

The Drivers and Barriers for the Development and Applications of Project Collaboration Systems in the Chinese Construction Industry

Z. Ren

Built Environment Division, Glamorgan University, UK

T. M. Hassan

Department of Civil and Building Engineering, Loughborough University, UK

F. Yang

Mouchel, UK

ABSTRACT: Fragmentation is one of the major problems facing the Chinese construction industry. With its rapid development, this problem becomes more severe in the industry. In response to this problem, different collaboration systems have been developed by domestic and foreign construction and ICT companies. Although a significant amount of money has been invested, the impacts are still unclear. This paper reports on the findings of a survey conducted in 2008, with contributions received from 42 construction organizations including developers, designers, and contractors. The paper discussed the major problems and issues involved in developing project collaboration system in Chinese construction industry, and identified the key issues that support and inhibit the application of collaboration systems. Both qualitative and quantitative analyses methods have been adopted to analyze the results obtained. The results reveal the state-of-the-art of collaboration systems in the Chinese construction industry and their impacts, at both Governmental and organizational levels.

1 INTRODUCTION

The construction industry is the third largest sector of the national economy in China, ranks next to heavy & manufacturing industries and agriculture. In 2006, the total fixed assets investment was \$1.9 trillion. About 70% of the investment was provided by construction and decoration enterprises (National Bureau of Statistics of China, 2007). In 2009, the Chinese Government announced a \$585.5 Billion investment scheme, mainly in the infrastructure industry to cope with the worldwide economic crisis (Xinhua News Agency, 2009).

Zhu (2008) identified four major problems in the current Chinese construction industry: a) Fragmentation of construction process, b) Fragmentation of project structure, c) Lack of communication, and d) Breakdown in supply chain. Therefore, the Chinese construction firms have been encouraged to adopt collaboration system at all the levels.

Unfortunately, most applications so far are at microscopic level focusing on individual problem solving facilities. Much of the impact has been allowed to just happen, without planning, and without accommodating changes in organizational structures and business processes. The result has been that the full potential of collaboration systems to improve

construction industry's efficiency, effectiveness and flexibility has seldom been reached.

Little work has been done to investigate the implementation and impact of collaboration systems, some fundamental questions relating to the full scale by which collaboration systems are applied have not been fully addressed. For example, what hardware and software are used to develop and implement collaboration systems, how successful collaboration systems have been developed and implemented in the industry, what are the benefits and difficulties construction firms facing.

This paper presents the outcomes of a recent survey which aims at investigating the current application and impacts of collaboration systems in the construction industry in China.

2 COLLABORATION SYSTEMS IN CONSTRUCTION

Construction project information is created from the beginning of project planning and it develops continually during design, engineering, and construction phase. Much of the project data generated from early project stages are useful for the later stage (Yu et al., 1998). This needs effective collaboration system to meet the target to share information, coordinate

work and improve efficiency. Collaboration systems have been used in the sectors including: planning and estimating, designing, supply chain collaboration and management, and facility management, etc.

Meanwhile, a number of issues need to be considered whilst developing and applying collaboration system in construction, which include:

- *Organizational issues:* The information age and global competitive environment has forced companies to respond with the implementation of productivity tools in the workplace. While it may be true that there is high potential for increased productivity through the implementation of collaboration systems attention must be given to the impact of change in organization. There are three aspects to be changed: operating procedures, organizational politics, and organization culture.
- *Technological issues:* The availability, cost and potential risks are the key issues which will be considered whilst developing collaboration systems in the industry. Current collaboration systems are mainly developed based on the technologies such as: e-commerce, Electronic document management systems, mobile communication, intelligent agent technologies, Semantic Web, Grid Computing, and 3G Wireless Communications.
- *Standardization issues:* Standardization is an important issue in expanding the sphere of influence that collaboration systems has in the construction industry, because the more non-proprietary the system is, the more potential functionality that a collaboration systems solution will have. However, the industry has become aware of data models as a way of representing technical and administrative information content, leading to the development of data structures that allows information to be exchanged among various computer applications (Eastman, 1999). Integration also requires the standardization of information representation through standards such as: ISO 10303, Standard for the Exchange of Product Model Data, International Organization for Standardization and Industry Foundation Classes (IFCs).
- *Security issues:* The issue of security is being addressed as collaboration systems application embraces the open-systems environment of the Internet. The key to the future of collaboration systems is the ability to make its communication paradigm ubiquitous. The rapid developments of the Internet have allowed and encouraged the creation of Internet and Intranet collaboration systems functionality.

