STRATEGIC ADOPTION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT): CASE STUDIES OF CONSTRUCTION CONTRACTORS

Vachara Peansupap[1] and Derek H. T. Walker

Cooperative Research Centre for Construction Innovation, RMIT University, Faculty of Business, Melbourne, Australia

Although the benefits from using information and communication technology (ICT) in construction processes is well known, construction companies are still slow in its adoption. One explanation of this trend in slow innovation adoption may be lack of innovation diffusion experience by senior managers who decide whether to be early or late ICT adopters. There is no easy answer to the question why this may be the case. Early adopters have to accept high risks due to uncertainties associated with adopting innovation whereas late adopters may lose any competitive advantage benefits through falling behind with offering novel services. Further, few practical case studies have been published on strategic ICT adoption by construction organisations. This paper aims to increase the understanding of the nature of early and late adopters of ICT and identify risks that may occur. Data from three case studies of large construction contractors' adoption of ICT indicates that construction contractors should be aware of early adoption of ICT risks, particularly if it requires commitment from external project participants. The paper also exposes issues that organisations should consider when adopting strategic ICT.

Keywords: adoption decision, strategic adoption, information technology .

INTRODUCTION

Many research studies have established the nature of benefits derived from using ICT in construction processes. For example, a study by Tam (1999) on the development of total information transfer system for project management, demonstrates that the use of such systems can save considerable time and cost for document transfer. Secondly, ICT applications can help improve project planning and scheduling and cost control (Abudayyeh *et al.* 2001, Sriprasert and Dawood 2002) Thirdly, ICT can improve data base distribution by use of a web-based electronic document management system (EDMS)—all documents can be stored in central database and be accessed from other locations (Björk 2002). Also, ICT can support the concept of information integration among construction process that helps to reduce errors from data re-entry and support real time construction project monitoring (Björk 1999, Anumba 2000).

Although the benefits of ICT use are well recognised, its adoption as a normal part of construction practice still faces barriers. A commonly assumed adoption barrier is the limited investment in ICT by the construction industry in general (Love et al. 2001). Specifically though, recent case study reviews by Björk (2002) illustrate that technical problems and the cost of using ICT systems only have limited influence in adopting

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[1] vachara.peansupap@rmit.edu.au

online document management systems. Also, an important barrier recently identified by (Love *et al.* 2001, Songer, Young and Davis 2001) is that many construction practitioners do not appear to have enough experience in understanding organisational and social issues of strategic ICT adoption. If strategic ICT adoption is effectively pursued, then this could counter barriers of limited funding for across-company deployment with organisations gradually investing in ICT to fit their financial constraints. We conclude that is useful to explore and better understand the experience of strategic ICT adoption through selected case studies of construction companies.

NEED FOR STRATEGIC ICT ADOPTION IN CONSTRUCTION

A deficiency in experience of strategic ICT adoption may cause several problems. First, it may result in a slow adoption decision of ICT by construction organisations because they are unsure how to begin this process (Abs 2001, Acif 2002). This in turn may result in loss of competitive advantage through ICT use. Second, unplanned ICT adoption may cause several continuing problems during the ICT implementation stage relating to organisational and individual facets. These include a slow and ineffective diffusion rate of ICT by potential users within an organisation, experience of technical problems, and a lack of clarity of the benefits of ICT use (Songer, Young and Davis 2001). Finally, improper adoption of ICT may result in a negative perception towards ICT use among expected users and lead them towards resistance to its adoption (Davis and Songer 2002). As a result, an organisation that lacks a coherent strategic adoption policy may obtain little benefit from ICT investment.

In this paper, we focus upon the strategic and tactical adoption of ICT adoption into organisations rather than ICT adoption criteria. It should be clear that strategic ICT *adoption* differs from strategic ICT *planning*. Strategic ICT planning is focused upon the long-term plan for ICT application use that supports the vision of the core business delivery strategy linking to an information system (IS) strategy that maintains competitive advantage (Björnsson and Lundegård 1993). For example Björnsson & Lundegård (1993) found that (based on a study of three European construction firms) there are two possible strategies of IS use to gain competitive advantage. These are the cost reduction strategy and a differentiate strategy identified by (Porter 1985). A cost reduction strategy emphasises using technology to improve productivity or process improvement to reduce cost. A differentiation strategy stresses creating a new product or service that opens up new business or service delivery opportunities. Therefore, the selection of appropriate strategic ICT planning policy will help organisations to select the suitable ICT application for supporting a business competitive advantage.

