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A Risk Ontology for ERP Post-Implementation

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Enterprise Resource Planning (ERP) systems have now become an integral part of organisational infrastructures. However, many companies are confronted with a wide range of risks at the post-implementation stage, namely when using, maintaining and enhancing their ERP systems. In spite urgent need for research in this area, there is a scarcity of studies focusing on post-implementation in contrast with a over abundance of studies focusing on implementation and project management aspects. This position paper aims to fill this significant research gap by presenting a risk ontology of ERP post-implementation. This ontology represents a first attempt in producing a comprehensive model in this area and consists of forty potential risks that may occur in ERP post-implementation. Additionally, the twenty predominant risks that compose the ontology, as well as their potential causes and impacts, are presented and discussed in this paper.

This ontology is an important contribution for both practitioners and researchers. For practitioners, this ontology is an important tool for risk prevention, management and control, as well as, for strategic planning and decision making. For researchers, it 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.

Keywords

Enterprise Resource Planning, ERP, Information System, Post-implementation, Risk

1. Introduction

An ERP system is a standard information system package that comprises a set of independent, integrated and configurable software modules provided by either single or multiple system vendors. As one of the most crucial tools to sustain business competitiveness, ERP system has been implemented by thousands of modern companies worldwide. It is however frequently argued that the 'go live' point of the system is not the end of the ERP journey, the system post-implementation stage is

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where the real challenges begin [1] [2]. It is expected that user companies will inevitably encounter a wide range of risks when using, maintaining and enhancing their ERP systems in the post-implementation stage. This is particularly true if we consider three apparent facts. First, some failures (e.g. insufficient user training) are prevalent in ERP implementation, even if the implementation project is considered a successful one. Such initial failures can cause problems in ERP post-implementation. 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. inefficient communication between functional divisions) existed in the business context may prevent companies from achieving long-term ERP success. The occurrence of undesirable risks in the ERP post-implementation stage can turn the 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 [3], current research which focuses on ERP post-implementation is extremely limited, no study in ERP post-implementation risk was identified in the literature reviewed.

This paper aims to fill this significant research gap by presenting a risk ontology of ERP post-implementation. It represents a first attempt in producing a comprehensive model in its area. The process of literature search could not return any other such models. This risk ontology represents a comprehensive checklist for practitioners to identify, prevent and manage possible ERP post-implementation risks, and provides a starting point for researchers to carry out further research in a field that is becoming increasingly important and remarkable. The risk ontology was developed as part of an ongoing PhD project. The project aims to identify and investigate the barriers and risks associated with ERP post-implementation in Chinese companies. The risk ontology was developed and used as the theoretical basis for constructing the questionnaire survey of the research project. It consists of forty potential risks that may occur in ERP post-implementation. After presenting the ontology, this paper discusses twenty of the most outstanding risks in the ontology as well as their potential causes and impacts.

2. What is an Ontology and Why Develop One?

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 [4]. 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 [4]. 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." [5]

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 [5]:

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- an ontology allows researchers to highlight and share common and novel concepts in their subject domain more easily and efficiently;
- other researchers can reuse the domain knowledge presented in the ontology and make further extension and development;
- 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.

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 [5]. Hence, the risk ontology presented in this paper, 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).

3. A Risk Ontology for ERP Post-Implementation

3.1 ERP Areas of Coverage in the Risk Ontology

Due to the size and complexity of an ERP system, identification of risk in ERP post-implementation is a very time-consuming and complicated task. In order to frame the study and generate meaningful and significant outcomes, the research project particularly looked at ERP post-implementation risks in four main categories that form the first level of the risk ontology (as shown in figure 1) and are described below:

- *Operational risk (OR).* Operational staff are daily users of ERP systems. Operational risks refer to risks that may occur as operational staff use ERP systems to perform daily business activities.
- *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. These risk events are identified as technical risks.

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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. After identifying the operational and analytical risks in general, the researcher specifically selected and focused on three business areas for identification of operational and analytical risks, namely sales and marketing area, material and production area, and financial and accounting area (see level 2 of the risk ontology in figure 1).

Besides, 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 1).

Consequently, forty potential risks in ERP post-implementation were identified through analysing and synthesising current business and information systems studies, case-studies and theoretical propositions. These risks are specified in level 3 of the risk ontology.