As the functions become more prevalent, users take ability to perform them for granted. Right now, however, the hurdle to cross is the interoperability between proprietary systems. Obviously, the security issue is of proportional importance to the degree of openness achieved by the proposed collaboration systems solution.

3 RESEARCH METHODOLOGY

The survey was conducted through questionnaire and Delphi survey.

3.1 Industry Survey

A total of 176 questionnaires were sent to respondents in various sections, including Architecture, Construction, Construction Supervision, and Estate Development based in Jiangsu, Shanghai and Beijing. Altogether 42 responses were gathered. The questionnaire survey collected the quantitative and qualitative data on aspects related to collaboration systems.

There are four major sections of the questionnaire:

- General information –the respondents' background, position and experience;
- Section A - the problems due to lack of the collaborative work;
- Section B - the current situation of the use of collaboration systems;
- Section C - the factors which inhibit or support the application of collaboration systems.

Data analysis was undertaken using SPSS. Two successive stages were followed. Descriptive statistics for means of some questions were calculated to examine general information. The hypotheses were tested using a one-tailed Mann Whitney U Test and Spearman Rank Correlation. To do this, U value and Spearman rank correlation coefficient were calculated for the two groups (architecture unit and construction unit). Comparisons between the sets of observations were made, using Spearman rank correlation coefficient to examine eleven collaboration technologies in greater depth.

Two rounds of Delphi studies were also conducted using a panel of six experts representing different construction sectors. The issue of implementation of collaboration systems to Chinese construction is a subjective one. There are no historical data available to be used to develop a framework which facilitates the application of collaboration systems in the Chinese construction industry. The problem does not lend itself to any precise analytical techniques. Therefore the use of Delphi method based on the subjective judgement of the group of experts was

appropriate to address this issue. Furthermore, there are also many other relevant issues such as the impact on the current procurement systems and change in the traditional company structure that need to be included to support the formation of good environment to application of collaboration systems. The use of the Delphi technique is also an efficient and economical method in soliciting the expert opinion and arriving at group consensus on the issue in this study. The method asks anonymity of response. This is important for this type of research whereby the subject matter is still new. Respondents might be reluctant to lend their opinion any issue, which is new to them, if the discussion is being carried out in open forum. The anonymous environment gave the respondents the freedom to express their opinion independently.

The Delphi study in this research closely adopted the standard process:

- Step 1: Determination the aims and objectives of the Delphi study
- Step 2: Selection of the panelists
- Step 3: Development of the first round Delphi questionnaire
- Step 4: Analysis of the responses, feedback and development of Second Round Delphi

In this Delphi study, 51 questions were used to evaluate the factors which promote and inhibit the use of collaboration systems in Chinese construction industry. Every question had a Likert scale of five ordinal measures of agreement (from 1 to 5) with regard to the importance of each factor presented in the questionnaire.

The main approach used to analyze the data generated from the panelists was the 'Relative Indices' (RI) technique and median score for each factor. RI computes the strength of 'indices of agreement or influence' for each factor. The ranking was made in descending order from the top. The factor with the highest RI value topped the ranking. Wherever there is tie between the factors, the factor that has the higher median will be ranked in the high order.

4 RESULTS

4.1 Results from Industry Survey

Figure 1 shows that phone is most commonly used (78%) communicate tools among project participants. It shows that the communication approach is unsophisticated. Although many companies have an Internet service, most important documents, such as design specification, were delivered by Fax or mail. These approaches are bound to result in time consuming. It implies that most participants in construc-

tion industry are not aware of the benefit from advance technologies, such as electronic document systems.

