

THE CURRENT STATE OF INFORMATION AND COMMUNICATION TECHNOLOGY USAGE BY SMALL AND MEDIUM TAIWANESE CONSTRUCTION COMPANIES

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SUMMARY: *Information and Communication Technology (ICT) is helping the construction industry communicate better and has the potential to change the industry beyond recognition. This paper reports on the findings obtained from a questionnaire survey conducted between April 2008 and June 2008, with contributions received from 51 organisations representing small and medium Taiwanese construction companies. The results indicate that a reasonable ICT investment is considered to be one which is less than TWD 1 million (roughly less than 0.1% of the respondents' annual turnover). It was also revealed that the three most useful ICT applications in improving the effectiveness of construction management in the Taiwanese construction industry are; Accounting, Computer-Aided Design and Drawing (CAD) and Financial Management.*

KEYWORDS: *Construction Management, Information and Communication Technology, Small and Medium Company*

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1. INTRODUCTION

Construction in Taiwan is one of the pillars of the domestic economy. The industry in its widest sense achieved an output of some Taiwan Dollar (TWD) 469 billion (14.3 billion US dollars) in 2004, equivalent to roughly 5-6% of GDP (Gross Domestic Product). In spite of a slow-down in the rate of increase of productivity, the construction industry remains the largest sector in terms of employment, providing jobs for 229,000 people in 2004 (Ministry of Interior, MOI, 2004). It also involves a very large number of small to medium sized enterprises (SMEs). MOI figures show that of the 13,012 construction companies in 2004, 95% have less than 50 employees, and 60% have less than 9.

The industry has become more liberal since the economy's membership of the World Trade Organisation (WTO) in 2002. The Public Construction Committee (PCC, 2003) report 'Yearly Report of Public Construction', indicated that the Taiwanese government's procurement market is worth more than TWD 200 billion (equivalent to 6.37 billion US dollars). It would also be opened up to the outside world and that the government procurement markets of other Government Procurement Agreement (GPA) signatories throughout the world with a total value of more than TWD 6.8 trillion (0.22 trillion US dollars), would be opened up to Taiwanese construction companies.

To grasp these opportunities, the PCC formulated a draft of the 'Program for Strengthening the International Competitiveness of the Taiwanese Construction Industry'. It is expected to bring about the establishment of a superior industrial environment, improve the industry's innovation and research and development (R&D) capabilities, promote sustainable operation and development, indicate international market trends and potential

competition, reinforce the industrial structure, and enhance the competitiveness of the construction industry. However, the Taiwanese construction industry is very challenging, due to the labour shortages, lack of transport links with China and heavy concentration, with the top 25 contractors controlling nearly 80% of the industry (Business Monitor International, BMI, 2008). In addition, potential price hikes of materials such as steel bars, sand and gravel are also a cause for concern as this would lead to an increase in the overall construction costs. Transport-related infrastructure has seen intense activity, with around US\$18bn being spent on the ongoing Municipal Rapid Transit (MRT) project in Taipei and surrounding regions over the past few years (BMI, 2008). The industry is expected to get a boost from the six-year Challenge 2008 Development Programme, which involves an investment of about US\$75bn for the construction of new research facilities and infrastructure. According to the BMI (2008) report *'The Taiwan Infrastructure Report 2008'*, forecasts that the Taiwanese construction industry will grow at an average of 2.91% over the 2008-2012 period. To improve communication, competitiveness and productivity within the construction industry, the Taiwanese government has placed a great deal of emphasis on the use of ICT as one of the main tools to help support the design and construction processes, and improve its quality and effectiveness. A national implementation strategy of ICT in the construction industry has been developed by the PCC (2003). The Construct ICT strategy has three main visions:

1. Encouraging improved sharing of information through the use of an integrated project communications framework based upon a project databases;
2. Developing an industry-wide knowledge base to facilitate improved on-line access and sharing of information between industry and project teams;
3. Using IT to improve specific elements of the construction process, including the better capture and appraisal of client requirements, integration of design and analysis activities and better supply chain integration.

Although some construction companies are using ICT, in varying degrees, recent criticisms have indicated that the level of ICT usage in the construction industry is still very low compared with other countries. A recent survey carried out by Hewage et al., (2008) revealed that the percentage of total annual revenue spent on ICT in Canada varies from 0.5% to 3% (average around 1%) depending on the project and the company. Although the percentage varies from year to year, it generally stays around 1%. The survey respondents identified the need for their corporations to increase spending on ICT because they believe it will give them a competitive edge. A similar survey conducted by BT Openworld (2002) indicated that 90% of small and medium UK companies want to improve their ICT. The survey also showed that companies were open to implementing the latest technology to improve their business performance.

