

# INFORMATION SYSTEM FOR PROJECT MANAGERS IN CHINESE CONSTRUCTION SMALL AND MEDIUM SIZED ENTERPRISES

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Ever since China entered World Trade Organisation (WTO) in the year 2001, its construction industry has been developing at a rapid pace. There is an urgent need for Chinese construction Small and Medium Sized Enterprises (SMEs) to re-examine their procurement system especially with the view to improve their current Information System. This paper represents the findings from a combination of literature review and questionnaire survey that sought to develop a new information system to support project managers of SME organisations undertaking the traditional procurement system in China. Initially, through a detailed investigation the benefits of Information Technology is articulated and related to the traditional procurement system in China. It is also demonstrated how the Information System performance metrics can assist the development of a new information system. These findings were exploited to map out a framework, which are defining a new Information System applicable to design stage, implementation, and maintenance strategy.

Keywords: IT investment; IS performance; SMEs; Construction process; Competitive advantage

## INTRODUCTION

Procurement systems detail a whole spectrum of pertinent issues, starting with the client or customer and running through managerial, cultural and IT based issues (McDermott and Rowlinson (1999). Basically, project procurement refers to the plans, activities, and processes included in the project development life cycle. More precisely, Mohsini and Davidson (1989) define procurement system as ‘the acquisition of new buildings or space within buildings, either by directly buying, renting or leasing from the open market, or by designing and building the facility to meet a specific need’. Meanwhile the Information system (IS) in the procurement system refers to the entire infrastructure, organization, personnel, and components for the collection, processing, storage, transmission, display, dissemination, and disposition of information (INFOSEC, 1999). Successful management of information during the construction process could yield competitive advantage to a construction company. However, two barriers seem to exist between the traditional procurement system and its integrated IS: on the one hand, Samuelson (2002) claimed that the greatest advantages with Information Technology (IT) are stated as better financial control and faster access to information, while the greatest obstacle is the cost, which is too high for investment and upgrading of systems. In addition, Avison and Shah (1997) expressed that many IS have failed, in the combination of budget and /or schedule overruns and for not meeting user’s requirement. Furthermore, Farbey *et al.* (1993) found that those responsible for implementing IT in organisations are totally committed towards the ‘success’ of the IT investment, often tend to ignore the ‘full’

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Yuan, Z and Khosrowshahi, F (2005) Information system for project managers in chinese construction small and medium sized enterprises. *In: Khosrowshahi, F (Ed.), 21st Annual ARCOM Conference, 7-9 September 2005, SOAS, University of London. Association of Researchers in Construction Management, Vol. 1, 549-58.*

cost implications of their investment and thus advocate optimistic estimates of benefits and cost savings.

As far as Chinese construction is concerned, the market has undergone a significant change since 1988: investments have grown at almost 15% every year. After China entered World Trade Organisation (WTO) in 2001, its construction market was opened to the world construction enterprises allowing a gradual entry for foreign investors to establish their own construction companies. Subsequently, the construction industry is facing a serious and fair competition, never experienced before. This has forced Chinese construction enterprises to improve their competitive capability and set up their own organisational style.

With the increasing investment in the construction industry and the rapid development of the information technology and Chinese new construction business environment, the IS in the traditional procurement system is not adequate to support the growth of the industry. It is necessary and inevitable that construction companies should re-examine their procurement system. This paper aims to develop a new information system to support Chinese project managers of Small and Medium Sized Enterprises (SMEs) undertaking the traditional and dominant mode of procurement system. This aim is achieved by identifying the key processes in the procurement system with the application of Construction Process Protocol level I that is Generic Design & Construction Process Protocol (GDCPP) and Level II that is a detailed sub-process level; justifying the appropriate information technologies for the current procurement system; applying the appropriate Information System performance metrics to evaluate the successful procedures in integrating an IS into a procurement system and Mapping the appropriate IS that integrates with the business strategy for various identified procurement process.

