grow at an estimated rate of 23.5% and reach US$652.8 million in 2008.

Despite this apparent success in ERP adoption, there are a number of risks associated with the facts that, these systems are "large and complex, expensive, take over a year or more to install, use new technology, and impact significantly on the organizational culture and existing business processes" (Willcocks and Sykes, 2000). There are many studies that addressed these risks and difficulties at the implementation phase (Sumner, 2000; Davison, 2002; Loh and Koh, 2004; Lientz and Larssen, 2006). However, there are equally important risks associated with the actual use and exploitation of these systems in real operational circumstances. The occurrence of these risks may often result in negative impact in ERP exploitation, and even lead to system and business collapses, such as the case of FoxMeyer Drugs' Bankruptcy as reported by Scott (1999).

For the purpose of this research, the following definition of risk was adopted: "the occurrence of an event that has consequences for, or impacts on" a particular business process (Kleim and Ludin, 2000:3). This definition implies a fundamental characteristic of a risk: uncertainty. That is, there is a

probability that the risk event may occur and can result in an impact on the business processes that may imply substantial losses. Kleim and Ludin (2000:4-6) provide a thorough classification of these risks in terms of probability of occurrence, frequency of occurrence, impact on the business processes, relative importance to other risks, and business exposure resulting from the occurrence of the risk. This paper contextualises these general principles of risk identification within the context of ERP use and exploitation.

# 3 RESEARCH METHODOLOGY

## 3.1 Research aims and objectives

The main aim of the study reported in this paper was to identify, assess and explore potential risks that Chinese SOE companies may encounter when using, maintaining and enhancing ERP in the system post-implementation phase. As part of this 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 investigate the causal relationships between them.

This research attempts to generate a set of meaningful findings that can be used by SOEs as an important tool for risk prevention, management and control, as well as, for strategic planning and decision making. It is expected to be of particular interest to ERP researchers, practitioners and user companies, and even ERP vendors and system consultants.

## 3.2 Research design

It was considered that undertaking a national study of the whole of China would not be an ideal choice, because the current economic situation and context in China are complicated and fluid. Specifically, there are important changes occurring in coastal regions, whereas other parts of the country are still very traditionally led by the central government. There are also significant variances in uptake of technology and IS and specifically of ERP in diverse industry sectors. Moreover, due to geographical and political reasons, it is extremely difficult to identify a valid sample to represent all companies in China (Manion, 1994). Therefore a nationwide study in China is not only unrealistic and potentially unfeasible, but may result in findings that are neither significant nor meaningful (Peng and Nunes, 2007a).

Faced with the necessity of focusing the research and the need of identifying an appropriate set of cases to carry out the study, the researchers adopted a PEST and a set of SWOT analyses as a combination to narrow the scope of the study, as well as to identify an appropriate industry sector and a region in China to base the study on. This rigorous approach was illustrated and discussed extensively by Peng and Nunes (2007a). As a result of the PEST and SWOT analyses, the researchers identified a reasonable and feasible set of Chinese firms for carrying out the research, namely SOEs in the electronic and telecommunication manufacturing sector in Guangdong in China (Peng and Nunes, 2007a).

In order to achieve the research aims, the study attempted to seek generalisable statements on risks that target SOEs may experience in ERP exploitation. Therefore, a deductive research design based on a cross-sectional questionnaire survey was selected. The questionnaire design was based on a risk ontology that was created though a process of critical literature review and is presented in figure 2. From this ontology it became apparent that out of the 40 predefined risks, some were related with business aspects, while the rest focused on technical issues. This clearly indicated that two different questionnaires needed to be designed to obtain perspectives of both managers and ICT experts.

In addition, the researchers attempted to identify which of the 40 predefined risk events would be perceived by respondents as risks for ERP exploitation, as well as, to assess the importance of each

identified risk according to its likelihood, impact and frequency of occurrence. In order to achieve these objectives, each of the 40 predefined risk events was examined in the questionnaire through four questions:

1) Whether this event could be perceived as a risk to ERP exploitation (1 = yes, 2= no).
2) What the probability of occurrence of this risk event could be (measured on a 3-point Likert scale, ranging from high [3] to low [1]).
3) What level of impact this risk could result in (measured on a 3-point Likert scale, ranging from high [3] to low [1]).
4) What the frequency of occurrence of this risk event could be (measured on a 5-point Likert scale, ranging from very often [5] to very rarely [1]).

