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# Surfacing ERP Exploitation Risks through a Risk Ontology

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## Abstract

**Purpose** – The purpose of this paper is to develop a risk identification checklist for facilitating user companies to surface, organise and manage potential risks associated with the post-adoption of Enterprise Resource Planning (ERP) systems.

**Design/methodology/approach** – A desktop study, based on the process of a critical literature review, was conducted by the researchers. The critical review focused on IS and business research papers, books, case studies and theoretical articles, etc.

**Findings** – By systematically and critically analysing and synthesising the literature reviewed, the researchers identified and proposed a total of 40 ERP post-implementation risks related to diverse operational, analytical, organisation-wide and technical aspects. A risk ontology was subsequently established to highlight these ERP risks, as well as to present their potential causal relationships.

**Research limitations/implications** – For researchers, the established ERP risk ontology represents a starting point for further research, and provides early insights into a research field that will become increasingly important as more and more companies progress from implementation to exploitation of ERPs.

**Practical implications** – For practitioners, the risk ontology is an important tool and checklist to support risk identification, prevention, management and control, as well as to facilitate strategic planning and decision making.

**Originality/value** – There is a scarcity of studies focusing on ERP post-implementation in contrast with an over abundance of studies focusing on system implementation and project management aspects. This paper aims to fill this significant research gap by presenting a risk ontology of ERP post-adoption. It represents a first attempt in producing a comprehensive model in its area. No other such models could be found from the literature reviewed.

**Keywords** Enterprise Resource Planning, ERP, Information System, Post-implementation, Exploitation, Risk.

**Paper type** Research paper

## 1. INTRODUCTION

As defined by Kumar and Hillegersberg (2000), Enterprise Resource Planning (ERP) systems are "configurable information system packages that integrate information and information-based processes within and across functional areas in an organization". As one of the most crucial tools to sustain business competitiveness, ERP has probably been "the most rapidly growing system area in operations today [… and] thousands of companies [of any size] have implemented or are in the process of implementing an ERP system" (Zhang et al., 2005). However, the implementation of ERP is never a straightforward task. According to Martin (1998), about 90% of ERP projects are late or over budget, and almost half fail to achieve the desirable results. ERP implementation success rate is only about 33% in general (Zhang et al., 2002). Previous research studies on ERPs thus mainly focus on risks, difficulties and factors that can affect successful implementation of the system (e.g. Helo et al., 2008; Zhang et al., 2005; Gargeya and Brady, 2005; Loh and Koh, 2004; Umble et al., 2003; Zhang et al., 2002; Sumner, 2000).

However, as more and more companies progress from implementation to exploitation of ERPs, practitioners and information systems (IS) researchers increasingly recognise that, the 'go-live' point of the system is actually not the end of the ERP journey (Willis and Willis-Brown, 2002; Yu, 2005). Very often, the system exploitation stage is where the real challenges will begin (Willis and Willis-Brown,

2002) and more critical risks may occur. Please note, that in this paper we will use the term exploitation as a synonym to post-implementation/adoption.

A risk can be defined as "the occurrence of an event that has consequences for, or impacts on a particular project" (Kleim and Ludin, 2000:3). This definition implies a fundamental characteristic of a risk, namely uncertainty. Specifically, 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. For the purpose of this paper, the researchers slightly modified the above definition given by Kleim and Ludin, and defined a risk to ERP exploitation as:

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

In fact, risks are inherent to every human endeavour (Wider and Davis, 1998). For ERP post-adoption in particular, user companies may inevitably be confronted with a wide range of risks when exploiting and optimising their implemented systems. This is particularly true, considering three apparent facts. First, some failures (e.g. insufficient user training) are prevalent in ERP implementation, even if the implementation project itself is considered a successful one. Such initial failures can inevitably cause severe problems in ERP post-adoption. Second, undesirable internal and external changes (e.g. loss of in-house IT experts, bankruptcy of system vendor) may arise over time, and can directly impact the use of ERP systems. Third, internal and external barriers (e.g. poor communication between functional divisions, unstable business environment) existed in the business context may prevent companies from achieving long-term ERP success. The occurrence of undesirable risks in the post-implementation stage will not just turn the initial ERP success into a failure, but may also lead to significant system and business disasters. Although many IS researchers recognize the importance of ERP post-adoption and even state it is the direction of the second wave ERP research (Yu, 2005), current research which focuses on this topic is extremely limited. No study in ERP post-implementation risk was identified in the literature reviewed.

