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Cloud ERP: a New Dilemma to Modern Organisations?

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ABSTRACT

For almost two decades, on-premise ERP has been adopted very prevalently in the industry. Accompanied with the emergence of cloud computing technologies in the late 2000s, there is an increasing trend for companies to migrate their hitherto internal ERP applications and databases into the cloud. Such ERP resources re-migration, which can offer a range of opportunities to user companies, is also associated with new challenges. The study reported in this paper aimed to explore potential benefits and barriers associated with the adoption of cloud ERPs. A set of in-depth interviews were conducted with 16 ERP and cloud consultants. The findings, derived from a thematic analysis, identified that whilst the economic and technical benefits promised by cloud vendors are attractive, the success of cloud ERP adoption can be affected by critical challenges related to diverse organisational factors as well as with current legal and technical complexity in the cloud environment.

1. INTRODUCTION

Enterprise Resources Planning (ERP) systems are enterprise-wide information system packages, which consist of a comprehensive set of software modules that aim to support and integrate all key business processes across various functional divisions of an organisation by using a single data repository [1]. Ever since its emergence in the early 1990s, ERPs have been widely implemented by thousands of knowledge-intensive organisations, with any size (e.g. including not just large companies, but also small and medium enterprises or SMEs), in many sectors (e.g. manufacturing firms, banks, universities, and hospitals), and in many countries (e.g. Western countries like the USA and Europe as well as Pacific Asian countries like China and India).

Traditionally, ERP resources (including data, module applications, and database servers) are internally hosted and maintained by user organisations (this is so called on-premise ERPs). This on-premise approach, which is still prevalently adopted by modern organisations to host and deploy ERPs, has certain inherent disadvantages, such as high initial investment and being too time-consuming to upgrade ERP installed on different user PCs [2]. These disadvantages embedded in on-premise ERPs are expected to be significantly improved with the support of cloud computing technologies. In the new cloud environment, ERP packages and related data will be hosted on a third party vendor-managed and controlled infrastructure. Companies can use their ERP applications and data as on-demand services through a web browser, without physically installing the system in local PCs or storing the data in local servers. This new ERP deployment model will require less hardware investments, as well as less fees and internal hazard for system maintenance and upgrade [3]. These attractive cloud features therefore result in an increasing trend for companies to consider migrating their hitherto internal ERP applications and databases into the cloud.

Current literature and studies on ERP are very rich, but the vast majority of them focus merely on on-premise ERPs [e.g. 4, 5, 6, 7]. In contrast, research on cloud ERP has been very limited. Furthermore, the benefits of cloud technologies in general and cloud ERP in particular seem to be frequently and even over emphasised by cloud providers, whilst

potential barriers and challenges related to this new ERP deployment method have not been fully explored and discussed in either the industry or the academia. The study reported in this paper therefore attempts to fill this knowledge gap. Specifically, it aims to seek in-depth insights from highly experienced IT professionals to identify and investigate potential benefits and barriers for migrating ERP systems to the cloud, as well as to provide useful lessons to help companies better prepare themselves for such crucial ERP and IT transformation. This paper is structured as follows: the next section presents a brief review of current ERP and cloud literature. The research methodology is then discussed and justified. Subsequently, the findings derived from the study are presented and discussed, followed by a discussion of the key lessons learned and recommendations, with conclusions drawn.

2. BRIEF REVIEW OF EXISTING ERP AND CLOUD LITERATURE

Unlike applications that focus merely on a single business area or a particular organisational level, ERP systems contain a very comprehensive set of functions aimed at supporting all business processes across the whole organisation. With these unique features, ERP has been widely perceived as the most important development in the corporate use of information technology in the 1990s [8]. 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 [7]. Given its value, importance and potential organisational implications, ERP has attracted very substantial attention from both the industry and the academia during the last two decades. Research on ERP has covered a wide range of interesting issues and topics, including ERP adoption benefits [e.g. 9, 10, 11], ERP selection criteria [e.g. 12, 13, 14], ERP critical success factors [e.g. 15, 16], and risks and barriers affecting ERP implementation and post-implementation [e.g. 1, 6, 7; 17].

On the other hand, cloud computing is an advanced IT outsourcing model, which allows organisations to use a pool of third-party hosting IT resources and applications as services virtually through the web, without physically holding these computing resources internally [3]. Since its emergence in the late 2000s, cloud computing has been widely perceived as an important strategic technology, which has the potential to change traditional IT usage in organisations and even transform the global IT industry [18]. The strong interest of researchers on cloud computing can be observed from the rapidly increased number of conference and journal papers being published in recent years. The topics covered in these cloud computing studies can be broadly divided into three areas, namely cloud computing features and benefits [e.g. 19, 20], conceptual and technical cloud frameworks/models [e.g. 21, 22], and issues and risks related to the adoption and organisational use of cloud services [e.g. 3, 23, 24, 25].