Both questionnaire scripts were originally developed in English and then translated into Chinese. The questionnaire could actually have been directly designed in Chinese, but since the literature review was undertaken in English as based mostly (90%) on English sources, the initial script was written in that language using its terminology. Furthermore, the study is based in an UK university and the entire research group uses English, so if the questionnaire questions were to be discussed and validated by both supervisor and colleagues, then the language would have to be English.

Substantial attention had been paid during the translation process in order to ensure that both the English and Chinese versions of the questionnaire were conceptually equivalent, and thereby ensure high internal validity. In order to further improve its validity, the Chinese version of questionnaire was pilot tested with a group of Chinese postgraduate students and researchers in the authors' department as well as Chinese managers working in one Chinese SOE. A number of corrections to the questionnaires were made according to the feedback received from the pilot test.

### 3.3 The sample

According to statistical data provided by the local statistical bureau, there are 118 SOEs operating in the Electronic and Telecommunication Manufacturing Sector in Guangdong. A complete contact list of these companies was retrieved from the Guangdong Statistical Bureau. The questionnaires were posted to the 118 SOEs with a cover letter, which explained the purpose of the study, provided assurances about confidentiality, stressed importance of the research and encouraged recipients to reply. In order to increase the response rate, a web-based version of questionnaire was also developed. The URL of the web-based questionnaire was embedded in the cover letter. Respondents could thus either complete the questionnaire and return it by using the pre-paid envelope, or fill in the web-based version and submit it online. One month after the original questionnaire, a reminder was sent out. Personal relationships and contacts were used wherever possible in the study in order to gain access to more companies, secure response and increase reliability and quality of the answers provided.

The questionnaires were sent to the operation managers and the IT managers of the 118 target SOEs, from which 2*42 valid and usable responses were received and analysed. This survey thus achieved a response rate of 35.6%. As shown in figure 1, the vast majority of respondents of questionnaire A held managerial positions in the company, i.e. operation manager, general manager or CEO, manager in the general management team and IT manager. On the other side, respondents of questionnaire B held IT or managerial positions in the firm. Respondents of this survey thus prove to be suitable stakeholders to participate in the research.

Furthermore ERP system seems to be of interest and importance to the vast majority of target SOEs, because 37 out of 42 respondent SOEs have adopted ERP. 3 of the 5 respondent SOEs, that had not currently adopted ERP, stated they were scheduling to implement ERP in the future. Among the 37 SOEs that have ERP, 6 of them are using foreign ERP systems, 27 of them have adopted domestic ERP packages, and 4 of them combined the use of ERP components provided by both foreign and domestic vendors. Moreover, 73.8% of respondent SOEs have been using ERP for 2 to 6 years.

These results further prove that, a research on ERP exploitation risk in Chinese SOEs at this present moment is a timely and meaningful study.

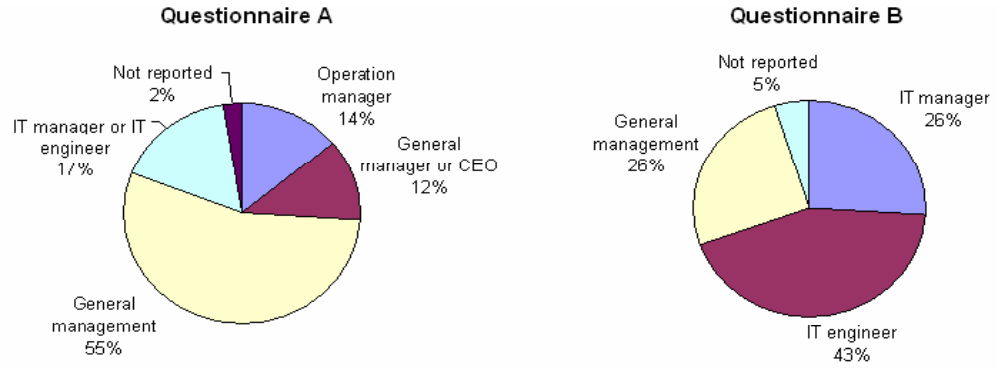


*Figure 1. Positions of respondents*

### 3.4 Validity and reliability

Internal validity in relation to questionnaire surveys refers to the questionnaire's ability to measure what it claims to measure (Saunders et al., 2007:366). Specifically, answers derived from a valid question in the survey should represent the reality of what the researcher is investigating (Saunders et al., 2007:366). In order to ensure that all questions in the survey have high level of validity and enable that valuable and accurate responses are collected, the questionnaire instruments used in this study were earnestly developed, translated and pilot tested. The Cronbach's alpha test was considered to test reliability or internal consistency of the responses. However, the exploratory nature of the survey implied that each item in the questionnaire referred to an independent and specific factor. Because a large amount of factors was covered in this, each factor was measured by a single item rather than multiple items. As a consequence the Cronbach's alpha was not applicable in this case.