3.2 Discussion of Risks Listed in the Ontology

From the forty risks presented in the Risk in ERP Post-Implementation Ontology (REPO), the following twenty seem to be the most predominant and prevalent risks in the ontology and will therefore be addressed in more detail in the reminder sections.

3.2.1 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 [6]. As a consequence, operational staff in the shop floor are the main users of ERP, and they do so extensively in their daily work [7]. If operational staff are reluctant to use the implemented ERP system the company's operational efficiency can be significantly reduced. This risk event may be caused 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. This risk is expected to have a high probability of occurrence, especially in the initial period that the system was just go-lived.

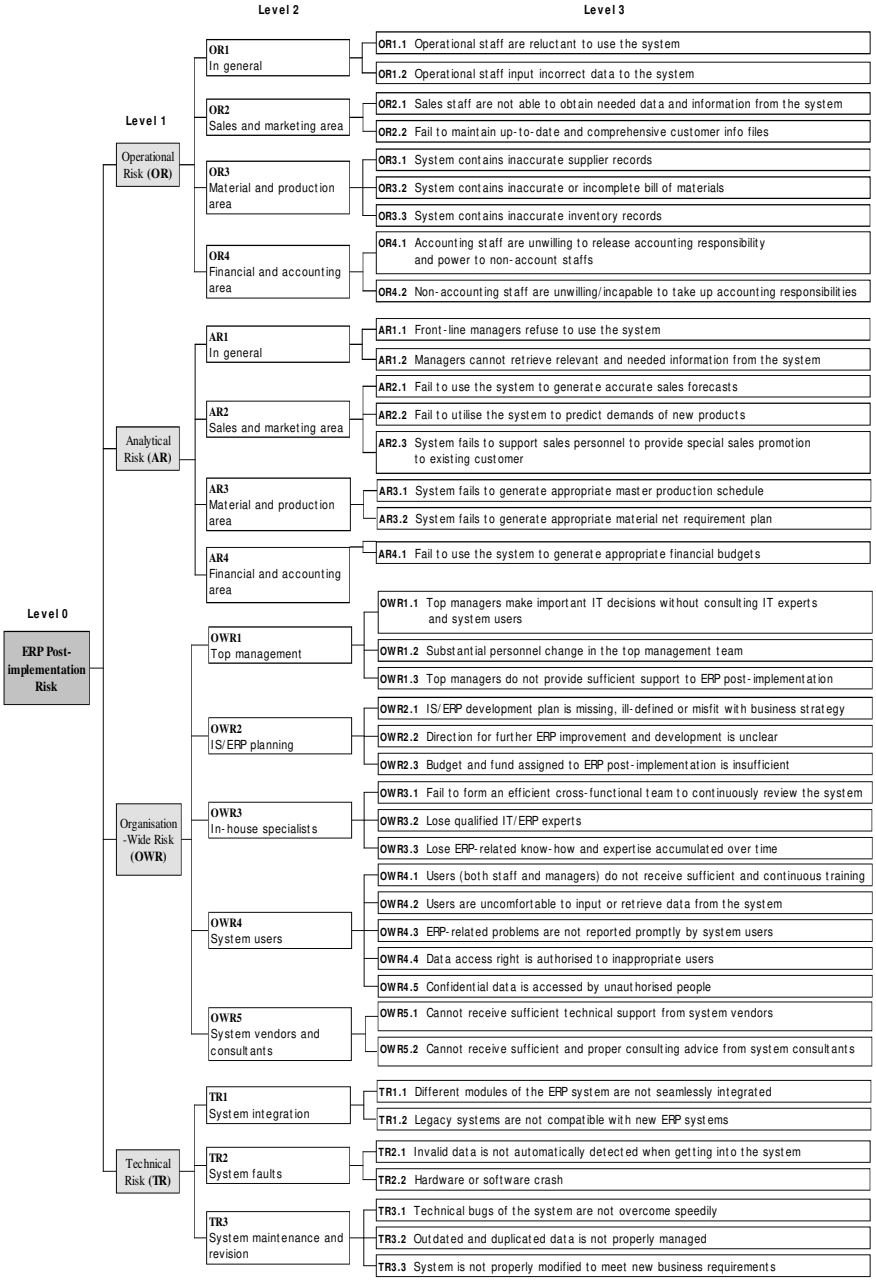

Figure 1 - Risk in ERP Post-Implementation Ontology (REPO).

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" [7]. 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 or just demotivation and tiredness. 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.