This paper thus aims at contributing to this significant research gap by identifying and investigating potential ERP exploitation risks through the process of a critical literature review. As a result of this extensive review, the researchers identified and proposed a comprehensive set of 40 risk events that may occur during ERP post-implementation. These ERP risks were found across operational, analytical, organisation-wide and technical aspects. This paper is organised as follows: it firstly presents the process of the critical review. Subsequently, an intensive discussion of 23 selected risk events is given, together with discussion of their causes and consequences. Finally, the paper presents a risk ontology that highlights all identified ERP risks, as well as discusses how this ontology can be applied in risk management practice. It is important to note that, the established risk ontology represents a first attempt in producing a comprehensive risk checklist to support risk management in this area. The process of literature search could not return any other such checklists.

## 2. METHODOLOGY

The study presented in this paper was driven by the general aim of helping companies to identify and explore potential risks associated with ERP exploitation. It attempted to develop and propose a risk identification checklist to support decision making for strategic risk planning and management.

In order to achieve these objectives, a desktop study, based on the process of a critical literature review, was conducted by the researchers. This critical review followed the funnelled approach proposed by Saunders et al. (2003:44-50), and relied on surveying and using secondary and tertiary sources. Literature search for this critical review consisted of two phases.

At the first phase of literature search, the researchers attempted to locate and retrieve articles that are directly related to ERP post-implementation risks. This literature seeking process involved an exhaustive search of a variety of prominent MIS journals and databases (as shown in table 1), by using a set of pre-defined search keywords and terms (as outlined in table 2). Nevertheless, this endeavour did not return any relevant articles on ERP exploitation risks.

| MIS journal searched | MIS database searched |
|---|---|
| MIS Quarterly | ScienceDirect |
| Journal of Management Information Systems | ACM Digital Library |
| Information Systems Research | Emerald Management Review |
| Communications of the ACM | IEEE Xplore |
| Industrial Management & Data Systems | JSTOR |
| Information & Management | Web of Science |
| Information Systems Journal | CSA Illumina |
| International Journal of Information Management | Etc. |
| Journal of Enterprise Information Management | |
| Business Process Management Journal | |
| Etc. | |

Table 1. Journals and databases searched

| For journal search | For database search |
|---|---|
| (searched within: title, abstract and/or full text) | |
| ERP post-implementation risks | ERP "AND" post-implementation "AND" risks |
| ERP exploitation risks | ERP "AND" exploitation "AND" risks |
| ERP post-implementation | Enterprise systems "AND" post-implementation |
| ERP post-adoption | Enterprise systems "AND" exploitation |
| ERP exploitation | Information system "AND" post-implementation |
| Information system post-implementation | ERP post-implementation/adoption |
| Information system exploitation | ERP exploitation |

Table 2. Keywords used for journal and database search at Stage One

Despite this current scarcity of studies on ERP post-implementation, it was identified from the critical review that the literature in general IS and ERP issues is very rich. Therefore, a broader and more extensive literature review was conducted at the second stage. Instead of looking for specific ERP post-adoption studies, this second attempt focused on general IS and ERP research papers, case studies, technical papers and theoretical articles. The aim here was to identify broadly any possible factors and issues that might lead to potential ERP exploitation failures. The same set of MIS journals and databases shown in table 1 were searched, but an alternative set of search keywords were used. These keywords included, but not limited to, those shown in table 3. Moreover, in order to identify and explore as many issues as possible, the survey of literature at this stage relied not only on academic papers, but also on books, industrial white papers, articles on IT professional websites, and even grey literature.

| For journal search | For database search |
|---|---|
| (searched within: title, abstract and/or full text) | |
| ERP failure | ERP "AND" failure |
| ERP issues | ERP issues "OR" risks "OR" challenges |
| ERP risks | ERP usage "OR" maintenance "OR" enhancement |
| ERP challenges | Information system "AND" failure |
| ERP usage | Information system issues "OR" risks "OR" challenges |
| ERP maintenance | IS usage "OR" maintenance "OR" enhancement |
| ERP enhancement | ERP adoption |
| Information system failure | Enterprise system adoption |
| Information system issues | Information system adoption |
| Information system risks | ERP "OR" information system "AND" sales marketing |
| Information system challenges | ERP "OR" information system "AND" accounting |
| Information system usage | ERP "OR" information system "AND" production |
| Information system maintenance | ERP "OR" information system "AND" purchasing |
| Information system enhancement | Etc. |

Table 3. Keywords used for journal and database search at Stage Two

With such efforts, the researchers successfully identified and reviewed a large amount of valuable literature, which addressed various IS, ERP and business issues and aspects. Subsequently, the retrieved articles and materials were systematically and critically analysed, compared and synthesised, and then used as raw materials to construct arguments and standpoints for risk identification. Consequently, through this critical literature review, the researchers established and proposed a comprehensive set of 40 ERP exploitation risks, as well as explored and analysed their potential causes and impacts.