## 4 RISKS ASSOCIATED WITH ERP EXPLOITATION

As described above, the first step in this research was a critical literature review aiming at identifying potential risks that may occur during ERP exploitation. The findings of this literature review were expressed in terms of a risk ontology (shown in Figure 2), which established 40 potential ERP exploitation risks. This ontology was proposed and discussed extensively by Peng and Nunes (2007b) and was characterised by four main categories:

- *Operational risks (OR).* Operational risks refer to risks that may occur as operational staff use ERP systems on a daily basis to perform business activities.
- *Analytical risk (AR).* 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.
- *Organisation-wide risk (OWR).* When using and maintaining ERP systems in the post-implementation stage, companies may encounter a set of risk events in relation to various internal (e.g. system users) and external factors (e.g. system vendor). Such risks may have impact to the entire company and therefore are referred to as organisation-wide risks.
- *Technical risk (TR).* 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.

Furthermore, it was considered that operational and analytical risks occur in different functional divisions in a company and are therefore very different in nature. Their study needs to take into account diverse aspects and sometimes very disparate triggers. After identifying the operational and analytical risks in general, the researchers specifically selected and focused on three business areas for identification of operational and analytical risks, namely sales and marketing area, purchase and production area, and financial and accounting area (see level 2 of the risk ontology in Figure 2). Additionally, the identified organisation-wide risks and technical risks were also rearranged into different categories: the sixteen organisation-wide risks were divided into five sub-categories, namely top management, IS/ERP planning, in-house specialists, system users, and system vendors and consultants; the seven technical risks were rearranged into three subsets, namely system integration, system faults, and system maintenance and revision (see level 2 of the risk ontology in Figure 2).