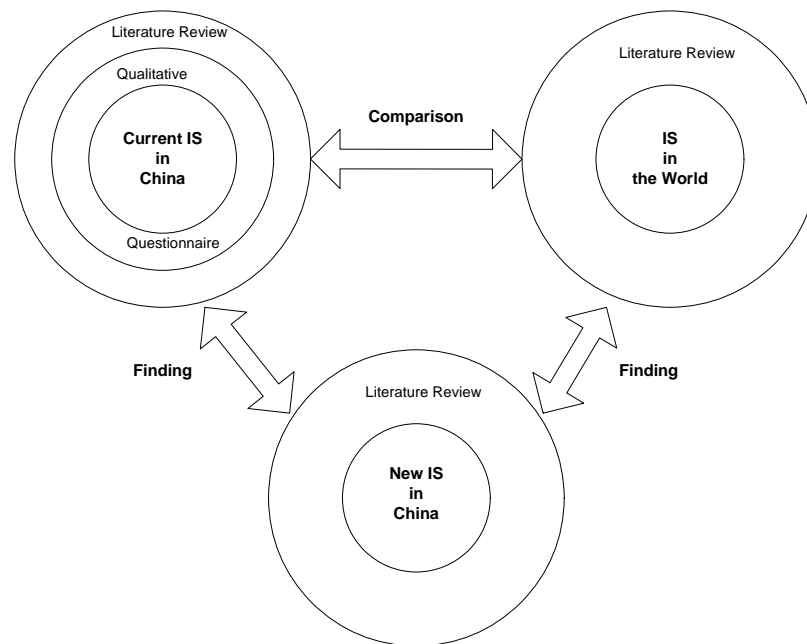
## **BACKGROUND TO CHINESE CONSTRUCTION INDUSTRY**

The construction industry plays a vitally important role in Chinese economy. The Chinese statistics department (2004) has pointed out that construction industry accounts for more than 7% of Chinese GDP and 4.8% on the recruitment of the total working labour of Chinese. In addition, the development of Chinese construction market has undergone three stages since 1979. The first stage is from 1979 to 1991: Chinese construction business started to develop in a fast pace due to chair Deng's new property policy. Second, from 1992 to 1997, the construction market grew in a dramatic speed which was more than 200% investment every year. Third, China entered WTO in the year 2001: Chinese government has opened its construction market to foreign investors. During the first quarter of the year 2004, the cost of the contracts amounted to £114bil (1746bil RMB).

Basically, the project development life cycle is broken into three parts that are design, construction, and sales by the Chinese government due to the reason of effective management and for preventing monopolisation. In other words, most of the designed projects are contracted through the public bidding with the agent of the construction department of the Chinese government. Moreover, Chinese construction companies are nationally divided into four grades: A+, A, B and Grade C. The allocation of the grade will determine the type and size of the building that the enterprise is allowed to undertake.

## RESEARCH METHOD

The research strategy is given in Figure 1, showing the research paradigm. Basically, this research is aided by two means: literature review and survey questionnaires. Initially, the current application of IS in Chinese traditional procurement system is identified through combination of literature review and a questionnaire. Meanwhile the world wide application of IS in project procurement system is critically analysed. These efforts paved the way towards the development of the proposed IS system.



**Figure 1** Research Methodology.

Here, the main purpose of the literature review is to focus and learn from the world wide experience relating to the use of IS in procurement methods adopted or involving SMEs. Since China is a developing country, its IS in the construction SMEs procurement system may well be different or out of date with the IS developments of construction industries of industrial countries. This wider examination of the literature will help to provide a guideline to map out an appropriate new IS to the Chinese traditional procurement system. This will be in the light of such differences as the language, culture, geography, etc between China and other countries. To this end, the Chinese construction SMEs are examined in the Chinese current publication, regulations, etc.

The questionnaires will concentrate on collecting the exploratory information relating to the procurement process, the attitude in IT investment and the methods of investment in new information system in Chinese construction SMEs. Here a Closed – End questionnaire is used, although it is less conducive to the transfer of meaning (Roger and Kindcaid, 1981), it requires less physical mental effort from the participants (Peterson, 2000) and is a one-way communication that ensures the linear data collection. As advised by Oppenheim (2003), while designing the questionnaire attention has been paid towards content validity, concurrent validity, and predictive

validity. Here, the questionnaire is divided into four parts. The first part examines the detailed procurement process of the selected companies in order to identify the specific procurement process in Chinese construction SMEs. The next part evaluates the use of information technology in the selected companies within the procurement process. Part three will ascertain the current application of the information system within the procurement process of identified companies. The final part concentrates on the selected companies' opinion on the application of IS performance metrics.