# 3. POTENTIAL RISKS FOR ERP POST-IMPLEMENTATION

## 3.1 ERP areas of coverage in risk identification

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

- *Operational risk (OR).* Operational staff are daily users of ERP systems. Operational risks refer to risks that may occur as operational staff use ERPs to perform daily 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 ERPs to carry out analytical tasks.
- *Organisation-wide risk (OWR).* When using and maintaining ERPs in the post-implementation stage, companies may encounter a set of risk events in relation to various internal (e.g. system users, in-house IT experts) and external factors (e.g. system vendor, system consultants). Such risks may have impacts on 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 ERP system from meeting its intended functions and performance requirements. These risk events are identified as technical risks.

Furthermore, it is 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. On the other hand, it emerges in the survey studies of Reimers (2001) and Tsai et al. (2005) that ERP systems are most frequently used in three business areas, namely sales and marketing area, production and purchasing area, and financial and accounting area. Therefore, the researchers specifically selected and focused on these three business areas for identification of operational and analytical risks. Consequently, a total of 9 operational risks and 8 analytical risks were identified.

Besides, the study also identified 16 organisation-wide risks and 7 technical risks. In order to have better classification of risk, the identified organisation-wide and technical risks were rearranged into more specific sub-categories. Specifically, the 16 organisation-wide risks were divided into five sub-categories, namely top management risks, IS/ERP planning risks, in-house specialists risks, system users risks, and system vendors and consultants risks. On the other hand, the 7 technical risks were organised into three subsets, namely system integration risks, system failure risks, and system maintenance and revision risks. Such systematic classification of identified risks provided the prerequisite for the researchers to establish the risk ontology, as further presented and discussed in section 3.6.

Overall, a total of 40 risk events associated with ERP post-implementation were identified. 23 of these ERP risks seem to be most predominant and prevalent. Therefore, these 23 risks and their associated causes and consequences are addressed in more detail in the following sections.

## 3.2 Operational Risks

*Operational staff are reluctant to use the ERP system*

ERP systems are mainly designed to integrate and automate transaction processing activities of companies (Chou et al., 2005). As a consequence, 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 ERP system the company's operational efficiency can be significantly reduced. This risk event may be triggered by various factors, including psychological anxieties of staff (e.g. unwilling to change and fear of loss of job), initial failures in system implementation (e.g. insufficient training), system pitfalls (e.g. poor user interface and system design) and lack of confidence in the system. Therefore, this risk event is expected to have a high probability of occurrence, especially when the ERP system just goes live.

*Operational staff input incorrect data into the system*

ERP systems require extremely high data accuracy to work effectively and efficiently. All preliminary data of ERP is inputted by operational staff. In a case-study reviewed it is stated that "the integrated data flowed so quickly through the system that there was little opportunity to track down mistakes before they showed up on everybody's screens" (Scapens and Jazayeri, 2003). In other words, if one operational staff inputs incorrect data into the system, it will raise immediate impact and may disturb the operation of the whole company. This risk event may be caused by human mistakes due to insufficient training, lack of experience, information overload or just demotivation and tiredness (Fisher and Kingma, 2001; Vosburg and Kumar, 2001). In certain cases, staff may even purposefully input incorrect data into the system due to cheer frustration or even in order to gain, by fraud, illegitimate benefits and resources from the company.

*ERP system contains inaccurate or incomplete bill of materials*

A bill of materials (BOM) is a list of the component parts required to make up a product together with information regarding their level in the product structure and the quantities required (Slack et al., 2004:770). The number of component parts required to make up a product can vary from less than ten (e.g. a toy) to more than a thousand (e.g. an airplane). A BOM can therefore be the most complicated piece of information contained in ERP systems. In order to ensure ERPs to work properly, BOMs must be accurate and complete. Otherwise, materials required in production may not be ordered at the right time and in the right quantities (Zhou et al., 2005:53). This can lead to a set of serious outcomes, e.g. increase inventory and cost, reduce production efficiency, increase production lead time, and reduce customer satisfaction, etc (Zhou et al., 2005:53).