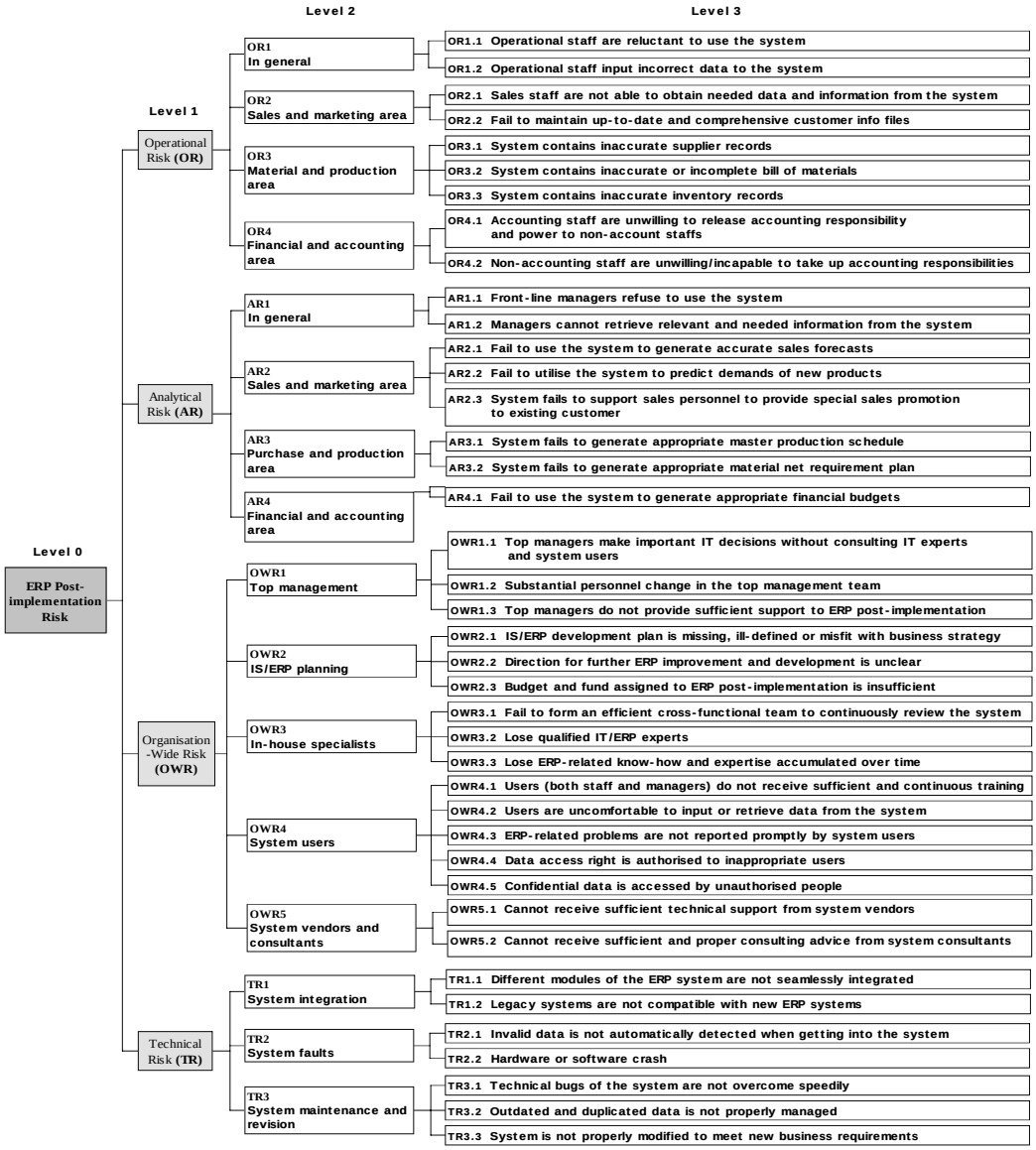


*Figure 2. Risk in ERP post-implementation ontology.*

This risk ontology was used as the theoretical basis to construct the questionnaire of this study as discussed above.

## 5 DATA ANALYSIS AND FINDINGS

The findings show that all of the 40 events, which were pre-defined in the theoretical risk ontology, were confirmed by the majority (80% or more) of respondents as risk events to ERP exploitation. However, perceptions of impact and probability of occurrence varied somewhat.

The survey asked respondents to assess the importance of each risk from three aspects, namely probability of occurrence, impact and frequency of occurrence. The mean was used in this study to provide a summary of responses associated with the likelihood, impact and frequency of each identified risk (as presented in Appendix A). Please note, that in this paper we will use the term likelihood as a synonym to probability of occurrence of the risk event. The researchers subsequently prioritised the 40 identified risks based on their means of likelihood and means of impact. This approach was found to be used by a number of other IS researchers (e.g. Fletcher and Wright, 1995; Wright and Donaldson, 2002). The top ten risks ranked by their means of likelihood are presented in table 1. The top ten risks ranked by their means of impact are presented in table 2. A third set of ranks based on the frequency of occurrence of each risk was neglected, because this seemed to be less important and relatively redundant.

| Rank | | Risk item | Mean of likelihood (L) |
|---|---|---|---|
| 1 | OWR5.1 | Cannot receive enough technical support from system vendors | 2.00 |
| 2 | TR1.2 | ERP system is not able to seamlessly integrate with other IS | 1.98 |
| 3 | AR1.2 | Managers cannot retrieve needed information from the system | 1.95 |
| 3 | TR3.2 | Outdated and duplicated data of ERP is not properly discarded | 1.95 |
| 3 | OWR5.2 | Cannot receive proper consulting advice from system consultants | 1.95 |
| 6 | OR3.3 | ERP system contains inaccurate inventory records | 1.93 |
| 6 | AR2.2 | Fail to use ERP to predict actual demands of new products | 1.93 |
| 6 | AR4.1 | Fail to use the system to generate appropriate financial budgets | 1.93 |
| 6 | TR1.1 | Seamless integration is not achieved between modules of ERP | 1.93 |
| 6 | TR3.3 | ERP is not properly modified to meet new business requirements | 1.93 |