Not only does successful ICT adoption require detailed strategic ICT planning but it also needs a matching ICT adoption strategy. Strategic ICT *adoption* refers to the ICT application adoption approach within an organisation. An ICT adoption strategy contains sub-processes, in which an organisation starts to become aware of, searches for, selects, and finally decides to adopt the ICT initiative. One potential problem is that the organisation can start to become aware of ICT benefits but is reluctant to adopt and invest in it. From the organisation's viewpoint, early adopters may be taking an unacceptable risk due to adoption uncertainties (Mitropoulos and Tatum 1999) while late adopters may lose competitive advantage benefits through offering novel services because they join the many offering those benefits (Love et al. 2001).

Other reasons reinforce the need for an effective ICT adoption strategy. First, ICT characteristics are different from many other information technology (IT) applications.

ICT packages provide general-use communication and collaboration software for all team members whereas engineering design applications such as computer-aided design (CAD) or engineering computational software is generally used by a small group of specialists. Second, ICT is characterised as being a communication technology that connects a wide range of users rather than individuals in stand-alone IT applications for specialists. Therefore, these diverse application types need different adoption strategies based on the way that users interact and communicate. Also, Markus (1987) found that communication technology success requires a large number of adopters feeling comfortable with applications before benefits of using ICT reached a *critical mass*. Thirdly, while there have many strategic IT adoption studies in the computer science literature, only a few have been undertaken on adopting ICT in the construction industry. This paucity of construction industry examples means that to better understand the adoption processes in the construction industry context, more construction organisations studies of strategic ICT adoption are required.

STRATEGIC ADOPTION OF ICT IN CONSTRUCTION

Most technological adoption studies focus upon adoption decision-making in the technological innovation diffusion process (Mitropoulos and Tatum 1999, 2000). These studies explored criteria forcing an organisation's adoption of new information technologies such as 3D-CAD and EDMS—it was concluded that the criteria are: a perceived need for competitive advantage; external requirements; technological opportunity; and finding solutions to process problems. They note that organisations tend to be early adopters when driven by competitive advantage or internal problem-solving process. They also discovered that an external requirement such as a client's needs does not significantly influence early adoption. Finally, technological opportunity appears to have low impact on early adoption due to the high cost of technology and lack of required skills. Thus, the early adoption decision may be most significantly influenced by competitive advantage or need to solve process problems.

Few recent studies have been focused on strategic adoption of ICT by construction firms. For example, a recent study of web-based project management implementation by Skibniewski & Abduh (2000) found that there are two strategies for adopting web-based project management. These strategic adoptions are an *in-house development* and *outsourcing* depending upon the level of internal systems and resources that support the main organisational functions. The former strategic adoption is suitable for sufficient resources to implement and the later strategic adoption is suitable for less and technical resources for development and maintenance.

Whyte & Bouchlaghem (2002) found that from the top 20 house-building companies in the UK there was only one company that presents the early adoption of virtual reality (VR) system. They reviewed the strategic adoption of VR system and categorised its implementation approach into *strategic* and *ad hoc*. The *strategic* approach considers software introduction based on long-term corporate strategy. The development of software involves top management support, user involvement, and a software developer. On the other hand, the *ad hoc* approach was developed on a sub-strategy that depends on a special department's needs. Under this approach, introduction of software is needed to support middle manager rather than top management. We can conclude that although strategic adoption can be classified as 'early adoption', the organisation may still choose an *ad hoc* VR adoption approach.

Mitropoulos & Tatum (2000) argued that strategic IT adoption behaviour may depend upon organisational innovativeness. Similar to Rogers (1995), they founded that organisational innovativeness relied on variables such as leader characteristics, internal characteristics of organisational structure and external characteristics of organisational structure. Although these characteristics influence an adoption decision, it can be argued that these variables are hard to change and can only be used to measure organisational innovativeness (Ginzberg 1981). Thus, research could focus upon the strategic management of IT adoption and implementation.

Strategic ICT adoption should be undertaken to facilitate greater understanding of the nature of early and late adoption. However, an adoption strategy may differ due to organisational innovativeness. For example, Mitropoulos & Tatum (2000) also found that contractors who have low innovative or technological capability will display a reactive attitude to IT adoption. Therefore, case studies should focus on leading construction organisations that have similar innovativeness instead of studying small-medium size construction organisations. The next section will highlight the findings of three cases of large Australian construction contractors with ICT adoption experience.

RESEARCH METHODOLOGY

According to Neuman (1997), case study qualitative research can be categorised as: exploratory, descriptive, and explanatory. To explore the nature of strategic ICT adoption, we chose a descriptive case study approach to obtain rich information from the participant's experience. Multiple sources of data can help us understand what was happening as well as how and why it followed a particular trajectory (Yin 1994). Data collection started with discussions with senior IT managers to understand the strategic adoption of ICT applications at the organisational level.