### **Sampling Characteristics**

The selected sample is based on the objective that is to 'provide a practical means of enabling the data collection and processing components of research to be carried out (Fellows and Liu, 2003)'. The focus of this research has been on the Grade A construction SMEs in China, because Grade A+ enterprises tend to have relationship with and adopt the standards of worldwide construction companies. Also, the top-down model of Chinese enterprises suggests that the low grading enterprises will set agenda for the higher grading enterprises. Further, organisations in China are chosen from one province – Guangdong province and two governments of provinces – Shanghai and Beijing. Guangdong province is one of the most modern provinces in China, often seen as the model in Chinese construction market and it is usually the pre-test province for the new policy of China. Second, Shanghai is one of the most developed and open cities in China and Beijing, being the capital of China and is going to hold the Olympic Game in 2008, is likely to have several new projects, which require the revision of their procurement information system.

## **DATA COLLECTION & ANALYSIS**

In total, 187 Grade A construction companies were approached for this survey: 97 companies from Guangdong Province, 42 companies come from Shanghai, and 48 from Beijing. Altogether 62 responses were received ending up with 59 valid responses (31.6% of original). The aforementioned 4 parts are discussed below:

### **Chinese Procurement Process**

Business Process Redesign or Business Process Reengineering (BPR) is crucial as organizations develop inter-organizational relationships, alliances, and other methods of cross company coordination (Attaran, 2003). When it comes to interaction with other companies, it is recognised that some reengineering will help to facilitate processing across the boundaries of the two organizations (Broadbent *et al.*, 1999). The objective of BPR is to design a process structure for the company that procures the strategic plan and moves the company effectively in the right direction information (Betts, 1999) and it is beneficial to business improvement in construction industry. A CSIRO study of process of improvement (Mohamed *et al.*, 1994) modelled the building process and identified potential savings in time of between 25% and 40% by reducing non-value added steps in the business process. The Construction Process Protocol began in 1995 to develop a framework using proven manufacturing principles to help construction firms to improve their business (Wu *et al.*, 2000) and was used in manufacturing experiences as a reference point (Kagioglou *et al.*, 1998b). In addition, it mapped 'the entire project process from the client's recognition of a new or emerging need, through to operations and maintenance' (Cooper *et al.*, 1998).

Further investigation has shown that most of procurement processes in a project life cycle are similar in Chinese construction SMEs enterprises, which include cost plan (97%), handover plan (63%), completed facility (90%), health and safety plan (95%), procurement plan (86%), maintenance plan (86%), communication strategy (46%), site and environment report (93%), risk management process (53%) and post project review plan (75%). Meanwhile, the other procurement processes in the construction process protocol just account for a small portion, which is merely 3% in all of the responses. However, it is increasingly recognised that in Chinese SMEs procurement process that information translation, clients' satisfaction and risk analysis are gaining less attention from the construction enterprises. This is indicated by data showing that only 46%, 53%, and 63% of participants are concentrated with the communication strategy, risk management process and handover plan respectively.

### **Information Technology in Chinese Construction SMEs**

Information Technology can improve the performance of a firm's business processes (Gyampoh-Vidogah *et al.*, 1999) and many companies are increasing their expenditure on IT in order to obtain or even sustain a competitive advantage in their respective marketplaces (Alshawi, *et al.*, 2003). The main applications of the Information Technology in current construction procurement process are categorised in Internet, Intranet, Extranet technologies, Data Interchange, and Virtual Reality. Internet, Intranet, and Extranet technologies provide great benefits to the procurement process such as time saving, real time communication etc. Here, database and data interchange play a crucial role in improving efficiency. Also, Industry Foundation Classes (IFCs) and Electronic Data Interchange (EDI) are the two recognised areas of data interchange technology. An IFC is a building model that enables different kinds of AEC application to exchange information between each other, while EDI enabling an organisation to review its current business practises, identifying ineffective or inefficient processes. As far as Virtual Reality is concerned, it allows visualising construction sequences and operations and could be used as part of project management tools.

According to the survey result, a serious gap exists between the mature, traditional procurement system and the new information technology application incorporated within the procurement process. 51% of the project managers who intend to invest in IT have highlighted the imperatives of the business requirement, suggesting that they already view IT from strategic perspective. Meanwhile, the cost of IT investment is still a serious limiting factor.

With 76% endorsement, the Internet is clearly accepted by most of the organisations as a mean to improve their procurement process. However, the application of Intranet and Extranet in Chinese construction SMEs enterprises' procurement process is still at their initial stage: only 37% are using the Internet tool and 17% are using Extranet. Meanwhile these two technologies are gaining momentum in construction industries of the industrial world. As for video conference and virtual environment, there was no response from the enterprises, possibly due to the high cost of purchasing the equipments and they are too new to apply in the current procurement process.