*ERP system contains inaccurate inventory records*

One of the main purposes for adopting ERP systems is to improve inventory recording and management of companies (Umble et al., 2003). However, despite the adoption of ERP, it is not uncommon that inventory records stored in the system may still be mismatched with actual stock levels (Zhou et al., 2005), probably due to inappropriate system usage, staff mistakes and/or human frauds. As a result of inaccurate inventory record, sales staff may not be able to inform customers about crucial stock information and availability. Without knowing the exact content of warehouses, production staff may be unsure of production schedules and issuing of procurement orders. Finally, account staff may be misled in their calculations of the actual value of current inventories, procurement orders and production costs. In short, operation of the entire company may be disturbed.

*Conflicts between accounting and non-accounting staff*

ERP systems "integrate information and information-based processes within and across functional areas in an organization" (Kumar and Hillegersberg, 2000), and therefore break down the traditional boundaries between functional divisions. This diluting of divisional boundaries has impacts for the organisation as a whole, but is particularly noticeable in accounting divisions. With the adoption of ERP solutions, the accounting part of a company is no longer distinguished from the operational one and the traditional relationship between workers and accountants needs to be redefined (Caglio, 2003). Specifically, traditional accounting responsibilities and activities (e.g. budgeting, cost recording, etc) are gradually passed down to non-account personnel in diverse functional divisions (Scapens and Jazayeri, 2003; Velcu, 2007). Both Scapens and Jazayeri (2003) and Caglio (2003) therefore point out that, efficient communication and co-operation between departments is essential to success under such a new working environment. In particular, accountants need to provide persistent help and professional guidance to non-account staff. In contrast, non-account staff should pass up-to-date financial information back to accountants.

It however can be argued that account staff in some cases may not be willing to release accounting responsibility/power to non-account staff. On the other hand, non-account staff may be unwilling or incapable to take up accounting responsibilities. Either of these two risk events may result in conflicts and arguments between functional divisions, which have a direct impact on operational efficiency and staff performance.

## 3.3 Analytical Risks

*Front-line managers refuse to use the ERP system*

Apart from operational staff, front-line managers are also key users of ERP systems (Shang and Seddon, 2002) and therefore a crucial factor in ERP success. However due to reluctance to change and insufficient training, front-line managers may refuse to use the system in real practice. As a consequence, they may not be able to use ERP to improve planning and forecasting activities and thus underutilise the full potential of their systems.

*Managers cannot retrieve relevant and needed information from the ERP system*

It is generally accepted that managers have different information needs according to their personal decision styles, contexts and actual situations. Formats and contents of reports generated by ISs should therefore be flexibly changed and customised in accordance with the actual needs of managers (Sage, 2005). However, not all ISs available in the current market can be flexible enough to satisfy this user requirement. In addition, structures and content of reports generated in a particular national context (e.g. USA) may not easily be used or even translate to other national contexts (e.g. China). Therefore, foreign ERP systems may not suit the needs of local companies due to cultural and political difference (Soh et al, 2000). As a consequence, managers engaged in certain situation may not be able to retrieve needed information from the system. The occurrence of this risk event may lead to poor decision making of managers and reduce system acceptance and usage.

*Fail to use the system to generate accurate sales forecast*

Generating sales forecast has been traditionally considered as one of the biggest challenges faced by companies (Davisa and Mentzer, 2007). It is widely acknowledged that, the generation of sales forecast is a very complicated task and requires the use of various types of inputs, e.g. historical sales data (Catt et al., 2008), sales data shared by partners in the same supply chain (Hosoda et al., 2008), and external market information (Davisa and Mentzer, 2007), etc. Although ERP systems often contain a set of analytical tools to facilitate sales planning (Catt et al., 2008), there is no guarantee that sales forecasts generated by ERPs will always be accurate due to inherent difficulties in predicting the fluid market. Inaccurate sales forecast can result in significant impact in companies, e.g. e.g. unreasonable sales quotas may be assigned to staff, and production plans and financial budgets set up by ERP may become inappropriate or infeasible (Zhou et al., 2005).

*System fails to generate appropriate master production schedule (MPS)*

A master production schedule (MPS) “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). MPS is one of “the most important planning and control schedule[s]” generated by ERP systems (Slack, 2004:489). The appropriateness of MPS can be influenced by the accuracy of sales forecast, which is the main input used to generate such production plans (Zhou et al. 2005:101). Inappropriate MPS can result in material or product shortage/overage, which can directly impact costs, delivery lead time and customer satisfaction.