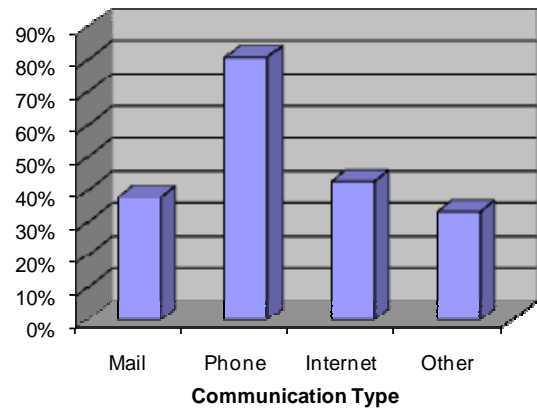


Figure 1: Percentage of communication approaches in companies surveyed

As the Figure 2 shows, nine respondents think their companies spent below 100,000 Yuan (\$14,630) on travel to inspect the status of the project, namely four architecture companies and five construction companies. Only four construction companies allocate above 300,000 Yuan (\$43,890) for travel fee. No architecture company surveyed spent above 300,000 Yuan (\$43,890) to inspect the project. This shows that architecture companies spend much less than construction companies to inspect project every year. Architecture companies hardly take part in construction, such as investigating construction site. It seriously breaks the work processes.

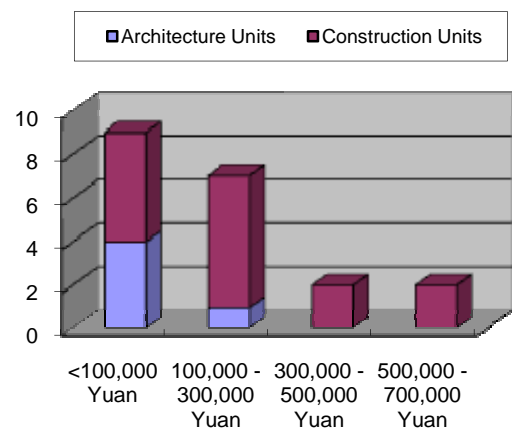


Figure 2: Analysis of the company expenditure on travel to inspect the status of projects every year

Figure 3 demonstrates that 47.6% respondents do not know the extent of affecting the project because of lacking timely information obtained. 38.1% of respondents think less than 10% projects need rework. The main reason that the majority of companies are not aware of the problem is the lack of a set of

benchmarks. Hence Chinese construction companies find it hard to carry out evaluation on the efficiency of work procedures by themselves. In other words, they do not know where they are being lagged behind the counterparts in other countries. Naturally they would not like to actively challenge by some new approaches or work mode.

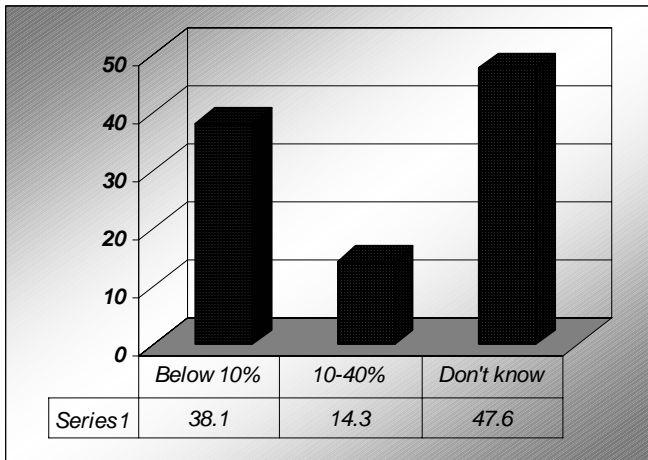


Figure 3: Percentage of projects which needed rework during to not obtaining useful information in time in companies surveyed

Figure 4 shows that 61.9% respondents reflect that their companies have not used any new work processes until now. The rest of the respondents indicate that most of the clients who require using these new work processes are foreign investors. Under Chinese circumstance, Government plays a key role of implementing new technologies. But in the case of the application of collaboration systems, the Government does not exert authority. On the contrary, foreign investors force their Chinese partners to use some new software to improve the efficiency of work. But owing to the limit of Chinese policies, they cannot involve all projects. Power of the driver is very little.