Over 22% of the participants considered an e-office system as mainly a document management system. About 24% considered Microsoft Project and Microsoft Office as their tool in assisting their procurement process. This suggest that the higher IT application, which could help to integrate the various procurement processes in a collaborative and efficient level, has not penetrated into Chinese SMEs construction

market or the project managers are not yet aware of the potential benefits of the new IT applications. In general, figures show low level exploitation by the companies: 19% on e-tendering, 3% on e-catalogue, 12% on 'on line material tracking systems', and only 37% on any applications on e-commerce.

### **Current Information System Evaluation**

The first step for developing a new system is to fully understand its current information system. This is examined by focusing on 10 information system performance elements: system administration, procedures and records, application software, computer hardware, relating training, hardware maintenance, on-going and operation support, reliability, communication ability, and data store capability. Taylor (2004) stated that these elements are the key indicators for a successful system. First, due to the low cost of purchasing the hardware and the mature hardware market in China, the computer hardware and hardware maintenance are awarded good comments by the project managers: 5% extremely good, 29% very good, 25% good for hardware and 2% extremely good, 25% very good, 46% good for hardware maintenance. Second, most of the participants are satisfied with the data store capability of their IS.

Third, despite their frequent use, respondents companies claimed that the administration of current information systems is poor (25%) or extremely poor (2%), procedures and records (27% very poor), related training (32% very poor; 5% extremely poor), on-going programme and operation support (53% very poor; 7% extremely poor), reliability (32% very poor; 3% extremely poor), and communication capability (54% very poor; 3% extremely poor).

Fourth, 'fair option' on the IS performance indicators take account of a big portion in all questions. Even in system administration, procedures and records, application software, computer hardware, relating training, and reliability, project managers ticked fair option accounting for the biggest portion, which are 61%, 64%, 37%, 36%, 32% respectively. This result may be attributed to the lack of specific measurement standards or approaches on IS performance or critical analysis on IS requirement integrated with a strategic point of view before implementing their IS. This hypothesis will be broken down into a detailed analysis in the next section – IS performance metrics.

### **Information System Performance Metrics**

Applying the right IS performance metrics could result in four great contributions to a company's competitive advantages. First, it helps to avoid the miss of the business opportunity since inappropriate systems and technology investments might not support the business objectives and may even become a constraint to business development (Betts, 1992). Second, a successful strategic management plan could provide guideline for accomplishing implementable information integration that is a key factor in construction IT (Department of the Environment, 1995). Third, with the assistance of IT investment strategy, the coherence of the procurement process would be increased. As a result, large sums of money that are spent on fitting things together retrospectively could be saved. Last but not least, IS performance metrics could contribute to share understanding and agreeing direction between users, construction managers and the IS specialists that leads to the reduction of the conflict, inappropriate solutions and misuse of resources (Betts, 1999).

IS performance metrics is consisted by five specific performance measurement approaches, which could not only help to better integrate the information technology into the current procurement process, but also guarantee the success of implementing a new information system into procurement process in the construction industry. First, SWOT analysis concentrates the internal and external business environment in construction industry to identify the current situation that relates to the strengths, weaknesses, opportunities, and threats inside the organisation. Second, Key Performance Indicators highlight the information needs and the investment requirements in new systems. Benchmarking pays attention to the evaluation of the current IS operation. Fourth, Balance Scorecard and Critical Success Factors are usually worked together and demonstrate the systems information provision, resource, organisation, skills and services, to determine coverage and contribution.

Although applying a right strategic approach would result in an improvement of the current IS, avoiding the unnecessary time and cost on the implementation stage, and even bring great competitive advantage to an organisation, however, Chinese construction SMEs still pay less attention to it. Through a Balance Scorecard and SWOT analysis point of view, 54 of the targeted organisations (92%) ticked finance aspect as one of the most important elements when considering an IT investment, meanwhile 56% of the participants also treat internal business improvement as a crucial role in this process. However, the other two aspects, which are users' requirement and internal learning and innovation, are gaining totally no more than 45% agreement, which are 37% and 8% individually. This result reveals that most of the SMEs construction enterprises in China still can not treat IT investment in a more comprehensive and strategic point of view. Moreover, only 44% (26 participants out of 59) of the Key Performance Indicators and 36% (21 participants out of 59) of the Critical Success Factors have been applied in the IT investment process. No more than 10% of the respondents are utilising Benchmarking or Balance Scorecard as their strategic approaches for their IT investment.