*System fails to generate appropriate material net requirement plan (NRP)*

Net requirement plan (NRP) of materials is one of the main analytical outputs generated by ERP systems. Companies launch material production and procurement orders based on their NRPs. Inappropriate NRP can therefore result in material shortage or over-ordering or producing, which may directly lead to delay and/or cease of production (Chen, 2001). ERP systems use three elements of data (i.e. MPS, BOMs and inventory records) as inputs to generate NRPs (Koh et al, 2000). Therefore, if any of these three elements are improperly maintained in ERP, the generated NRP will also be problematic. Furthermore, ERP systems, like their former generation MRPs, use fixed lead time to plan for material purchase and product manufacture, and cannot flexibly respond to changes on lead time (Musselman et al., 2002). Koh et al. (2000) argue that, “this ignores real life uncertainties of supply unavailability and variability of queue, set-up and run times on the shopfloor”. This issue may often result in the generated NRPs to become questionable and even infeasible.

## 3.4 Organisation-Wide Risks

*Top managers make important IT decisions without consulting IT experts and system users*

Top managers are neither experts in IT/IS nor users who use the ERP system extensively in their daily work. They therefore typically lack sufficient experience of operational situations, operational expertise and technical knowledge to make appropriate decisions on IT solutions on their own. Hence, decision being made by top managers without the involvement of users and IT managers is a risk that may occur in IT projects (Lientz and Larssen, 2006:116). If this risk event occurs in ERP post-adoption, it may not just discourage in-house experts, but may also lead to inappropriate ERP maintenance or enhancement decisions.

*Top managers do not provide sufficient support to ERP post-implementation*

Top manager's attitude "will affect not only the flow of funds and information to the [IS] project, but also the subordinates view the project" (Gargeya and Brady, 2005). Top management support is therefore frequently reported as a crucial factor affecting the success of ERP implementation (Gargeya and Brady, 2005; Loh and Koh, 2004). This factor is certainly also critical to ERP post-adoption. In truth, lack continuous support from top managers can be a significant risk event that may lead to a set of negative consequences in ERP post-implementation, e.g. conflicts and arguments in ERP issues cannot be solved efficiently, IS development plan is missing or inappropriate, insufficient funds are assigned to system maintenance and enhancement, etc.

*ERP post-implementation development plan is ill-defined or misfit with business strategy*

The implemented ERP system has to be continuously reviewed and enhanced in the post-adoption stage (Willis and Willis-Brown, 2002). A clear IS/IT/ERP development plan is the prerequisite to enable these activities to be carried out successfully. Establishing, implementing and sustaining an efficient IS strategy depends on the commitment of top managers and endeavour of in-house experts. If the IS development plan of the company is missing, ill-defined or is a misfit with the business strategy (Lientz and Larssen, 2006:124-126), the company will not be able to retain a correct direction for further ERP development. As a consequence, the implemented ERP system may gradually become incapable to support business strategies and goals.

*Budgets and funds assigned to ERP post-implementation are insufficient*

Insufficient resources and funds can prevent ERP projects from progress and full completion (Loh and Koh, 2004; Ifinedo and Nahar, 2009). This factor is certainly also critical for system maintenance, upgrade and revision in the post-adoption phase. However, budgets and funds assigned to ERP post-implementation may not always be sufficient due to various reasons, e.g. lack of top management support, lack of appropriate ERP development plan, and post-implementation cost is insufferably high, etc. The occurrence of this risk event may inevitably impact long-term ERP success.

*Lose qualified IT/ERP experts*

High-skilled IT/ERP staff are valuable organisational assets, and are crucial for system maintenance and enhancement (Ifinedo and Nahar, 2009). However as widely acknowledged, due to high market demand for this type of professional, companies sometimes may find it difficult to retain their highly qualified ERP experts (Sumner, 2000). This risk event may have a high probability and frequency of occurrence in user companies that have a less efficient retention scheme.

*Lose ERP-related know-how and expertise accumulated over time*

In-house IT experts will be able to accumulate a large amount of know-how and expertise through the process of ERP implementation and utilisation (Scott and Vessey, 2000). It is therefore essential and important for user companies to capture such implicit knowledge from their IT experts, in order for such knowledge to be shared effectively across the firm and with fellow IT staff. However, this may not always be the case due to inadequate information sharing behaviour and a lack of systematic knowledge management practices in user companies (Burrows et al., 2005). Consequently, when highly skilled IT experts leave the firm, valuable ERP knowledge and expertise that they possessed may also be lost.

*Data access right is authorised to inappropriate users*

It is important for companies to draw a clear policy to specify what types of data access rights can be given to users according to their departments and job functions (Loh and Koh, 2004). It is also crucial to clearly specify who should be responsible for authorising access to the system (Loh and Koh, 2004). Otherwise, data access right of the ERP system may not be allocated to appropriate system users. As a consequence of this risk event, system data may be accessed and modified by irrelevant user, which can result in data loss, errors and information leakage. Furthermore, users may not be granted access to necessary information and data that may nonetheless be available in the ERP.