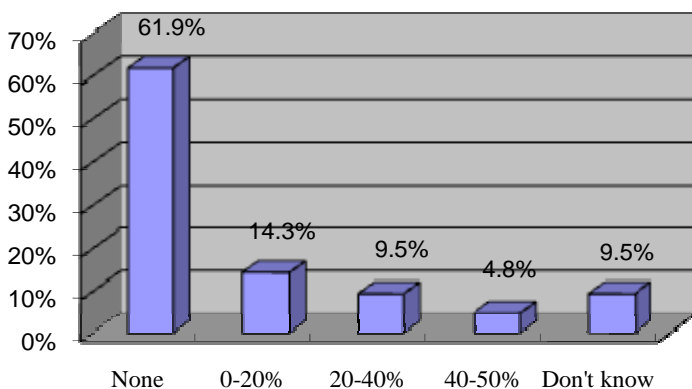


Figure 4: Percentage of projects which involved the new business processes

Although Figure 5 shows that the ability to use basic computer software is satisfying, most of the respondents only evaluate the permanent staff. In fact, a

large number of temporary workers are employed on site. Most of them have limited knowledge of basic computer literacy. The operation of some advance technologies, such as mobile technologies, is impossible. As a result, the companies will spend more money on training their workers.

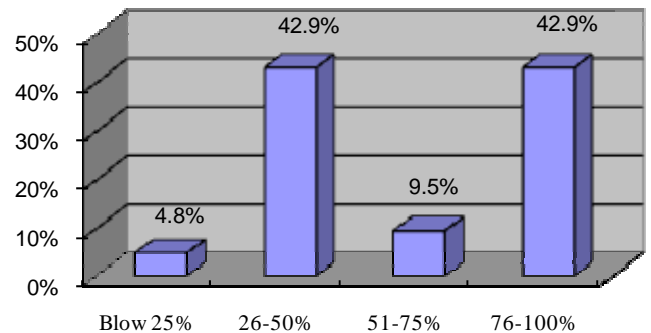


Figure 5: Percentage of staff with IT skills in companies surveyed

Figure 6 shows only 8.2% respondents are familiar with collaboration system. In other words, nearly nobody uses these collaboration technologies. But a few respondents have learned the systems, who will become main contributors to realize the applications of collaboration systems. This result indicates that collaboration systems are a fresh field in the Chinese construction industry.

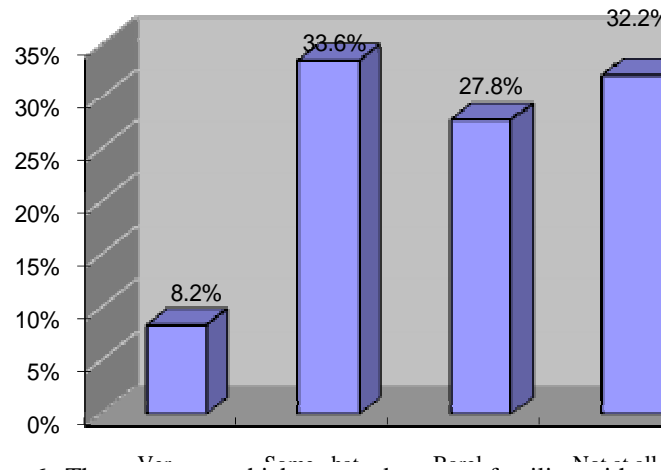


Figure 6: The extent to which respondents are familiar with collaboration systems

All of the respondents indicate that their companies provide Internets service and 88% of companies have their own Intranet. It explains that there is an excellent IT infrastructure in Chinese companies regardless of the connection of Internet or setting up Intranet. Furthermore, the facilities meet the requirement of actual work. These features mean that hardware will not become constraint of application of collaboration systems in China.

Table 1: Relative Indices of the construction unit and the architecture unit to collaboration technologies

Collaboration technologies	Respondents in architecture companies actual scores (%)	Respondents in construction companies actual scores (%)
1. Telephone	100	97
2. E-mail	76	73
3. Video conference	32	29
4. Groupware	32	36
5. Text Chat/ Instant Messaging	68	52
6. Document Management	52	77
7. Knowledge Management	44	48
8. Intranet	56	68
9. Virtual Reality	20	26
10. Project Management	44	72
11. CAD	100	84

From analysis of the results shown in the above Table 1, the following picture emerges:

- 1) With regards to various collaboration technologies, most respondents show that traditional communication ways, like CAD and e-mail, are still used frequently. It does not indicate that some technologies can involve the important work processes. For example, the majority of companies do not submit their tender files by way of e-mail. Therefore, most companies have not really touched the advanced collaboration systems.
- 2) Some expensive technologies, such as video-conference and virtual technologies are hardly used in China. Hence, the application of such technologies is a long-term strategy and should be realised step by step.
- 3) Some technologies, such as project management and document management, are used in relatively more frequency. When the issues are investigated deeply, some concepts are not understood. Document management in most companies is based on paper work, not electronic document. Project management only involves the use of some software relating to planning and estimating, therefore they work with themselves, and do not collaborate with partners. Collaboration systems will lose their advantages to a great extent. Construction companies do not establish a real collaborative work environment.