However, an extensive review of the literature identified a number of issues and gaps in current ERP and cloud research. In particular, studies reported in the existing literature mainly treated ERP and cloud computing as two separate research areas. On the one hand, the vast majority of ERP studies focus solely on issues related to on-premise systems and are now getting somehow overly abundant. Studies of ERP in the new cloud environment are rarely found in the literature. On the other hand, cloud researchers just looked at issues of cloud computing in general, but neglected the variances and unique features embedded in different types of cloud applications and services, such as cloud ERPs. In fact, cloud applications, also known as Software-as-a-Service (SaaS) applications, can take many different forms, ranging from simple personal document storage tools (e.g. Google Docs), to corporate email systems (e.g. Google Apps Email), to enterprise-wide applications (e.g. cloud ERPs). Given the inherent complexity and importance of ERP systems, cloud ERP is

arguably one of the most valuable and influential SaaS applications available in the market. We therefore consider that cloud ERP should be the next wave of ERP and cloud research. By linking and building on existing ERP and cloud literature, researchers can identify a number of meaningful and underexplored research issues associated with cloud ERP, such as:

- While the benefits of cloud computing in general have been well reported in the literature, it is interesting to investigate further how these cloud features can add values to ERP solutions as well as to explore what new advantages cloud ERPs can offer comparing with traditional on-premise packages.
- One important conclusion, which has been frequently drawn from previous ERP studies [6, 7], is that potential failure of on-premise ERPs cannot be simply attributed to technical aspects (e.g. software packages and ICT infrastructure), but more importantly should also be attributed to business, organisational and human problems. Further research should thus be done to investigate whether this important conclusion is still valid in the context of cloud ERPs.
- As discussed above, a considerable number of research has been done to identify the specific issues and risks (e.g. data privacy and security concerns) associated with the adoption and use of cloud technologies in general. It is important to validate these general cloud findings in the context of cloud ERP, as well as to identify and investigate how the advanced cloud features may originate new challenges for cloud ERP adoption and usage.

The study reported in this paper attempts to make a first step toward addressing these significant knowledge gaps related to cloud ERPs.

3. RESEARCH METHODOLOGY

Given the exploratory nature of this study, an inductive approach with the use of in-depth interviews emerges to be suitable for achieving the research objectives outlined above. As highlighted by Saunders et al. [26] and Bryman [27], interview as a typical qualitative tool is very useful and efficient in gathering and exploring rich human insights and perceptions on complex social phenomena (e.g. the adoption of cloud ERP in an organisational context). May [28] reinforces that the interviewer can often probe beyond answers and can extend the predetermined questions flexibly to seek further clarification and explanation. These characteristics of interview were considered to be not just useful but in fact highly valuable for generating a rich set of findings on cloud ERP benefits and challenges. Based on these considerations, in-depth interview was used as the data collection method in this study.

3.1.   Participants and interview administration

Although cloud ERP has received increasing attention from the industry, this concept is still relatively new to many user companies. Therefore, it was considered that business managers and users may not currently have sufficient knowledge to offer rich insights on the cloud ERP issues under investigation. In contrast, IS consultants and ERP experts working in the frontier areas of the IT industry were expected to hold more in-depth knowledge on cloud ERP issues. Consequently, these considerations led the researchers to target on IT professionals and consultants as the prospective interview participants of the study.

Subsequently, the researchers contacted the CEO of ASN Consulting Ltd. (the real name of the firm is disguised for confidentiality purposes), who kindly agreed to get involved in the study. ASN Consulting is an IT outsourcing firm located in India, with over 100 employees and 12 years of operational history. This IT company was selected due to the fact that it has

not just been a successful player in the ERP market for the last 10 years, but is also one of the pioneers to provide cloud services and more recently cloud ERP solutions to client companies across Pacific Asian regions, Europe, and USA. In order to retain their success in the original ERP market and the new cloud sector, many IT consultants of the firm were effectively trained to have a good mixture of knowledge and experience on both ERP and cloud solution implementation. Therefore, these IT experts were deemed to be able to offer valuable insights to the cloud ERP issues being studied.