*Confidential data is accessed by unauthorised people*

Confidential data of the company must be stored in a secure place and carefully managed. If important and confidential information is accessed by unauthorised people, this may potentially lead to information leakage and business crisis (Yosha, 1995). The causes of this risk event may be poor data protection and access policy of the company and poor IT security (Wilding, 2003; Loh and Koh, 2004). Additionally, confidential information of the firm may also be disclosed to competitors and other unauthorised people by internal staff, who may have low loyalty to the company (Wilding, 2003).

## 3.5 Technical Risks

*Different modules of the ERP system are not seamlessly integrated*

Very often an integrated solution from one single ERP vendor may not satisfy all business needs of the company. Therefore, it is not uncommon for modern companies to procure suitable software modules from different system vendors to form their own unique ERP system (Currie, 2003). This approach however may increase complexity and difficulty in harmonizing integration issues. In other words, companies may face a risk that seamless integration may not be achieved between current modules or between current and new modules of the ERP system. Moreover, Sage (2005), one of the world's leading ERP vendors, reinforces that even all modules of the ERP system is provided by the same vendor, it does not mean they can achieve solid integration. Consequently, this issue may lead to system fragmentation in the company, through the creation of technological islands which are very often totally isolated and non-communicant.

*Legacy systems are not compatible with new ERP systems*

ERP systems are frequently criticised for having low compatibility with other IS applications (Fletcher and Wright, 1995; Elbertsen et al., 2006). In fact, it is often difficult for an ERP system to be seamlessly integrated with another information system (e.g. legacy system of the company, system of the newly merged or acquired company). The occurrence of this risk event may lead to poor data and business process integration and the creation of the same insulated technological islands as discussed above.

*Outdated and duplicated data is not properly managed*

Arranging, purging and updating organisational data are fundamental processes to ensure the highest level of accuracy possible (Loh and Koh, 2004). Therefore, companies should develop and retain good and disciplined system maintenance processes to ensure quality control of the data stored in the ERP system (Loh and Koh, 2004). It could be argued that if outdated and duplicated data of the ERP system is not discarded properly, it may lead to low data accuracy, erroneous analytical reports and eventually poor decision making at both operational and strategic levels. Additionally, redundant data may reduce speed of data searching and retrieval and increase data storage space and management cost.

*System is not properly modified to meet new business requirements*

User requirements of the company will constantly change under highly dynamic and competitive market conditions (Ecklund et al., 1996). The implemented ERP system should therefore be continuously reviewed and enhanced in the post-implementation phase (Willis and Willis-Brown, 2002), in order to meet new user requirements. However it could be argued that this task may not always be carried out properly in many companies due to low flexibility of the ERP system, high reconfiguration cost, lack of in-house experts and insufficient support from system vendors and consultants. If this risk event occurs, the ERP system may gradually become less efficient to support user needs, which may significantly impact business operational efficiency and ERP acceptance.

## 3.6 The establishment of an ontology for the identified ERP risks

### 3.6.1 What is an ontology?

Conceptualization refers to the objects, concepts and other entities that are assumed to exist in a domain of interest and the relationships that hold among them (Gruber, 1993). Whereas a conceptualization is an abstract and simplified view of the world that we wish to represent for some purposes, an ontology is an explicit specification of a conceptualization (Gruber, 1993). Therefore, an ontology could be seen as a diagrammatic model and a knowledge base that:

> "defines a common vocabulary for researchers who need to share information in a domain. It includes […] interpretable definitions of basic concepts in the domain and relations among them." (Noy and McGuinness, 2001)

Ontology is a tool that has been commonly used in computer sciences and programming, and is increasingly adopted by social sciences researchers to highlight and share key concepts and ideas in their study. There are three reasons why an ontology is worth developing in research studies (Noy and McGuinness, 2001):

- Firstly, an ontology allows researchers to highlight and share common and novel concepts in their subject domain more easily and efficiently;
- Secondly, other researchers can reuse the domain knowledge presented in the ontology and make further extension and development;
- Thirdly, concepts and assumptions made in the ontology can be easily changed and extended in accordance with changes of the researcher's knowledge about the subject domain.

Furthermore, despite the procedures for developing an ontology may be varied by subject domains, two tasks lay at the core of ontology development: first, defining concepts to be covered in the ontology; second, organising these concepts into a taxonomic (subclass–superclass) hierarchy, in which upper level contains general concepts and lower level covers more specific concepts (Noy and McGuinness, 2001).