The ranking established from the survey for factors that inhibit the application of collaboration systems is in the following order: Organizational culture; lack of top management support; software constraints; lack of IT specialists; low IT literacy of

staff; cost exceeds benefit; hardware constraints; security of information.

The ranking established from the survey for the factors to support the application of collaboration systems is in the following order: Company policies; Government subsidies; IT budget; staff trainings; improved security on the Internet; WTO entry.

Through the survey, three aspects of information are obtained, namely the information problem in China, the current status of the application of collaboration system in Chinese construction companies, factors which affect its application. The collaboration systems in Chinese construction are still not common. Existing collaboration technologies can satisfy the demand of construction Chinese industry.

4.2 Results from Delhi Study

The major findings from the two rounds of Delphi study are:

External factors

1. The priority order of major stakeholders who influence the application of collaboration systems:
 - Client (funding from Government);
 - Client (funding from other source);
 - Contractors;
 - Architects, Engineers;
 - Construction Supervisors;
 - End users (customers);
 - Estate developers;
 - Quantity Surveyors; and
 - Suppliers.
2. The priority order of major stakeholders who contribute the application of collaboration systems:
 - Client (funding from Government);
 - Contractors;
 - Client (funding from other source);
 - Engineers;
 - Architects;
 - Construction Supervisors;
 - Quantity Surveyors;
 - Estate developers;
 - End user (customers); and
 - Suppliers.
3. The important factors which were being considered that need to be changed to support the application of collaboration systems by the panellist are:
 - Existing 'traditional' procurement system;
 - Relationship between the various functional groups on projects;

- Initiative of the client and Government in supporting the application of collaboration systems; and
- Necessary education to enhance practitioner's academic knowledge in respect to collaboration.

The less important factors needed change to support the use of collaboration systems

- Role of the Client in project leadership;
- Change the criteria to select the tender, based on the high value, not only low price;
- Change the labour-intensive nature of the construction industry; and
- Specific regulations should be set up to create a reasonable competition environment for collaboration development in the construction industry.

4. The panellists considered the following major factors as barriers to achieve the application of collaboration systems

- The low average level of the knowledge and skill of practitioners within the whole construction industry;
- Initiative of the Client and Government in supporting the application of collaboration systems;
- Insufficient research relating to collaboration systems within Chinese Universities and Academic Associations; and
- Lack of specialists within both construction and IT knowledge.

The minor factors considered as the barriers to achieve the application of collaboration systems

- Inadequate ordinances and legislations within the construction industry;

Internal factors

1. The following major factors considered as barriers for the application of collaboration systems are:

- Lack of understanding of the systems and confidence in the systems;
- Traditional company structure; and
- High cost of collaboration technologies.

2. The minor factors considered as barriers within companies to achieve the application of collaboration systems:

- Unclear of the benefits from the collaboration systems by the leadership
- Low level of IT literacy

3. Some important measures which should be considered by panellists when utilising the collaboration systems within companies:

- Appoint a competent information co-ordinator;

- Carry out effective training to improve staff ability to use advanced management software;
- Set up a project database;
- Establish effective company structure to smooth the barrier between different sections; and
- Conduct overall analysis of strengths weaknesses, opportunities and threats for the company from the use of collaboration systems.

4. Some measures which can be ignored

- Develop policies to change the attitude of employees (they are expected to be more open in their attitude towards the used of collaboration technologies); and
- Provide some opportunities to visit foreign construction companies.

IT factors

Some IT issues should be significantly considered:

- The coverage area of Internet through wired connection;
- The security of current Internet service;
- The differences in project procedure between the West and China mean the mature collaboration technologies will be difficult to use in China; and
- Less related software are being developed and implemented in Chinese companies.