With support of the CEO, 24 experienced IT consultants, who had previously contributed to various ERP and cloud outsourcing projects in ASN Consulting, were identified and initially contacted. 16 of them were available at the time of data collection and were thus involved in the interviews, including 6 ERP project managers, 3 senior system analysts, 4 senior cloud consultants, and 3 junior cloud consultants. As shown in Table 1, the levels of experience of these interviewees vary according to their job titles. For instance, the ERP project managers interviewed had an average of 6 years of working experience in ERP. In contrast, senior cloud consultants had less ERP experience but more cloud expertise than ERP project managers. However, all interviewees indicated that they had certain level of practical experience in both ERP and cloud solutions. The researchers thus believe that these interviewees, with different job roles and at various levels, can offer a good combination of expertise and experience to provide meaningful insights to this study.

Table 1. Profile of interviewees

Job title	Years of IT industrial experience	Years of ERP experience	Years of cloud experience
ERP Project Manager (ERP-PM), n = 6:	Ave. = 9	Ave. = 6	Ave. = 1
ERP-PM 1	10	7	1
ERP-PM 2	8	5.5	1
ERP-PM 3	9	6	1
ERP-PM 4	9	5.5	1
ERP-PM 5	10	7	1
ERP-PM 6	8.5	6	1
Senior System Analyst (S-SA), n = 3:	Ave. = 8	Ave. = 5	Ave. = 1
S-SA 1	9	5	1.5
S-SA 2	7.5	4.5	1
S-SA 3	7.5	5	1
Senior Cloud Consultant (S-CC), n = 4	Ave. = 6	Ave. = 2	Ave. = 3
S-CC 1	7	1.5	3.5
S-CC 2	6.5	2	3
S-CC 3	5.5	2	3
S-CC 4	5.5	2	3
Junior Cloud Consultant (J-CC), n = 3	Ave. = 2	Ave. = 1	Ave. = 1
J-CC 1	2	0.5	1
J-CC 2	2.5	1	1
J-CC 3	2	1	1
Total number of interviews: 16			

In order to allow the interviewees to share their experience and perceptions more openly and thus lead to a more significant and interesting set of findings, the in-depth interviews were conducted in a relatively unstructured form. However, the following few questions, which were derived from the literature review, were used to guide the conversation:

- What are the main benefits or motives for companies to transform their on-premise ERP to a cloud solution? What are the advantages of cloud ERP comparing with traditional on-premise systems?
- What possible barriers, challenges or difficulties can prevent companies from adopting cloud ERP? Furthermore, will general challenges affecting on-premise ERP success (e.g. lack of top management support) still apply to cloud ERP packages?
- What recommendations can be given to companies to enhance their possibility of success in the cloud ERP journey?

Due to geographical limitation, it was found too costly and time consuming for the researchers to travel from the UK to India to collect data. In order to keep the research cost within budget but also ensure that both verbal and non-verbal (e.g. body language of interviewees) information can be captured, online video (rather than face-to-face) interview was conducted over Skype, and was recorded by using the Evaer software. On average, the interviews lasted between 40 and 80 minutes. In order to enhance the trustworthiness of data, written transcription was done on the same day that the interview had taken place. Moreover, the transcription of each interview was sent to the interviewee to read through, and thus allowing the researchers to identify and remove potential bias or incomplete interpretation.

3.2. Interview data analysis

The interview data collected was analysed by using a thematic analysis approach. Thematic analysis is one of the predominant techniques to be used for analysing qualitative data [29]. It is a process of searching, identifying and exploring codes and themes that emerged as "important to the description of the phenomenon" [30], through "careful reading and re-reading of the data" [31]. Following guidelines given by prior researchers [31, 32], the thematic analysis conducted in this study consisted of five stages, as summarized in Table 2.

Table 2. Five stages of the thematic analysis.

Stage	Description of the process
1. Getting familiar with the data	Get known the data by reading and re-reading the data set.
2. Coding the data	Develop the coding scheme, and code the textual data in a systematic fashion across the entire data set by using NVivo.
3. Connecting codes with themes	Collate codes into themes and sub categories, gather all data relevant to each theme and sub category.
4. Reviewing themes & developing Ontology	Check if the themes and sub categories work in relation to the coded quotes and the entire data set, generate an ontology of the analysis.
5. Reporting findings	Final analysis of selected quotes, relating results back to the research question & literature, presenting findings.