### 3.6.2 Risk in ERP post-implementation ontology (REPO)

By following the above principles, the Risk in ERP Post-implementation Ontology (REPO) was developed to highlight the 40 identified ERP exploitation risks. As shown in Figure 1, this risk ontology consists of three hierarchical levels ranging from general risk categories (e.g. operational risks) to specific risk items (e.g. operational staff are reluctant to use the ERP system).

In addition, it clearly emerged from the findings of the critical literature review that, the occurrence of an ERP risk may often be related to the occurrence of other risks. More specifically, as shown in above sections, an identified ERP risk may often be the cause or consequence of a set of other risks. Therefore, this ontology also highlights a number of potential causal relationships between the ERP risks identified, based on the results of the critical review.

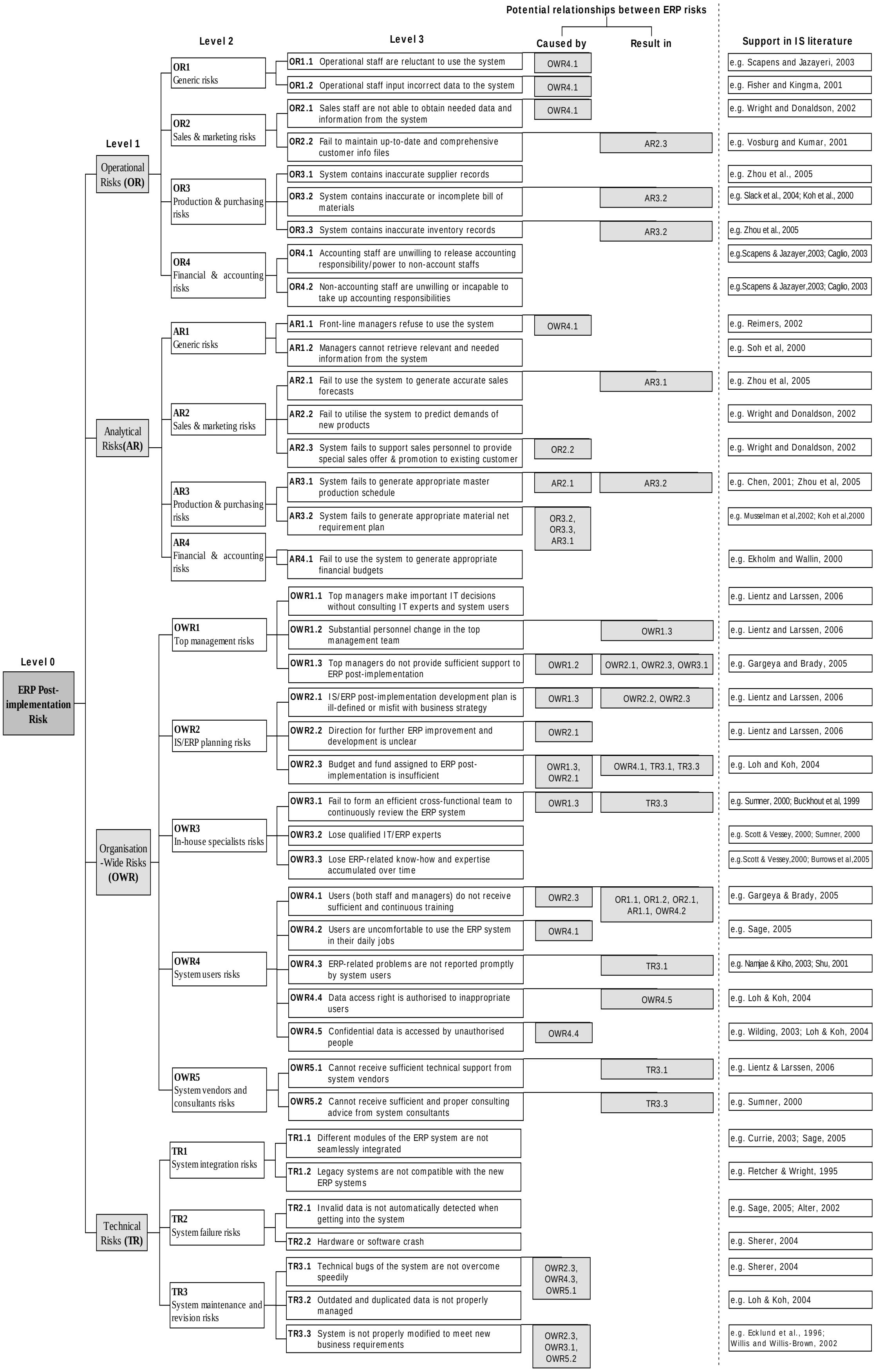


Figure 1: Risk in ERP Post-implementation Ontology (REPO)