Our research project investigated the ICT adoption and diffusion practices of three top-tier Australian construction contractors from a population of 13 similar companies that managed projects of AUD$00's millions with annual turnovers exceeding AUD$500 millions during year 2001. We selected these three on the basis of availability and the opportunity to conduct interviews utilising an interview instrument designed with reference to the components from research phase 1 (Peansupap et al. 2003). Semi-structured, face-to-face interviews were conducted with a key ICT innovation champion from each organisation. We followed these interviews with the ICT implementer or ICT manager involve in rolling out the ICT application at the group or individual level. Finally, we conducted seminars to gain feedback and to validate our findings and conclusions.

FINDINGS OF CASE STUDY ON ICT ADOPTION

From the interview, three case studies show the different strategies of ICT adoption. Case study A (CA) and case study B (CB) are examples of proactive strategy in ICT adoption whereas case study C (CC) represents a reactive strategy in ICT adoption. Each case will be analysed as follows: the purpose of ICT use, the type of potential adopters/users, the ICT initiative sponsor, the adoption direction, the force behind the adoption decision, the ICT adoption approach, and the ICT adoption strategy. Table 1 provides summary ICT adoption findings within these three construction contractors.

Three case studies (CA, CB, and CC) show the similarities on adoption purposes. These purposes are to improve quality assurance of construction project document, to

help communication and coordination both within and between project teams, and to enhance information accessibility and provide a single source of information.

Table 1: Nature of ICT adoption and diffusion at organisation

Nature of ICT adoption	Case A	Case B	Case C
Purpose of ICT use			
- Underline quality assurance policy by using ICT to manage construction project document	√	√	√
- Help communication and coordination both *within* and *between* project teams	√	√	√
- Improve information accessibility and provide a single source of information	√	√	√
Potential adopters/users			
- Internal staff	√	√	√
- External project participants	-	√	√
ICT initiative Sponsor			
- Support from regional senior managers, quality managers and IT people. This group initiates the adoption of ICT.	√		
- Support from e-business group forming expertise and IT people. This group initiates the adoption of ICT.		√	
- Group of e-business unit built the technological community of practice that has the role to explore and initiate ICT adoption.			√
Adoption direction			
- Top-down and a task-oriented team	√	√	
- Top-down and a strategic community alliance			√
Force behind the adoption decision			
- Demand *pull*	√	√	√
- Technology *push*	√	√	√
ICT adoption approach			.
- Develop in-house ICT development			
• *Program a user interface based on a commercial software database environment*	√		
• *Design application's user-interface in which it is connected to a commercial software database*		√	
- Adopt external ICT product/service. It was selected to use external web-based project management service.			√
ICT adoption strategy			
- The strategic adoption of ICT is classified as the proactive because organisation develops own ICT application to support their need because there was no readily available ICT application at that time.	√	√	
- The strategic adoption of ICT is classified as reactive because its current ICT use is part of a strategy for preparing staff to adopt a next generation industrial ICT platform.			√
Adoption decision			
- The adoption decision is obtained by senior management commitment to invest in ICT system.	√	√	
- The organisation developed ICT decentralisation adoption by suggesting and analysing suitable ICT application for project use.			√

For potential adopters, CA's system is focused more on internal staff only whereas CB and CC are more focused on both internal staff and external project participants. As the focus of potential users from CB and CC involves both internal and external

project participants, it should gain greater commitment of ICT use from both groups otherwise the adoption and use of ICT may be inhibited because of a confused mixture of communications in both electronic and paper form. As a result, the internal adoption of ICT by the main contractor may seem successful but its involvement with other project participants indicated a resistance to the use of ICT. This may cause slow ICT adoption and diffusion by a main contractor who needs to be an early adopter.

As main contractors need to gain competitive advantage, early adopters need sponsors who can initiate and support ICT adoption. The adoption of ICT usually starts from commitment from both senior managers and IT specialists. ICT use needs a shared understanding of both practical construction processes and ICT technical knowledge to identify possible application to manage and reinforce current processes. In addition, the development of ICT needs financial support from senior managers. Sponsors in CA and CB consist of senior managers, quality manager and IT people (indicating a top-down influence direction). In CC, the e-business manager has the main role in building a core strategy and technological community of practice (COP) and then persuaded middle managers and site engineers to use ICT (top-down direction as well as a COP). It should be said that the use of COP helped develop commitment throughout top managers and middle managers in CC.