As a result of the data analysis, the researchers identified and explored a set of 15 key benefits and 18 critical barriers associated with the adoption of cloud ERPs. These identified cloud ERP benefits and barriers were respectively organised into 9 different sub categories. In order to organise and represent these findings systematically, an ontology was used. An ontology is 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." [33]

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 studies [6]. Although 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 [6, 33]. Following these guidelines, an ontology was produced as shown in Figure 1. Radiating from the centre of the ontology are the two key themes explored (i.e. Cloud ERP benefits and barriers), which are in turn linked to the sub categories and specific benefit/barrier items as emerged from data. This ontology is then used as the frame for reporting the interview findings in the next section.
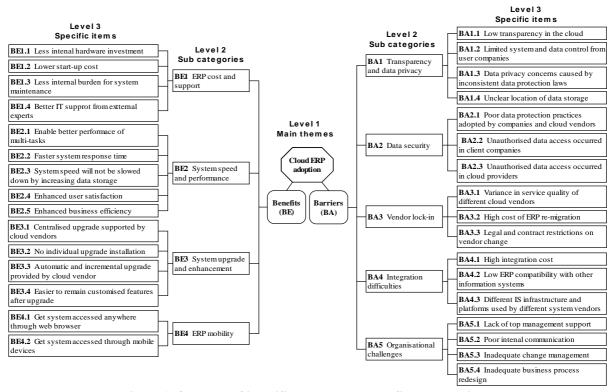
Level 3
Specific items

BE1.1 Less intenal hardware investment

BE1.2 Lower start-up cost

BE1.3 Less internal burden for system maintenance

BE1.4 Better IT supprot from extternal experts

BE2.1 Enable better performce of multi-tasks

BE2.2 Faster system response time

BE2.3 System speed will not be slowed down by increasing data storage

BE2.4 Enhanced user satisfaction

BE2.5 Enhanced business efficiency

BE3.1 Centralised upgrade supported by cloud vendors

BE3.2 No individual upgrade installation

BE3.3 Automatic and incremental upgrade provided by cloud vendor

BE3.4 Easier to remain customised features after upgrade

BE4.1 Get system accessed anywhere through web browser

BE4.2 Get system accessed through mobile devices

Level 2
Sub categories

BE1 ERP cost and support

BE2 System speed and performance

BE3 System upgrade and enhancement

BE4 ERP mobility

Level 1
Main themes

Cloud ERP adoption

Benefits (BE)   **Barriers (BA)**

Level 2
Sub categories

BA1 Transparency and data privacy

BA2 Data security

BA3 Vendor lock-in

BA4 Integration difficulties

BA5 Organisational challenges

Level 3
Specific items

BA1.1 Low transparency in the cloud

BA1.2 Limited system and data control from user companies

BA1.3 Data privacy concerns caused by inconsistent data protection laws

BA1.4 Unclear location of data storage

BA2.1 Poor data protection practices adopted by companies and cloud vendors

BA2.2 Unauthorised data access occurred in client companies

BA2.3 Unauthorised data access occurred in cloud providers

BA3.1 Variance in service quality of different cloud vendors

BA3.2 High cost of ERP re-migration

BA3.3 Legal and contract restrictions on vendor change

BA4.1 High integration cost

BA4.2 Low ERP compatibility with other information systems

BA4.3 Different IS infrastructure and platforms used by different system vendors

BA5.1 Lack of top management support

BA5.2 Poor intenal communication

BA5.3 Inadequate change management

BA5.4 Inadequate business process redesign

Figure 1. Ontology of identified cloud ERP benefits and barriers.

4. RESEARCH FINDINGS

4.1. Benefits of cloud-based ERPs

The interview findings confirmed that when advanced cloud technologies are used to deploy ERP systems, user companies can expect to receive a range of new benefits that they cannot generally obtain from traditional on-premise ERPs. This section presents and discusses the findings on cloud ERP benefits, in comparison with on-premise ERPs, and with support from the literature.

Reduced ERP cost and better support

High implementation and maintenance cost has been frequently reported as a crucial factor preventing companies (especially small sized enterprises) from adopting on-premise ERP systems [34]. In particular, an on-premise ERP will generally require user companies to invest substantial financial and human resources to purchase, install, maintain and improve the software package and related IT facilities (e.g. servers, hardware, and any necessary facilities to run it) [2]. When companies (especially large multi-national firms) have a high number of ERP users, installing and constantly upgrading the software package on the PCs of

all users will be very costly and time consuming. An ERP Project Manager interviewed reinforced that "if the company does not currently have enough in-house IT personnel to handle the various ERP deployment tasks, additional resources will need to be spent on recruiting new IT experts and/or providing further training to current staff" (ERP-PM 1).