System contains inaccurate inventory records

Inventory record is one of the most important elements of organisational data stored in ERP systems. Due to human mistakes and/or frauds, inventory records stored in the ERP system may be mismatched with actual stock levels. Modern companies are also keen to store their stocks in third-party warehouses in order to reduce inventory cost. This may potentially increase difficulty in stock recording. As a result of inaccurate inventory record, sales staff may not 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.

Non-accounting staff are unwilling and incapable to take up accounting responsibilities

ERP systems "integrate information and information-based processes within and across functional areas in an organization" [8], 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 [9]. Specifically, non-accounting staff, e.g. sales and production staff, are now asked to document and be responsible for their own costs, expenditures and budgets, which were originally managed by accountants and financial directors [7]. When traditional accounting activities are gradually passed down to non-accounting staff due to the use of ERP system, it is may be expected that non-accounting staff may be unwilling or incapable to take up these new accounting responsibilities. If this risk occurs, it may result in conflicts between accounting and non-accounting departments, and even lead to resistance to use ERP system in the firm. Additionally, non-accounting staff taking on accounting duties may be ill-prepared to do so and therefore produce unreliable data, leading to the same problems discussed above.

3.2.2 Analytical Risks

Front-line managers refuse to use the ERP system

In response to demands posed by the new global economy in conjunction with the implementation of ERP systems, managers on the front lines, "where some say the real work is done" [10] are assigned with a broader set of responsibilities and tasks (e.g. budgeting, planning, forecasting, quality management and benchmarking, etc) than ever before. As a consequence, front-line managers become key users of the ERP system [7] and therefore a crucial factor in the success of these systems. However due to reluctance to change and insufficient training, front-line managers may often refuse to use the ERP system in real practice. As a consequence, they may not be able to use the system to improve planning and forecasting activities and thus underutilise the full potential of their ERP 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 [11]. Formats and contents of reports generated by information systems should therefore be flexibly changed and customised in accordance with the actual needs of managers [12]. However not all information systems 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 [13]. 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.

3.2.3 Organisation-Wide Risks

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

Top managers are neither experts in information technologies (IT)/information systems (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 advice or involvement of the IT managers is a risk that may frequently occur in IT projects [14]. If this risk event occurs in ERP post-implementation, it may lead to inappropriate ERP maintenance or enhancement decisions, and reduce motivation of staff and in-house experts in the user company.

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

The attitude of top managers "will affect not only the flow of funds and information to the [IS] project, but also the subordinates view the project" [15]. Top management support is therefore frequently reported as one of the most crucial factors affecting the success of ERP implementation in companies [16] [15]. It can be argued that this factor is also crucial to the success of ERP post-implementation. 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 post-implementation cannot be solved, IS development plan is missing or inappropriate, etc.

IS/ERP development plan is missing, ill-defined or misfit with business strategy

The implemented ERP system has to be continuously reviewed and enhanced in the post-implementation stage. 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 [14], 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 budgets and funds can prevent the ERP implementation from progress and full completion [14, 16], and can disturb system maintenance, upgrade and revision in the post-implementation phase. Budgets and funds assigned to ERP post-implementation in the company may be insufficient due to various reasons, e.g. lack of top management support, lack of appropriate IS development plan, and post-implementation cost is insufferably high, etc.

Fail to form an efficient cross-functional team to continuously review the system

A cross-functional team, which should include members covering an adequate range of knowledge from both a technical perspective and the different operational perspectives of functional divisions in the company, is crucial to enable the success of an ERP implementation project [15, 17]. Following the same line of reasoning, it can similarly be argued that continuous review and upgrade of ERP in the post-implementation phase also depends on an efficient cross-functional team. Otherwise, the organisation may not be able to adapt the ERP to emerging changes in both the business environment and internal processes. Similarly, pitfalls and shortcomings resulting from the implementation and/or unidentified requirements require these cross-functional teams to work together in order to find appropriate solutions and enhancements. However, forming these efficient cross-functional teams is not an easy task [16] [18] and can often be very controversial inside the organisation. The company may not have as

many specialists as required to form an efficient ERP team. Alternatively, in-house specialists may do not have sufficient skills and expertises to enable continuous ERP success. Moreover, team members may perceive their participation as an unwelcome deviation from their operational duties and therefore lack the motivation to participate fully. Or conversely, team members may volunteer to be part of this type of cross-functional team for internal political or power grabbing reasons and then be equally motivated to provide a full contribution. Inefficient communication and collaboration between departments and lack of top management commitment can also significantly reduce efficiency of the ERP team.