The force behind ICT adoption in CA is similar to CB. In CA and CB, both demand-pull and technology-push forces trigger adoption of ICT. They seek solutions to particular problems (demand pulling supply) or ICT suppliers may 'sell' a technology solution for a generic problem (technology pushing demand). On the other hand, the force of ICT adoption in CC is a technology-push influence rather than demand-pull.

The ICT adoption approach of CA is to select an in-house ICT development strategy. The development of software was based on a commercial software database in which IT programmers can customise the interface to suit the organisation's needs. This was slightly different from CA, CB that adopts an in-house ICT development strategy but they developed web programming that interfaces with a commercial software database. On the other hand, CC chose to outsource by adopting an external ICT product/service. CC chose to use an external web-based project management service.

The ICT adoption strategy of CA and CB is classified as proactive because these organisations develop an ICT application to support their own needs because there was no readily available ICT application at that time. The strategic adoption of ICT in CC is classified as reactive because its current ICT use is part of a strategy for preparing staff to adopt a next generation industrial ICT platform.

Finally, the adoption decision in CA and CB is obtained through senior management commitment to invest in ICT systems. CC developed ICT decentralisation adoption by suggesting and analysing suitable ICT application for project use.

INTERPRETIVE CASE STUDY ANALYSIS

As construction organisations typically do not have sufficient experience in strategic ICT adoption, this case study of ICT within three large construction organisations may be useful in providing an understanding of how an organisation strategically plans to adopt and diffuse ICT. Due to the limitation of space, this analysis is focused only on strategic ICT adoption.

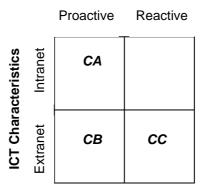**Strategies for ICT adoption (Proactive/Reactive)**
From the case studies, CA and CB show proactive strategic ICT adoption whereas CC demonstrates a reactive strategic ICT adoption.

CA involved the development of an in-house groupware application that supported internal construction processes such as tendering, project and a project history package. Two reasons for developing ICT were that (1) the organisation was expected to gain competitive advantages from early adoption of ICT and (2) other off-the-shelf ICT applications at that time lacked functions that supported the organisational needs.

Similarly, CB involved the development of an in-house collaboration system. The ICT system was a web-based document application that supported project collaboration and document exchange. The e-business group in CB decided to invest in the development of its own ICT application because CB expected to gain an advantage from using ICT for communication, collaboration and quality assurance. Furthermore, CB intended that other project team participants would use the system.

CC showed late strategic ICT adoption using web-based document management. For instance, CC adopted an external web-based document service rather than develop an in-house ICT application. Interviewees mentioned that adoption of this ICT involved two trial pilots before moving to the diffusion of this application throughout the organisation. The senior IT manager stated that adopting this ICT later was due to an industrial standard web-based document management not being available at that time. As a result, the organisation intended to use current ICT as the antecedent if adopting an industry standard web-based document management at a future time.

From the three case studies, we conclude that there is a direct relationship between the characteristics of ICT and its strategic adoption. In general, when construction organisations seek to gain a competitive advantage from early ICT adoption, they tend to choose a proactive strategy. By using this strategy, organisations are required to commit to investing in developing their own ICT application because during this early period, off-the-shelf ICT product may provide fewer functions than the organisation needs. As a result, a proactive strategy should be carefully used, especially when this applies to extranet application platforms that depend on the adoption by both internal staff and users from other organisations. In other words, the adoption of an extranet application platform is far more complex than adopting an intranet application platform because the adoption involves both internal and external factors.

Figure 1: Relationship between strategic adoption and ICT characteristics

External factors appear to have less influenced upon the use of proactive strategic adoption of intranet ICT application. For example, CA provides an example of proactive ICT adoption strategy—using an intranet ICT platform. Most respondents had a positive perception of their ICT use. Respondents also believed that their use of ICT increased the competency of their company. For example, they also used it as a document management system for all document communication on the construction projects. Many respondents used it extensively to manage their 'requests for information' (RFIs). When they received the RFI response, they would input reference information such as received date and document number that they could use to refer back to hard copy forms of this information. Some respondents in their head office scanned hard copies of documents and stored them in the system.

Their proactive strategic adoption of the ICT intranet may have confronted them with fewer problems because users felt that it could be used as an internal document communication and management tool. Despite some limitations perceived by subcontractors who did not use the intranet, CA users did not recognise this as a significant ICT application barrier. More importantly, the intranet application was designed to fit in with the internal professional user's needs and organisational procedures. For example, respondents mentioned that ICT was compatible with the work process in which they could correspond through a template such as fax, memo, RFI, letter etc. Thus, all correspondence could be created and stored in the system so that they could send it through ICT or print it and fax to other construction project participants. Finally, as the Intranet ICT application was developed for intra-organisational use, the users could receive full support from their organisation such as Internet access or computer. The above evidence suggests that external factors have limited influence on the development of a proactive strategy of ICT adoption in construction companies.