Such typical costing issues associated with on-premise ERPs can be significantly improved by adopting cloud solutions. As confirmed and highlighted by all of the seven Cloud Consultants interviewed, cloud providers will host all necessary IT/ERP infrastructure facilities for user companies, who will no longer need to purchase and keep these IT resources internally. The initial cost of ERP implementation "can thus be substantially reduced within the cloud environment" (ERP-PM 1, 2, 4 & 5). Cloud vendors also have the responsibilities to "provide day-to-day maintenance service and support to client companies, as well as to keep the client's ERP data secured" (S-CC 1). All ERP Project Managers and Cloud Consultants interviewed considered that these services will not just minimise the maintenance burden of in-house IT staff, but can also reduce potential cost of IT training and allow internal IT experts to concentrate on more strategically important tasks of the company.

Enhanced system speed and performance

System users typically want the implemented on-site ERP to have fast response time and high data processing speed. Failing to satisfy this essential requirement will not just inevitably lead to user disappointment but will also affect their efficiency in handling related business tasks. Unfortunately, in actual practice inadequate IT infrastructure (e.g. slow server speed and low data storage capacity) can often substantially affect system speed, which can be further reduced by the increasing amount of outdated and duplicated data accumulated during day-to-day ERP use [6]. In addition, an ERP Project Manager (ERP-PM 3) interviewed highlighted that certain mission-critical tasks performed by ERPs require very time consuming calculation in the company's computers. For instance, net material requirements plan (MRP) is a crucial analytical output generated by ERP to guide product manufacturing and material purchasing [6]. Owing to the limited capacity of internal IT infrastructure, and also because of the number and complexity of the transactions involved, MRP calculation can generally take many hours of computer time and require all other ERP activities of the company to be ceased [35]. In order to avoid other ERP and business tasks to be affected, "companies normally tend to keep the frequency of MRP calculation very low, such as only once per week/month" (ERP-PM 3). This typical ERP practice however will "make it difficult for companies to react efficiently towards fast-changing market conditions and business needs" (ERP-PM 3 & 4).

In contrast, cloud providers can offer much powerful IT infrastructure (e.g. hundreds of servers and huge data storage capacity) to host ERP and its ever increasing data. Therefore, all of the four Senior Cloud Consultants interviewed stressed that when the speed of internet connection is high, the response time of cloud ERPs can be expected to be much higher than on-premise ones and will not be slowed down by the increasing amount of ERP data. Also owing to such powerful IT infrastructure, cloud ERPs will allow companies to "perform multiple activities easily at the same time, including the hitherto time-consuming and CPU-intensive tasks like MRP calculation, without affecting normal PC performance" (ERP-PM 3). Such enhanced system speed and performance can in turn increase user satisfaction and business efficiency, as perceived by all interviewees.

More effective system upgrade and enhancement

With on-premise ERP, the software package will need to be installed on the PCs of every single system user. However, when ERP providers release new versions or enhancements of the system, it will be very time consuming for companies to upgrade their packages on all user PCs [2]. For a multi-site or multi-national company, "upgrading ERP across diverse geographical locations can become a particularly complicated and difficult task to manage" (ERP-PM 5). Furthermore, an implemented ERP system will normally have undergone certain customisations to suit particular business needs. The customised ERP functions however are usually "tied to the current system, and will therefore not be carried forward to the upgraded version without re-configuration/customisation" (ERP-PM 3). These inevitable upgrade difficulties are some of the main reasons that prevent companies from updating and enhancing their on-site ERP packages, as highlighted by all Project Managers interviewed.

In contrast, the interview findings identified that cloud ERPs can be centrally upgraded by the system provider, with minimal to no effort from internal IT staff. Specifically, the interviewees stated that automatic upgrades on specific ERP components will be released by cloud providers on a regular basis. This approach allows cloud vendors to improve their ERP packages incrementally and constantly. All customised cloud ERP features and functions will not be affected during such gradual upgrades. Furthermore, once the upgrade is completed, all users (regardless their locations) can access the new version of the system through their web browsers, without any further individual installation. These cloud features "significantly reduce the time and resources required from user companies to carry out upgrades and enhancements of their ERPs" (S-CC 4).

Enhanced ERP mobility

The interviewees highlighted that when on-site ERPs need to be physically installed and operated on local PCs, this feature presents a location restriction for users to access the system. For example, when managers and operational staff are in the manufacturing shop floor, they will not be able to access their work PCs located in the office. This location restriction can often lead to "delay and even mistakes in entering important data, such as new inventory or production records, into on-site ERPs" (ERP-PM 2). Similarly, when managers are on their way to visit business partners, customers and suppliers, they may not be able to check or update ERP data hosted in the company's local servers. Such limitation can potentially "affect the efficiency of decision making and problem solving of business managers, when they are working outside the company" (ERP-PM 4). If companies want to allow business managers and users to have remote access to an on-site ERP database, further investment will normally be needed to customise the ERP package and purchase additional hardware equipment (e.g. remote machines to transfer data).