## 4. APPLYING REPO IN RISK MANAGEMENT PRACTICE

Risk management is a vital and essential process in achieving successful delivery of any IS projects (Van Scoy, 1992; Dey et al., 2007). Effective and continuous risk management is certainly also critical for ensuring long-term success in IS and ERP post-adoption. Various frameworks of software risk management have been suggested by professional bodies (e.g. the Software Engineering Institute or SEI, and the Institute of Electrical and Electronics Engineers or IEEE), as well as by individual IS scholars (e.g. Boehm, 1991; Dey et al., 2007). Regardless the actual framework being adopted, three fundamental activities form the core of any risk management cycle, namely risk identification, risk analysis/assessment, and risk control.

Furthermore, as highlighted by Keil et al. (1998), "before we can develop meaningful risk management strategies, however, we must identify these risks". Therefore, effectively identifying potential risks is always an important first step towards achieving successful risk management in IS/ERP innovation. A number of checklists for IS risk identification have been suggested in the literature. For instance, the SEI has developed a risk taxonomy, which provides a framework for studying and organising a rich set of software development risks (Carr et al., 1993). Other researchers (e.g. Keil et al., 1998; Baccarini et al., 2004; Zhou et al., 2007) have identified an additional set of IS risks, which may be used in conjunction with the SEI risk taxonomy (Esteves et al., 2005). However, a further investigation on these risk checklists identified that, these existing lists focus mainly on software development and project management factors, but do not cover issues related to system post-adoption aspects.

Therefore, the REPO risk ontology established and presented in this paper is a useful and meaningful tool to fill this knowledge gap. This risk ontology is developed with the objective of facilitating the systematic identification of risks in the context of ERP post-adoption. A thorough search and review of the literature cannot identify any other such models. Furthermore, it should be stressed that not all risks contained in the ontology are equally important. In particular, it is expected that different risk events can lead to different consequences and have different impact levels. Their probability and frequency of occurrence will also vary in different organisational contexts. Therefore, when applying REPO in risk management practice, it is essential for managers to assess and prioritise the identified risks. Risk mitigation plans should be established to address the risks that are most concern with one's working environment. Additionally, as pointed out by Zhou et al. (2007), the usefulness and value of a checklist as the one proposed "may be questioned if the list is used monolithically and never improved". In truth, Vidalis (2003:20) reinforces that "nothing is staying stable in our world […hence] having a generic list is a drawback, unless it is being updated constantly". Therefore, the REPO ontology does not aim at being a definite and hierarchical set of identified risks. Instead, it is hoped that this ontology can undergo a process of continuous examination and evolution through practice.

## 5. CONCLUSIONS

This paper reported on a desktop study, which aimed to fill the current research gap of ERP post-implementation by developing and proposing the REPO risk ontology. The study has led to several important conclusions. Specifically, the results confirmed that successful implementation of the system is not the end of the ERP journey. In truth, a wide range of risks may occur in diverse business and system-related areas during ERP post-adoption. More importantly, the findings also show that an ERP risk may often be the cause or consequence of other risks. Because these identified risk events seem to be interwoven and related with each other, they may be very difficult to manage, mitigate and contain. As a consequence, in order to ensure long-term ERP success, IS managers must become aware of these risks and take proper risk mitigation actions as early as possible.

The results of this study have implications for both practitioners and researchers. For practitioners, the established risk ontology can be used as a systematic tool and checklist for risk identification, assessment and management, as well as for strategic planning and decision-making. The risk relationships highlighted in the ontology can also help managers to identify and explore possible triggers of risks. Furthermore, the applicability of this risk ontology may not be limited in the ERP context. In truth, because many risk items contained in the checklist were initially grounded from general IS literature, it is deemed that the ontology will also be useful in supporting risk identification in IS post-adoption in general. For researchers, on the other hand, this paper contributed to the theory of IS risk management in general, and provided valuable insights into ERP post-adoption risks in particular. The literature-based risk ontology also provides a starting point and foundation for IS researchers to carry out further research in these increasingly important research areas.

The major limitation of the study is related to the fact that the REPO risk ontology is developed from a critical literature review process but has not been further tested. Further research should therefore be conducted to address this limitation. In particular, a questionnaire survey may be a well suited method to validate the proposed risk ontology, as well as to test the proposed relationships between risks. Moreover, a well performed qualitative study may also bring extra flavour to the results by seeking anecdotal evidence to explore further the causes and consequences of risks.

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