Measures to support the use of collaboration systems

- Top manager support. In China, state-owned companies cover 90% of GDP in the construction industry. As the top management is not the true owner of those enterprises, they therefore lack true incentives to usher any innovative systems in their organizations, i.e. in the bottom of their hearts, they are very conservative. Thus, in terms of inner sides of any organization, leadership issue should be a priority. The core of leadership is to deal with crisis and adapt to external change in this area. Without leadership, any bespoke training and new systems will not be used.
- Foreign competitors. As more and more foreign companies step into the Chinese market, there will be competitors for those Chinese companies, which will force them to adopt some advanced IT technology in construction. Otherwise, the market share of those companies will be shrunk day after day.
- Government and Client support. Government and Client involvement should be an effective propeller at the current stage in China. To seek

a close corporation with those agencies in China, would be a short cut to revolutionizing this technique in China.

- Improve construction culture. The present Chinese construction market is not a totally fair competitive market that will limit the use and effect of collaboration systems.
- The appropriate application strategy. China has its own characteristics. The low labour cost is an advantage of China. At present, the trend has not and will not continue to change in a considerably long period. So if the application of collaboration systems will increase the expense which may not bring obvious benefits to the company, the system will not attract any companies, no matter how advanced it is. Therefore, the process of using the systems needs a proper sequence.

Government policies and activities

- Set up a bidding policy which stipulates that this technology must be used by any prospective bidder, being compulsory.
- Improve existing infrastructure of IT in China.
- Set up policy stipulating that computer skill certificate will become a necessarily for any staff working at the site.
- Add IT item in any BOQ to any bidding document.
- Change low cost orientation in bidding management to value for money orientation
- Government should standardize the market and develop corresponding regulations to encourage the use of this system.

5 DISCUSSIONS

This section summarises the results from pervious surveys and proposed some useful measures to facilitate the application of collaboration systems in Chinese construction industry.

5.1 *Results from PEST and SWOT analysis*

In order to explain these results in systematic fashion, the PEST and SWOT tool are used (Lynch, 2000). By the way of PEST analysis, it is planned to obtain an up-to-date and holistic view of the state of IT operation in Chinese construction. Then the strengths, weaknesses, opportunities and threats facing the Chinese construction organizations are identified when implementing collaboration systems.

Policies

1. From four aspects, the current Government policy about science and technology systems is stated, namely: change the mode of investing science and technology systems, encourage the enterprise and non-Governmental institutions to explore new technologies, regard the technologies as commodities and transfer the research results to the market as soon as possible.

2. The objective for the further IT development in construction (Ministry of Construction 1996) was put forward. To achieve the objective, four main missions were worked out. They are to develop new construction technologies, to transform and popularise research results, to encourage enterprise to advance technical progress and to strengthen international science and technology co-operation.

Economic

Firstly, many statistics show that the construction industry plays a key role in Chinese national economy and there is rapid development in recent years.

The trend of Chinese construction further stated in the further, this is

- Enforce infrastructure construction, such as energy, transportation
- Add housing construction
- Enforce construction of cities and towns
- Encourage foreign construction companies to enter China

Sociocultural

In this part, the current Chinese construction situation is stated from two aspects, namely, construction culture and construction education

Some factors about construction culture were identified (Pheng & Leong, 2000):

- Between participants in the project, trust and mutual respect is important;
- Family businesses are still very dominant in China and there is a heavy reliance on family contacts both locally and internationally;
- There are a lot of difference project standard between China and foreign;
- In China, many people pay more attention to financial issues relating to projects, rather than value;
- Bureaucracy and bribery are still prevalent in China. There is no exception in the construction market.

Within the regard to construction education, an important characteristic is that employees in construction industry are not sufficient educated at large. In order to popularise new technology, training will take more effort.

Technological

Technology transfer and High-Tech R&D are considered as two main issues in this technological aspect.

On the one hand, the overall status on technology transfer in China was reviewed. Then to encourage technology to be transferred from foreign, the Government and organisation should adopt some activities, such as: organisation reform, openness policy, targeted fields, industry-education co-operation, technology exchange service, State financial support, tax preference and so on.

On the other hand, the development of collaboration system has entered into the mature period in the Western, but based on special situations within Chinese construction, how to full use these technologies in China is a huge challenge. Therefore Chinese Government should attract foreign-funded, high-tech R&D investment to help the Chinese construction counterpart to do further research in this field. Some features are listed to facilitate foreign R&D investment.

Strengths

There are two advantages to applying the collaboration system in Chinese construction companies. One is the rapid development within the telecommunications industry, which makes some companies set up a excellent communication system, for instance, Internet connection. These provide basic preparation to popularise the collaboration systems. Another is huge demand for the application of advance technology in construction; these are proved from the policy issued by Chinese Government. These two factors will enhance the companies' confidence in using successfully collaboration systems.