The adoption of cloud ERPs can fundamentally improve these practical issues. In particular, cloud applications can be easily accessed anywhere through web browsers, by using not only PCs but also handheld mobile devices (such as smart phones and tablet PCs), with no extra customisation or hardware cost. A Senior Cloud Consultant (S-CC 2) interviewed pointed out that such enhanced ERP mobility allows "business managers to check and update important data in cloud ERPs immediately after the data occurs regardless their locations, and thus ensuring high business efficiency and performance".

4.2.   Barriers for adopting cloud-based ERPs

When the business benefits and opportunities offered by cloud technologies are attractive, the interview findings suggest that companies cannot underestimate potential challenges and

barriers associated with the adoption and use of cloud ERPs. This section presents and discusses a set of critical cloud ERP barriers as emerged from the interview data.

Cloud transparency and data privacy

The advanced cloud computing model enables cloud ERP providers to separate enterprise data from internal hardware and servers of user companies. This inherent feature of cloud computing however also determine that IT operation within a third-party cloud provider will be by no means transparent to user companies, who also have limited control on the subscribed cloud services [3, 24].

The interviewees confirmed that such lack of transparency and control is a typical phenomenon in the cloud environment and can often raise concerns related to data privacy. In particular, the interviewees (i.e. ERP-PM 2 & 6; S-CC 3 & 4) highlighted that client companies may often worry about where their enterprise data will be physically stored by cloud vendors and whether the privacy of these sensitive data will be fully protected. A further review of the literature reinforced that due to technical and costing reasons, data stored in the cloud may often be moved by cloud providers between different servers located in different countries and geographical locations, without informing the client companies [25]. However, different and inconsistent data protection laws may be applied in different countries, and can thus increase the possibility for data privacy to be jeopardized [3]. For instance, European customers adopting cloud services provided by US vendors are often concerned about the U.S Patriot Act, which empowers the US government to access any data without obtaining consent of the data owner [20]. Consequently, the interview findings suggest that these transparency and data privacy concerns are currently preventing many companies from adopting cloud technologies in general and cloud ERPs in particular.

Data security

The terms 'data privacy' and 'data security' are often used concurrently and even interchangeably [e.g. 36]. However, we would argue that these two related concepts are indeed different in nature. In particular, data privacy refers to the right of client companies to be sure that their confidential data kept by service providers is controlled and used properly (e.g. not to be disclosed to any unauthorised individuals and/or organisations). On the other hand, data security relates to the practice of the protection of data against unauthorised access, disclosure and use. It should be pointed out that poor security practices will inevitably lead to poor data privacy. However, data privacy can also be jeopardised by other non-security reasons (e.g. inconsistent data protection laws used in different countries, as discussed above).

It is frequently mentioned in the industry that cloud vendors can provide a better IT infrastructure to protect data security. However, a review of the literature suggested that data leakage and loss are more likely to be caused by human reasons in practice, rather than by technology failure [6]. In particular, the integrated nature of ERP determines that data stored in the system can be shared and used across different departments of the organisation. Managers can thus often access the data of not only their own department but also other business areas. With traditional ERPs, managers may often keep multiple copies of these important enterprise data on their staff PCs, laptops, disks, and memory sticks. However, if any of these hardware equipment is lost or stolen, there is a high risk for the data stored inside to be disclosed to unauthorised people. Alternatively, there may also be a possibility for internal staff to download sensitive enterprise data from the system and give it to business

competitors to exchange higher return [6]. A number of interviewees (i.e. ERP-PM 1, 2 & 6) confirmed that these typical data security risks can also occur when using cloud ERPs.

Moreover, when ERP data are hosted by a third-party cloud provider, companies will have even less control on whom (from the vendor side) may access and download their crucial enterprise and customer data. Such lack of control in the cloud environment will inevitably introduce further data security threats to client companies. A Senior Cloud Consultant interviewed confirmed that such data security risks may be more likely to occur with cloud vendors that are "smaller in size, using inefficient data protection and monitoring practices, and having higher staff turnover" (S-CC 4).