Lose qualified IT/ERP experts

Recruiting and retaining qualified and high-skilled IT/ERP staff is crucial for system maintenance and revision in ERP post-implementation. However as widely acknowledged, due to high market demand for this type of professional and inappropriate retention programme, it may be difficult for companies to retain high qualified ERP experts [18]. Failing to retain qualified IT/ERP experts is thus expected to be a risk event, which has a high probability and frequency of occurrence in ERP post-implementation.

Users (both staff and managers) do not receive sufficient and continuous training

Staff should be adequately trained during the cycle of ERP implementation in order to enable them to have sufficient skill and knowledge to maximise their use of the system when it was 'go-live' [16]. However, the ERP system will be constantly upgraded and improved during the system post-implementation stage. In order to ensure that staff can use any newly installed functions effectively, they should be provided with continuous training. Furthermore, experience emerging from a number of case-studies reinforces that sufficient training should not only be provided to staff who will use the system daily, but also to managers who can then facilitate and better control the changes taking place within the company [15]. However, it is common knowledge that staff and managers of many companies may not receive sufficient and continuous ERP training, usually due to lack of funds, resources and expert trainers. The occurrence of this risk event may lead to significant resistance to the use of ERP system in the company, as well as misunderstanding and use of newly implemented features and facilities.

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 [16]. It is also crucial to clearly specify who should be responsible for authorising access to the system [16]. 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.

Cannot receive sufficient technical support from system vendors

Sufficient technical support from system vendors is crucial for companies to successfully maintain and upgrade their ERP system in the post-implementation phase. However, due to various issues (e.g. inadequate vendor performance, vendor withdraws from the market for commercial reasons or failures, vendor is acquired by another company etc), user companies may not always be able to receive sufficient and continuous technical support from their system vendors [14]. Additionally, when the ERP system is provided by multiple vendors, it becomes more difficult for the company to manage the very complex relationships with these vendors and receive sufficient support from them. As a consequence, technical pitfalls of the implemented ERP system may not always be solved speedily and properly.

3.2.4 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 common for modern companies to procure suitable software modules from different system vendors to form their own ERP system. 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. This 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 accused to be too difficult to integrate with legacy systems and to infirm from low compatibility [19]. 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 discussed above.

Hardware or Software crash

Hardware or software crash can happen at any time when using a computerised information system. It is therefore a risk event that has a high probability of occurrence during ERP exploitation and use. The occurrence of this risk may result in system to be out-of-work for a period of time and thus disturb normal operation of the company. System users and in-house IT staff should ensure appropriate system operation and technological infrastructure maintenance (e.g. networks, databases management systems, servers, etc) in order to reduce the frequency of occurrence of this risk event.

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 [16]. Therefore, companies should develop and retain good and disciplined system maintenance processes to ensure quality control of the data stored in the ERP system. 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 may be constantly changed under highly dynamic and competitive market environment conditions. The implemented ERP system should therefore be continuously reviewed and enhanced in the post-implementation phase 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 occurs, the ERP system may gradually become less efficient to support user needs, which may impact business operational efficiency and ERP acceptance.

4. Conclusions

As more and more companies reached the 'go-live' point of their systems, ERP post-implementation is becoming an increasingly hot topic in both the industry and the research field. Nonetheless, as a fairly new research area, current study in ERP post-implementation is still limited and no study with a specific focus on ERP post-implementation risk was found in the literature reviewed. This paper aims to fill this significant research gap by presenting the REPO risk ontology for ERP post-implementation. The authors would like to stress, that not all risks contained in the ontology are equally important.

This risk ontology is considered as an important contribution for both practitioners and researchers. It is hoped that this risk ontology may be used by practitioners for strategic planning and decision making, as a checklist to identify, prevent and manage ERP post-implementation risks in their workplace. However, impact, probability and frequency of occurrence of each risk event identified may be perceived differently in different organisational contexts. Thus, as with any ontology, REPO does not aim at being a definite and hierarchical set of identified risks. It is thus suggested that, when using this ontology in decision making and risk management, practitioners should select and focus on the risks that are most concern with their working environment. Finally, and on the other hand, it is hoped that REPO may be used as a starting point for researchers to carry out further research in this increasingly important research area. It will be interesting if other researchers can reuse and extend this risk ontology through their studies, and test the suitability of this ontology within their own research contexts.

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