*Table 1. Top ten ERP risks ranked by mean of likelihood*

| Rank | | Risk item | Mean of impact (I) |
|---|---|---|---|
| 1 | OR1.2 | Operational staff input incorrect data into the system | 2.44 |
| 2 | AR3.2 | System fails to generate appropriate material net requirement plan | 2.30 |
| 3 | OWR4.5 | Confidential data of the system is accessed by unauthorised people | 2.29 |
| 4 | OR3.2 | ERP system contains inaccurate or incomplete bill of materials | 2.28 |
| 5 | OR3.3 | ERP system contains inaccurate inventory records | 2.27 |
| 5 | AR3.1 | Master production schedule generated by the ERP system is irrelevant | 2.27 |
| 5 | OWR1.1 | Top managers make important IT decisions without consulting IT experts | 2.27 |
| 8 | OWR2.1 | IS/ERP plan is missing, ill-defined or misfit with business strategy | 2.18 |
| 9 | AR2.1 | Sales forecast generated by ERP is inaccurate and inappropriate | 2.17 |
| 10 | OR2.2 | Customer info files contained in ERP are out-of-date or incomplete | 2.15 |

*Table 2. Top ten ERP risks ranked by mean of impact*

It is however apparent that the top ten risks presented in table 1 are not the same as those presented in table 2. In other words, an identified risk that had a high mean of likelihood might not have a high mean of impact, and vice versa. This was to be expected and shows a clear awareness of the managers of the SOEs that there was a clear difference between frequency of a risk and critical impact of the same risk. This is a well known phenomenon in IS. In fact, from the risk management perspective, both likelihood and impact should be considered simultaneously rather than separately when assessing the identified risks (Yeates and Cadle, 1996:196). The highest priority should be given to risks that have both a high likelihood and a high impact (Yeates and Cadle, 1996:196; Chapman and Ward, 1997:140). Very often frequent risks are not critical and therefore are considered to be acceptable risks by the organisation. On the other hand, critical risks, even if they only occur very infrequently may be considered as un-acceptable risks to take and need a number of risk management mechanisms in place to both mitigate and resolve them. Finally, it is evident that risks that are both critical and frequent need to be addressed with the highest priority as they often become non-manageable and therefore extremely dangerous for the organisation.

As a consequence, instead of looking at their likelihood and impact separately, this paper identifies and discuses a set of most critical risks by examining both their means of likelihood and means of impact. In other to do so, the researchers firstly calculated the average of the means of likelihood of the 40 identified risks: 1.83, as well as, calculated the average of their means of impact: 2.04. It was subsequently found that the means of likelihood of 25 risks were higher than the average of 1.83. On the other hand, the means of impact of 21 risks were higher than the average of 2.04. After further comparison, the researchers identified that there were 16 risks, of which the means of likelihood and the means of impact were both higher than the average level of the 40 risks. In contrast, the remainder 24 risks had either a low mean of likelihood or a low mean of impact (i.e. lower than the average level). It is thereby reasonable to state that, in comparison to the other 24 identified risks, these 16 risks (as shown in table 3) seemed to be more significant and thus should receive a higher priority. Since all of these 16 risks had a high mean of likelihood and a high mean of impact, they should receive equal and substantial attention from target SOEs. Therefore no further ranking was made to prioritise these 16 risks.

| Category | | The 16 critical ERP exploitation risks | Mean of L | Mean of I |
|---|---|---|---|---|
| Operational risks | OR2.2 | Customer info files contained in ERP are outdated or incomplete | 1.88 | 2.15 |
| | OR3.2 | ERP system contains inaccurate or incomplete bill of materials | 1.83 | 2.28 |
| | OR3.3 | ERP system contains inaccurate inventory records | 1.93 | 2.27 |
| Analytical risks | AR2.1 | Sales forecast generated by ERP is inaccurate and inappropriate | 1.85 | 2.17 |
| | AR2.2 | Fail to use ERP to predict actual demands of new products | 1.93 | 2.10 |
| | AR3.1 | Master production schedule generated by ERP is inappropriate | 1.80 | 2.27 |
| | AR3.2 | System fails to generate appropriate material net requirement plan | 1.85 | 2.30 |
| | AR4.1 | Fail to use the system to generate appropriate financial budgets | 1.93 | 2.10 |
| Organisation - wide risks | OWR2.1 | IS/ERP plan is missing, ill-defined or misfit with business strategy | 1.83 | 2.18 |
| | OWR2.2 | Direction for ERP improvement and enhancement is unclear | 1.85 | 2.08 |
| | OWR3.2 | Lose qualified IT/ERP experts | 1.83 | 2.05 |
| | OWR3.3 | Lose ERP-related know-how accumulated over time | 1.90 | 2.10 |
| | OWR5.1 | Cannot receive enough technical support from system vendors | 2.00 | 2.05 |
| Technical risks | TR1.1 | Seamless integration is not achieved between modules of ERP | 1.93 | 2.05 |
| | TR1.2 | ERP system is not able to seamlessly integrate with other information systems | 1.98 | 2.04 |
| | TR2.2 | Hardware or software crashes | 1.88 | 2.05 |