Vendor lock-in

The market of cloud services in general and cloud ERP in particular is still relatively new and immature. As such, a number of interviewees (i.e. ERP-PM 2, 4 & 5; S-SA 2 & 3) cogently stated that the quality of cloud ERP applications and services provided by different vendors can vary significantly. If client companies feel unsatisfactory about their current cloud services, they may inevitably want to switch to a different service provider. However, the interview findings identified that changing to a new cloud ERP provider may not always be easy due to a number of reasons. Firstly, under the complicated cloud infrastructure, it can be very costly and time-consuming for moving ERP data from one cloud provider to another. Secondly, certain legal restrictions made by current cloud providers may make it difficult for user companies to retrieve and relocate their ERP data to a different cloud server either during or at the end of the existing service contract. Furthermore, a new ERP package, either on-premise or cloud-based ones, will reshape and change an organisation's culture, distributions of power, structure, and business processes [7]. Therefore, changing an existing ERP package will also imply essential changes in many other operational, organisational and managerial aspects. Owing to these potential difficulties and challenges, user companies may not be able to switch their cloud ERP vendors even in the case of service dissatisfaction. A further review of the literature identified that this issue, often known as the vendor lock-in scenario, occurs very commonly in the cloud environment [3, 20]. Consequently, the interviewees (i.e. ERP-PM 2 & 5; S-SA 2) suggested that user companies must be very careful when making decisions towards the selection of their cloud ERP vendors. Considering potential difficulties for changing vendors either during or at the end of the cloud contract, companies can suffer substantial financial loss if they did not make a strategically correct vendor selection decision at the very beginning.

Integration to other IS applications

A single ERP package may not satisfy all business needs of user companies, especially for large and multi-national firms. Therefore, it is common for organisations to use a number of other IS applications (e.g. legacy systems and other systems that aim at supporting specific functional requirements), which will normally need to be integrated with ERPs [6, 7]. However, since ERP systems are very complicated and have low compatibility, integrating ERP with other IS applications traditionally involves many technical challenges and very high cost [6, 37].

The interview findings confirmed that this integration issue will also apply to cloud ERPs and in fact will become even more difficult to manage in the cloud environment. In particular, client companies that have limited control in the cloud "will not have sufficient freedom and right (as they do with on-premise ERPs) to customise a cloud ERP and integrate it with other applications" (ERP-PM 5). On the other hand, different IS applications can be

developed by using very different technologies and platforms. As a result, it may "not be feasible for cloud vendors to modify their ERP system to allow seamless integration between the package and various IS applications purchased by different client companies" (S-CC 2 & 4). These interviewees (i.e. ERP-PM 5; S-CC 2 & 4) therefore concluded that client companies must be fully aware of these additional integration difficulties of cloud ERPs, in order to avoid disappointment.

Typical organisational challenges

As discussed in the literature review section, it has been frequently and constantly reported in previous research that organisational rather than technical barriers (such as, lack of top management support, poor cross-functional communication, inefficient business process reengineering, and inadequate change management, etc), are the main triggers of potential failure of on-site ERP implementation and post-implementation [6, 17, 34, 37]. Many of these typical organisational barriers were confirmed by the interviewees to have crucial impacts on cloud ERP adoption and diffusion. Specifically, 4 ERP Project Managers interviewed (i.e. ERP-PM 1, 3, 4 & 6) stated that insufficient top management involvement in user companies will inevitably demotivate employees and lead to poor cross-functional cooperation during cloud ERP adoption. These barriers will in turn raise difficulties in managing the very technical, organisational, cultural, process, and job changes entailed by cloud ERPs. Without effectively manage these essential changes, significant misfits can exist between the system and its organisational environment. Consequently, the implemented cloud ERP may "neither be accepted by the users nor support the business to enhance core competences" (ERP-PM 1 & 6). These findings clearly point to the fact that despite the advanced technical features, the success of cloud ERP innovation is still heavily dependent on the context of application. Therefore, the various crucial organisational barriers, which are well documented in previous IS and ERP literature, should still receive sufficient attention during cloud ERP adoption and usage.

5. FURTHER DISCUSSION AND RECOMMENDATIONS

Following the analysis of the interview data, the researchers further identified a list of valuable lessons and recommendations, which business managers and system users should be particularly aware of, in order to better prepare themselves for the implementation of cloud ERPs:

- The interview findings demonstrated that cloud solutions can bring in a set of new features to overcome some of the technical deficiencies inherent in on-premise ERP systems (e.g. high initial investment cost and complicated system upgrade). However, cloud technology should not then be simply perceived as the panacea to resolve all critical ERP challenges. In fact, and as discussed above, many typical ERP implementation issues, especially those related to human and organisational aspects (e.g. lack of top management support), can still occur in cloud ERP projects and significantly affect project success. The complexity and crucial impact of these typical ERP problems cannot be underestimated by senior managers and business decision makers during cloud ERP adoption and exploitation.
- On the other hand, the interview findings also identified that the unique features of cloud computing will introduce a set of additional ERP challenges and risks to user companies (e.g. new data privacy and security threats, and the concern of vendor lock-in). However, these cloud challenges may not always receive full consideration from business managers, who may not have sufficient knowledge on cloud

technologies and may even be blinded by their previous on-premise ERP success. The interview findings showed that failure to identify and address these cloud challenges can lead to substantial financial loss and reputation damage in user companies. Therefore, a thorough understanding and preparation of these additional cloud challenges is vital for companies to achieve and sustain business success through their cloud ERPs.