Weaknesses

In the traditional Chinese construction company, some factors still inhibit adopting some advance technologies:

- The traditional management style does not adapt the development of collaboration systems;
- There is a lack of support from top Managers;
- Some information technologies do not execute their maximum advantages under the current office management;
- There are significantly insufficient specialists with both construction and IT knowledge;
- There is not a set of regulations to make information be systematic and standardised.
- There existence of the resistances from employee facing change.

Opportunities

Owing to the rapid development of Chinese economy, there are a lot of great opportunities to be created.

Firstly, with many world class projects built during 2008 Summer Olympics, Chinese constructors co-operated with their foreign counter partners. As a result, some new technologies and management style, including collaboration systems have been imported into China.

Secondly, WTO entry requires the Chinese construction market to be further opened, vice versa. This will provide opportunities to touch some innovative technologies and learn from foreign counterparts.

Thirdly, under the 'Go West Strategy', the initial objective is adding the infrastructure construction, such as railways, roads, and electronic power plants. Therefore Government will add the investment in construction industry. As a result, this is an effective solution to the Chinese construction recession in recent years.

Finally, with more foreign investment into China and joint ventures between Chinese and foreign construction firms, collaboration systems are introducing into China.

Threats

WTO entry provides some opportunities, but brings challenges to Chinese construction organisations as well. Foreign companies may have some negative impacts upon Chinese companies that have a lot of problems.

On the other hand, many construction companies lack of the confidence in obtaining the benefits of new technology investment thus reject spending more money and humans adopting them. Consequently, the ability of competition with foreign enterprise is reduced.

5.2 Implementation strategy

5.2.1 Strategy for development

Based on the above the PEST and SWOT analysis, a strategy is designed to facilitate the application of collaboration systems within the Chinese construction industry. The strategy divides into the following four parts:

- It will be essential for relevant Government departments to prepare strategies for collaboration systems in the construction industry;
- It will promote the awareness of commercial benefits of IT among managers in construction

companies in China and encourage them to seriously consider collaboration systems in their business;

- The research will also increase the competence and confidence in applying IT by local companies by providing management guidance on the selection and development of collaboration systems applications; and
- It will be greatly beneficial to the teaching and further research of construct IT in all organisations involved in the field of education in China.

5.2.2 Strategy executed

To achieve all the objectives, some measures must be taken from Government and construction companies.

Government should do the following:

- To establish an index system to evaluate progress in construction;
- To transform the function of the Government and increase the ability to self-managed;
- To establish an intermediaries market to service technological improvement;
- To learn from some useful policies of importing advanced technologies in other developing counties;
- To adjust the present policy of importing technologies in order to favors software technology in the form of license, consultation, management etc, and rely less on hardware in the form of equipment imports.

Construction companies should do the following:

- Company restructures. This is to deepen the process of enterprise reform. Experience shows that only when enterprises become fully independent economic entities, responsible for their profits and losses, will they be cautious in implementing policies and responsible for the risks and benefits in their operations. These are the basic foundations for success in technological improvement. It can be realized through establishing modern corporations, clarifying property rights, separating ownership from management rights, and nurturing a group of entrepreneurs.
- The principles of importing advance technologies. Instead of building new plants, emphasis should be placed on rehabilitating and improving existing factories. The interest should be away from importing technology that is incorporated into equipment and toward the importation of technology know-how, a shift which Chinese commentators have characterized as a move from “hardware” to “software”, or from “eggs” to “hens”. Finally, the level of transfer

should be shifted from assimilation to adaptation and development. This requires recipient firms to possess capabilities for problem identification and solving on their own initiative. These capabilities can be developed through the cumulative effects of technology and teamwork among the firms

On the other hand, within any companies, financial matters will be consideration than other issues when investing collaboration system. An investment modelling illustrates some potential investment and return when a company draws out of the investment scheme of collaboration systems (Figure 7).