*Table 3. The sixteen critical ERP exploitation risks*

It should be noted that these critical risks did not cluster around a specific subset of the main categories. This means that critical risks seem to be found across the organisational processes and not conveniently localised around one category, namely not around the technical category. Therefore, this study seems to confirm that failure of ERP systems may not just be conveniently related to the technical infrastructures and software packages. Actually, what this study confirms is that it is in operational, management and strategic thinking areas that the majority of risks were identified.

In addition, the study aimed at also investigating if the occurrence of particular risks was related to the occurrence of other risks. In order to explore potential correlations between the identified ERP risks, a bivariate analysis was conducted. A bivariate analysis is a statistical technique that aims at identifying the correlation between two variables. Specifically, this study used bivariate analysis to explore if the probability of occurrence of a particular risk was related to the increase of the probability of occurrence of other risks. As illustrated earlier, Likert scales were used in the survey to examine the likelihood of each identified risk, data variables generated were therefore ordinal data sets. According to Field (2005:130-131) and Bryman and Cramer (2005:225), Spearman's rho ($r_s$) is the most common and appropriate approach to use to measure bivariate correlations between ordinal variables. As a consequence, Spearman's rho was adopted for this study. Moreover, one-tailed test was used to test the statistical significance (P value) of each directional correlation identified. By following this approach, the researchers identified 10 significant relationships between all the 40 identified risks. Figure 3 presents a concept map to summarise and represent these correlations. A full description of each of these correlations is presented in table 4.

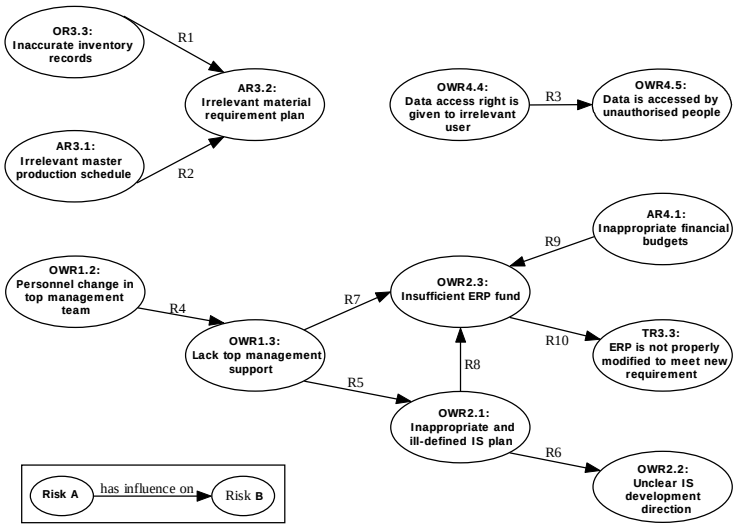


*Figure 3. Concept map of correlations between identified ERP exploitation risks.*

| | Correlation | $r_s$ |
|---|---|---|
| R1 | As the probability of having inaccurate inventory record increases, the probability of having inappropriate material requirements plan increases. | .439(**) |
| R2 | As the probability of having inappropriate production schedule increases, the probability of inappropriate material requirements plan correspondingly increases. | .573(**) |
| R3 | As the probability of assigning data access rights to irrelevant user increases, the probability unauthorised people accessing sensitive system data increases. | .464(**) |
| R4 | As the probability of having personnel changes in the top management team increases, the probability of having insufficient top management support increases. | .276(*) |
| R5 | As the probability of having insufficient top management support increases, the probability of having inappropriate and ill-defined IS plan increases. | .402(**) |
| R6 | As the probability of having inappropriate and ill-defined IS plan increases, the probability of having unclear IS development correspondingly increases. | .795(**) |
| R7 | As the probability of having insufficient top management support is higher, the probability of having insufficient ERP fund will be higher. | .373(**) |
| R8 | As the probability of having inappropriate and ill-defined IS plan is higher, the probability of having insufficient ERP fund will be correspondingly higher. | .710(**) |
| R9 | As the probability of having inappropriate financial budget increases, the probability of having insufficient ERP fund will correspondingly increase. | .324(*) |
| R10 | As the probability of having insufficient ERP fund increases, the probability that the implemented system cannot be continuously modified will increase. | .348(*) |