- After successful implementation, an on-premise ERP system can be maintained by the system vendor, a selected third-party IT consulting firm, or the IT department of the user company. In contrast, a successfully implemented cloud ERP package will need to be hosted, maintained and supported only by the system provider throughout the entire post-implementation phase. Because client companies will interact with their cloud vendors in a more frequent and long-term basis, the role of system provider becomes more critical than ever before in the cloud environment. Therefore, the selection of cloud ERP vendor will need to be performed very carefully. Apart from general ERP selection criteria (such as, system functionality, technical capacity, vendor support and fee, and industrial reputation) that are well reported in the literature [e.g. 12, 13, 14], the interview findings suggest that an additional set of cloud-specific requirements will need to be taken into analysis, such as location of data storage, data protection standard and practice, legal restrictions, and cloud service quality and availability.

- Last but not least, the findings presented in this paper clearly show that both on-premise and cloud-based ERPs have their unique features, advantages, and drawbacks. It is therefore not adequate to simply conclude that one is better than the other. In fact, due to the cloud challenges reported in this paper and also the substantial ERP investment being made previously, many companies may currently have reservation for replacing their existing on-premise ERPs completely with a cloud-based one. In this case, the interviewees suggested that it will be a good option for companies to consider a hybrid solution that contains their original on-premise ERP system but also integrates a degree of cloud services. This alternative approach allows companies to gain some initial experience on the benefits of cloud ERPs while also minimise potential risks. The decision of implementing a full cloud ERP can be made at a later stage, when the firm is truly prepared.

6. CONCLUSIONS, IMPLICATIONS AND FUTURE STUDY

ERP systems have evolved from large monolithic packages installed on premise to more flexibly deployed SaaS applications available in the cloud. This paper reports the findings of an empirical study that identified and explored a set of crucial benefits and barriers associated with the adoption of cloud ERPs. It can be concluded that while the economic and IT benefits promised by cloud vendors are attractive, the success of cloud ERP adoption can be affected by a range of critical challenges related to different organisational and management aspects, as well as with current legal and technical complexity and deficiencies associated with the cloud environment. Faced with this new IT dilemma, it is important for CEOs and IT managers to consider the overall technical, organisational and strategic implications brought by cloud ERPs within the context of their enterprises, as well as to make a thorough assessment on the pros and cons of the system before making decisions toward the selection and use of this type of ERP solution.

The results of this study have important practical and research implications. In practical terms, the research findings provide valuable insights to support CEOs and in-house IT managers in the process of strategic planning and decision making towards successful cloud

ERP adoption. In particular, the identified cloud ERP benefits and barriers can serve as the foundation for managers to carry out Cost vs. Benefit comparison and analysis as a part of the feasibility study of their cloud ERP projects. On the other hand, the list of barriers presented in the paper highlights some of the most crucial issues that cloud ERP providers should strive to improve, if they want to make their products and services become more widely used in the industry and consequently facilitate the ERP transformation initiated by innovative cloud technologies.

In research terms, this study adds to the knowledge of ERP and cloud computing in general and contributes meaningful insights into cloud ERP benefits and barriers in particular. The results of this study confirmed that many previous findings about on-site ERP barriers, risks and success factors can still be valid and applicable to a cloud ERP context. The study further extended these existing theories by establishing an empirical ontology, which contains a set of new benefits and barriers that are specifically related to cloud ERPs. This established cloud ERP benefit and barrier ontology can serve as a good starting point for IS and ERP researchers to carry out further investigation in this increasingly important research topic.

The major limitation of this study is related to the fact that the findings were derived from a relatively small number of in-depth interviews. Although this approach was justified above as suitable to the research context, a follow-up questionnaire can be carried out to further valid and generalise the interview findings. Furthermore, it can be expected that the level of impact of the identified cloud ERP barriers may vary in organisations operating in different sectors (e.g. manufacturing firms and financial institutions), which may also receive relatively different benefits from cloud ERP adoption. When this study focused on cloud ERP benefits and barriers in general, further studies can investigate and explore these issues in relation to the specific conditions of diverse industries. Overall, since cloud ERP is receiving an increasing attention from the industry, further research on this topic is strongly recommended.

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