Finally, other systematic approaches are referred by 12% of the respondents, which shows that the application of Key Performance Indicators, Benchmarking, Critical Success Factors, and Balance Scorecard are still not fully appreciated as critical approaches for successfully developing an information system for the Chinese construction SMEs procurement system.

## **FINDING AND MAPPING THE NEW INFORMATION SYSTEM**

Based on the procurement process analysis in Chinese construction SMEs, the IT application in Chinese construction industry, current information evaluation and the IS performance metrics, the framework of the new IS are defined. These are supplemented by another three related strategies, which relate to the design stage, implementation, and maintenance strategy. Firstly, the new IS in the traditional procurement system is defined in the following five characteristics.

1. Providing more flexibility between procurement process & information transportation.
2. Integrating a higher IT especially for increasing communication ability.
3. Clear structure to reduce the difficulty of continual update of the new IS.
4. A strategic combination of the Information Technology and procurement process.

5. An Information System that is mainly developed for the cost plan, completed facility, health and safety plan, and site and environment report process; some interactive sub-Information systems' should be prepared as an alternative.

### **Supplemented Strategies for the New Information System**

Initially, the design stage refers to the IT selection for the IS, which could be approached by what is called tailor-made solution or a software package. On the one hand, tailor-made solutions could match with what a company needs and fit the development requirement of the information system. In addition, tailor-made software requires less computer resources, as it is developed based on the analysis of the current facilities. Furthermore, as the tailor-made software is aimed for specific need of the information system, the company could change its functions in a much easier and convenient way and it is likely to include user participation during the design process. However, it is a risky process because the software is adapted in one company only and has not been widely tested. Also, could be a time consuming process because of the design and modification that should be accorded to its specification. On the other hand, purchasing a software package too has its positive and negative aspects. Firstly, since the packages are already developed and tested, it can be installed far more quickly than the tailor-make one. Secondly, software packages are always developing and keeping up to date to its customers and these upgrades may bring additional advantages that a company may not have. On the other hand, there is the disadvantage that the adoption of an off-the-shelf package is likely to restrict the desired business model of the company. Moreover, because packages software is designed from the normal deployment of the computers, they usually demand extra computer resources, such as higher computer processor, larger memory space, etc. IS develop manger are advised to be aware of the advantages and disadvantages of these approaches, and select a right approach or integrate different packages and tailor-made solutions as appropriate for their specific organisation.

As regards implementation, there are two considerations: one is to 'transform the detailed design into code in such a way that is consistent with the design as well as the non-functional constraints contained in the specifications (Jones, 1990)' and the other is to prepare for unit testing and debugging. Moreover, direct cutover, parallel operation with single cutover, parallel operation with phased cutover, and pilot system operation are the four alternatives for installing an new IS.

Finally, maintenance strategy accounts for a big partition in the new IS investment and may have a serious impact on the users or even the organisation's competitive advantages. Shemer (1999) estimates that 55% of all software errors must be corrected during the maintenance period and maintenance frequent consumed 70% of the software budget. The application of IS performance metrics in the maintenance stage would play a role of improving the new IS performance consistently.

## **CONCLUSION**

This paper outlines the current procurement process in Chinese construction SMEs that is considered in combination with the Generic Design & Construction Process Protocol (GDCPP), Process Protocol Level II and Chinese construction business environment. Evidently, significant discrepancies exists between the current level of IS exploitation within the traditional procurement system and the potential that exists fro the use of IT and IS, in general and in relation to Internet, Intranet, Extranet, Data Interchange, and virtual reality technologies, in particular. Although the organisations



have realised the importance of the integration or development of the new information technology, the practical implementation and the pace of the change is somewhat slow and its initial stage. On the other hand, the computer hardware, hardware maintenance and data storage capabilities are satisfactory and adequate.

It is shown that pitfalls exist in such areas as system administration, procedures and records, training, programme and operation support, reliability and communication capability. Further, the IS performance metrics application on IT investment in the improvement of a procurement system is not strong enough in Chinese construction SMEs.

Ultimately, a new proposed system for Chinese construction SMEs' procurement system is defined as having five characteristics so as to provide more flexibility between the procurement process and information transportation; integrating IT, increasing communication capabilities; continual updating of the IS; and strategic combination of the IT and procurement process.

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