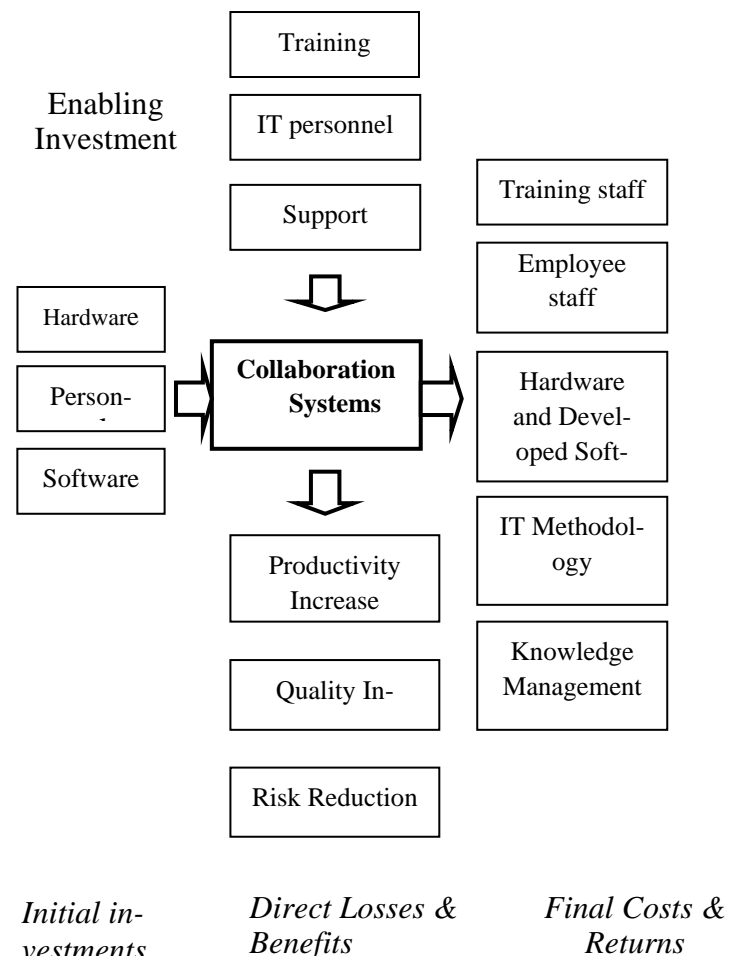


Figure 7 Collaboration Systems Inputs and Outputs (Venkatraman 1997)

6 CONCLUSIONS AND RECOMMENDATIONS

To date, collaboration systems have made little impact on the construction and property industry in China. It is envisaged that findings of this research will provide essential information for the Government to prepare relevant policies regarding the applications of collaboration systems within the construction and property industry in China. It will also contribute in bridging the gap between researchers and developers on the one hand and building industry professionals and practitioners on the other.

The success of collaboration systems applications to a large extent relies on the industry's attitude towards IT. The rapid growth of personal computing may soon bring about a significant change in the industry's attitude towards IT. Given the competitive nature of the construction and property industry in China, we must do whatever we can to make the most from IT as business needs and technology change, and to make IT a strategic contributor to the success of our business.

The research focussed on the fundamental aspect of implementing collaboration systems within the Chinese construction industry. Collaboration systems are a relatively new technology in construction industry. This is especially true from an organisational aspect. As a result from the current work undertaken it is recommended here that further research effort is undertaken in the following areas:

- The implementation of collaboration system requires the across-function team. This may raise some issues relating to the basic component and characteristic of the team.
- The implementation of collaboration systems is difficult to achieve on the traditional platform of procurement. Despite some literatures showing D&B and Partnering as a suitable platform to initiate collaboration systems implementation in construction, it requires many amendments. Therefore it is recommended that a research effort to investigate the required changes be made to the existing D&B or Project Management procurement approach to suit their application as a platform to implement collaboration systems in construction.
- The studies undertaken in this research have used samples from the constructor and designer group of respondents. It is recommended that further research made to include the respondents from other key areas such as the Government, Clients, the key supply to assess the environment of developing the collaboration systems.
- With rapid development of information technology, the collaboration systems always keep changing as well. It is recommended that further study to explore next-generation collaboration systems based on new information technologies, such as 3G Wireless technologies and Semantic Web technologies.
- The framework in this dissertation puts forward many suggestions and aims, such as Government policy and company restructuring. The aims cannot be realized in one step. Therefore, further research should design schemes which divide aims into different specific objectives in conjunction with the Chinese industry. For ex-

ample, the regulation of WTO illustrates that the Chinese construction market will open to the world step by step in the coming five years.

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