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

*Table 4. Correlations between the identified ERP risks*

The findings of the bivariate analysis were quite illuminating. Investigating both the list of significant correlations and the concept map in Figure 3, it becomes apparent that the majority of the correlations occurred between analytical and organisation-wide risks. This points out to a clear break with the traditional view of ERP failure. It is clear from the bivariate analysis, that the impact of analytical and organisational-wide risks plays a fundamental in potential failure of ERP due to the potential causal effects between risks. Technical risks that are very often seen as the main perpetrators in ERP failure seem to be important but not strictly related to other risks. On the other hand, analytical and organisation-wide risks seemed to be interwoven and closely related with other similar risks. Consequently, the occurrence of these risks is much more difficult to manage, mitigate and contain.

## 6 CONCLUSION

Successful implementation of ERP is not the end of the journey but a new beginning. A wide range of risks and challenges are faced by companies when using, maintaining and enhancing their ERP systems in post-implementation. Many user companies, especially those at the beginning stage of implementing ERP, may perceive ERP systems as an omnipotent solution to all business problems. This however is not the case in reality. Specifically due to various external and internal reasons, a set of operational and analytical risks, that can affect business operation and decision making efficiency,

can still occur even after ERP was adopted. On the other hand, due to the level of sophistication of ERP, the era of ERP post-implementation is often fraught with organisation-wide and technical risks of which the occurrence can significantly impact system and business performance.

The study has led to several important conclusions. In particular, ERP system seems to be of interest and importance to the vast majority of SOEs studied. All of the 40 risk events predefined from an extensive literature review were perceived and identified by the majority of respondents as risks to ERP exploitation. Specifically, the study identified 16 critical risks that were distributed across organisational processes and operation. Therefore, the study established that potential failure of ERP systems cannot be conveniently attributed to technical aspects, such as the software package and the ICT infrastructure. In fact, the findings of the study suggest that it is in organisation processes and procedures that the more dangerous and difficult-to-manage risks can be found.

Moreover it should be stressed that, due to the inherent limitation of a survey research, the findings derived from this questionnaire may only be generalisable to similar regions, company types and sectors as the ones studied. Further research in this area is thereby strongly recommended. Further research efforts may reuse and extend the risk ontology presented in this paper, and test the suitability of this ontology within an alternative research context. Some qualitative studies may also be carried out to explore extensively the causes and consequences of the identified risks in a specific context.

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**Appendix A:** Means of likelihood, impact and frequency of the 40 identified risks