CC shows a successful example of using a reactive strategic adoption. The company used an extranet ICT platform that was serviced by an outside company (outsourced). This organisation intentionally used this strategy because it expected that future industrial ICT platforms would be the next generation of document management systems in which everybody had the same platform of document management. Thus, the organisation intended to use the current ICT application service as a pilot project to prepare its staff rather than developing its own system—this was a strategic action.

Thus a reactive adoption strategic may be suitable for an extranet ICT application platform because the extranet application involves a commitment from both internal and external multiple users. However, a proactive ICT adoption strategy may be difficult to be successful and requires many resources to provide internal and external staff. In addition to the development of an ICT extranet application to be functioning, the readiness of other construction project participants is required. It is necessarily to provide top management resources and may also involve the full benefits of the ICT application to require uncontrollable external factors for its adoption by project-external participants to drive the organisation into an ICT adoption proactive strategy.

POSSIBLE RISKS FROM EARLY ADOPTION

This section focuses on possible risk that may occur from early adoption. From the above section, the nature of adoption may be categorised into a proactive strategy (early adopter position) and reactive strategy (later adoption position). The case study

findings reported here also highlight the risk that may occur due to the selection of an early adopter strategy—possible risks are discussed as below.

Technological Readiness and Standardization
In an early adoption phase, technology infrastructure development uncertainty may be a significant risk, especially if the organisation decides to develop their ICT system. The early adopter may select the incorrect software technology that may be replaced with a more effective one. In addition, the early adopter may be faced with a nascent technological infrastructure, for example, a slow bandwidth for Internet connection with associated high hardware and software costs.

The development of ICT should include import and export functions that are compatible with thestandard of information exchange such as *Standard for the Exchange of Product model data* (STEP), *Industry Foundation Classes* (IFCs). This standard facilitates interoperability—different ICT systems communicating and exchanging information between organisations and data formats. Without standard communication standards, each organisation independently develops their own system and finds difficulty in communicating and transferring information between systems.

Ownership Barrier
From the contractor's viewpoint, the issue of ownership may influence the early adoption of ICT into the organisation. The introduction of ICT into the project participants may be a very difficult process. Problems may be created if project participants have their own traditional ICT standards and systems, they may not want to use the lead contractor's ICT platform. Other project participants may be forced to enter information into both their and other ICT systems resulting in wasted time.

Industrial Culture Barrier
Conceptually, ICT was designed to help communication and coordination within and between project teams. The effective use of ICT needs commitment from all project participants. Otherwise, organizations that communicate electronically through ICT would need to send the documents in the traditional way with organization that did not use ICT while also communicate using the lead contractor's ICT platform. This may trigger a risk to early ICT innovation adoption that needs to gain benefits from its use.

Critical Mass Influence Effect
The success of ICT requires a critical mass of adopters; organisations that are not early adopters may be faced with a critical mass influence risk. First, some may wait for ICT use benefits. Second, organisations may not have experienced staff to cope with supporting this new technology. Therefore, this situation is similar to a 'chicken or egg' situation because adoption reluctance of the late adopter may create a critical mass risk to the early adopter who attempts to introduce the new ICT system.

CONCLUSIONS AND LIMITATIONS

This paper aimed to increase understanding of early and later ICT adoption and to identify associated risks. The data from three case studies of large construction contractors shows that construction contractors should be aware of risks of being an ICT early adopter, especially if it requires commitment and participation from external project team members. This paper also discusses issues that organisation should be aware of in strategic ICT adoption. As the case studies are focused upon leading

construction organisations, further research on strategic adoption should be undertaken to compare this group with small-medium construction organisations.

Further, this research is limited to a snapshot view of these organisations from a technology strategy point of view and therefore, in terms of wider implications of general business performance such as market share, share price increase or other performance measures of business success, it would not be appropriate to generalise these findings to imply a causal affect upon business performance. It would be of value for expected leading indicators of management strategy such as level of pro-activeness or re-activeness to be studies in terms of general business performance such as has been undertaken in the Banking sector (Lloyd-Walker 1999) or for how ICT strategy interacts with strategic initiative relating to leadership and human resource management (Walker et al 2005). The interplay between ICT strategy and other management initiatives is complex and was considered beyond the scope of this paper.

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