| Level 1 category | Level 2 sub-category | Level 3 risk item | | Mean of likelihood | Mean of impact | Mean of frequency |
|---|---|---|---|---|---|---|
| Operational Risk (OR) | Generic risk (OR1) | OR1.1 | Operational staff are unwilling to use the ERP system | 1.45 | 2.03 | 2.03 |
| | | OR1.2 | Operational staff input incorrect data into the system | 1.12 | 2.44 | 1.61 |
| | Sales and marketing risk (OR2) | OR2.1 | Sales staff are not able to obtain data and information they need from the system | 1.71 | 2.00 | 2.44 |
| | | OR2.2 | Customer info files contained in the ERP system are out-of-date or incomplete | 1.88 | 2.15 | 2.35 |
| | Materia and production management risk (OR3) | OR3.1 | ERP system contains inaccurate supplier records | 1.80 | 2.02 | 2.41 |
| | | OR3.2 | ERP system contains inaccurate or incomplete bill of materials | 1.83 | 2.28 | 2.15 |
| | | OR3.3 | ERP system contains inaccurate inventory records | 1.93 | 2.27 | 2.49 |
| | Fin. & acc. risk (OR4) | OR4.1 | Account staff are unwilling to release accounting responsibility and power to non-account staff | 1.70 | 1.81 | 2.11 |
| | | OR4.2 | Non-account staff are unwilling and incapable to take up accounting responsibilities | 1.38 | 1.54 | 2.06 |
| Analytical Risk (AR) | Generic risk (AR1) | AR1.1 | Front-line managers refuse to use the ERP system | 1.35 | 1.85 | 1.75 |
| | | AR1.2 | Managers cannot retrieve relevant and needed information from the system | 1.95 | 1.98 | 2.48 |
| | Sales and marketing risk (AR2) | AR2.1 | Sales forecast generated by ERP is inaccurate and inappropriate | 1.85 | 2.17 | 2.29 |
| | | AR2.2 | Fail to use ERP to predict actual demands of new products | 1.93 | 2.10 | 2.38 |
| | | AR2.3 | System fails to support sales personnel to tailor special sales offers to existing customers | 1.73 | 1.71 | 2.10 |
| | Materia and production management risk (AR3) | AR3.1 | Master production schedule generated by the ERP system is inappropriate | 1.80 | 2.27 | 2.34 |
| | | AR3.2 | System fails to generate appropriate material net requirement plan | 1.85 | 2.30 | 2.33 |
| | Fin. & acc. risk (AR4) | AR4.1 | Fail to use the system to generate appropriate financial budgets | 1.93 | 2.10 | 2.32 |
| Organisation-Wide Risk (OWR) | Top management risk (OWR1) | OWR1.1 | Top managers make important IT decisions without consulting IT experts or system users | 1.46 | 2.27 | 1.90 |
| | | OWR1.2 | Substantial personnel changes in the top management team | 1.89 | 1.89 | 2.53 |
| | | OWR1.3 | Support from top managers to ERP post-implementation is insufficient | 1.60 | 2.05 | 2.12 |
| | IS/ERP planning risk (OWR2) | OWR2.1 | IS/ERP development plan is missing, ill-defined or misfit with business strategy | 1.83 | 2.18 | 2.45 |
| | | OWR2.2 | Direction for ERP improvement and further development is unclear | 1.85 | 2.08 | 2.65 |
| | | OWR2.3 | Insufficient resources and funds are assigned to ERP training, maintenance and enhancement | 1.55 | 1.93 | 2.43 |
| | In-house specialists risk (OWR3) | OWR3.1 | Fail to form an efficient cross-functional team to continuously review and revise the ERP system | 1.85 | 2.03 | 2.59 |
| | | OWR3.2 | Lose qualified IT/ERP experts | 1.83 | 2.05 | 2.57 |
| | | OWR3.3 | Lose ERP-related know-how accumulated over time | 1.90 | 2.10 | 2.43 |
| | System users risk (OWR4) | OWR4.1 | ERP users (both staffs and managers) do not receive sufficient and continuous training | 1.80 | 1.83 | 2.59 |
| | | OWR4.2 | Users are uncomfortable to use the ERP system in their daily jobs | 1.89 | 1.82 | 2.53 |
| | | OWR4.3 | ERP-related problems are not reported promptly by system users | 1.83 | 1.98 | 2.50 |
| | | OWR4.4 | Data access right to ERP is authorised to inappropriate users | 1.24 | 2.12 | 1.76 |
| | | OWR4.5 | Confidential data of the system is accessed by unauthorised people | 1.29 | 2.29 | 1.64 |
| | System vendors and consultants risks | OWR5.1 | Cannot receive enough technical support from system vendors | 2.00 | 2.05 | 2.59 |
| | | OWR5.2 | Cannot receive sufficient and proper consulting advice from system consultants | 1.95 | 1.98 | 2.46 |
| Technical Risk (TR) | System integration risk (TR1) | TR1.1 | Seamless integration is not achieved between modules of the ERP system | 1.93 | 2.05 | 2.41 |
| | | TR1.2 | ERP system is not able to seamlessly integrate with other information systems | 1.98 | 2.04 | 2.48 |
| | System failure risk (TR2) | TR2.1 | Invalid data is not automatically detected when getting into the ERP system | 1.83 | 1.98 | 2.28 |
| | | TR2.2 | Hardware or software crashes | 1.88 | 2.05 | 2.33 |
| | System maintenance and revision risk (TR3) | TR3.1 | Technical bugs of our ERP system is not speedily overcome | 1.90 | 1.98 | 2.44 |
| | | TR3.2 | Outdated and duplicated data of our ERP system is not properly discarded | 1.95 | 1.98 | 2.46 |
| | | TR3.3 | ERP is not properly modified to meet new business requirements | 1.93 | 2.00 | 2.32 |