In addition, according to 'The IT-Barometer 2007 survey' (Samuelson, 2008), 100% of the respondents work at workplaces with computers in Sweden and Finland. Over 70% of them, including site workers, have their own computer, their own e-mail address and access to the Internet at their workplace. The survey also showed that almost all of the respondents use electronic trade in some way or other in 2007, only 5% of the respondents stated that they did not use it at all. In 2007, the use of project webs had become more common and about 70% of the consultants and almost 50% of the contractors have been using project webs in Sweden and Finland. This paper presents the findings of a survey conducted in Taiwan. The aim of the survey was to examine the current state of ICT usage by small and medium Taiwanese construction companies.

2. RESEARCH METHODOLOGY

To determine the current use of state-of-the-art ICT applications by small and medium Taiwanese construction companies, a questionnaire study was conducted, which was designed and based upon a review of current literature and the research objectives. Two types of questions were used in the questionnaire; closed-ended questions and open-ended questions. Almost all the postal questionnaires have closed-ended questions to ensure consistency of respondent feedback. As it is not possible to design all questions as closed-ended, some questions were left open-ended, to obtain numerical data or to solicit some written comment. A total of 7 multiple-choice questions were included in the questionnaire.

Before the main survey was undertaken, a draft version of the questionnaire was piloted with two Taiwanese construction companies (turnovers between TWD 0.1– 2 billion (USD 3 – 61 million) and below TWD 0.1 billion (USD 3 million). This pilot study was intended to elicit responses that would help to test the wording of the questionnaire, identify ambiguous questions, and also provide an indication of the time to complete the questionnaire.

A number of the comments and suggested amendments from the pilot study respondents were used to amend the questionnaire prior to its final distribution.

A total of 100 small and medium construction companies were selected as the sample of the survey. The name and postal address of the sample respondents were obtained from the author's network of contacts (most of them

are members of the Institution of Small and Medium Contractor) and also from organisations such as the Taiwan Construction Research Institute (TCRI), Chinese National Association of General Contractors (CNAGC), Construction Magazine and Contractor Development Foundation (CDF). Although some of respondents were obtained from the author's network of contacts, not all free random selection. However although they can in no way be considered to representative of the industry as a whole they do provide important indications. Prior to posting the questionnaire, a telephone call was made to each organisation in order to identify the person in the company with responsibility for ICT. In some organisations this person was known as the ICT manager but in most of the organisations, this person usually had other responsibilities apart from ICT. A total of 51 valid returns were received during April 2008 and June 2008, representing a response rate of 51%. This response rate was considered to be very favourable compared to the questionnaire survey response rates experienced by Shen & Fong (2002) and Hussey & Hussey (1997) who suggest response rates of less than 10% are more likely. Naoum (1998) more optimistically however suggests that a typical response rate for postal questionnaires is likely to be between 40% - 60%. The data obtained from the questionnaire survey was analysed according to the company's turnover value, which was distinguished in two categories as indicated in Table 1.

TABLE 1: Questionnaire response rate

Categories	No. sent	No. returned	Response rate
Below TWD 0.1 billion	50	24	48%
TWD 0.1 billion to TWD 2 billion	50	27	54%
Average	100	51	51%

3. SURVEY RESULTS AND DISCUSSION

The results have been classified under the following headings:

- a). The appropriate level of ICT investment.
- b). ICT applications
- c). Current use of CAD software
- d). Virtual reality
- e). Communication systems and procedures
- f). Tendering online
- g). Knowledge management

3.1. The Appropriate Level of ICT Investment

There is a general viewpoint held that ICT investments by construction companies often fail to deliver their anticipated benefits (Tan, 1996; Rivard, 2000; Martin, 2003; Yang, 2007). This low return on investments (ROI) is perhaps related to a lack of understanding of the relationship between the technology, its business and the organisational context. Another possible reason is that construction firms may focus too much on cost reduction and short-term ROI (Barthorpe & Chien, 2003). However, construction is not slow to adopt a new idea, if the short and long-term benefits are evident.

The survey results revealed that the majority of respondents (72.5%) indicated that a reasonable ICT investment is less than TWD 1 million (roughly less than 0.1% of the respondents' annual turnover). This figure compares with the rule of thumb applied by Ramesys (2001) that 2.5% - 3% of SMEs annual turnover is considered an appropriate level of ICT investment. A survey conducted by Hewage *et al.*, (2008), indicated that the percentage of total annual revenue spent on IT varies from 0.5% to 3% (average around 1%) depending on the project and the company. It was found that there is a big gap of ICT investment by small and medium Taiwanese construction companies. A further 25.5% reported that a reasonable level of investment is between

TWD 1 million and TWD 5 million, only a small share of respondents (2%) invest between TWD 5 million and TWD 10 million.

3.2. ICT Applications

There are many specialised ICT applications that are designed specifically for use in construction. The authors' survey results are shown in Table 2 and Figure 1 where most of respondents used ICT applications in Accounting (76.5%). The majority of respondents also broadly used Financial Management (56.9%) and Electronic Document Management applications (54.9%). This was followed by Estimating (49%), Project Management (47.1%) and Human Resources Management (39.2%) applications.

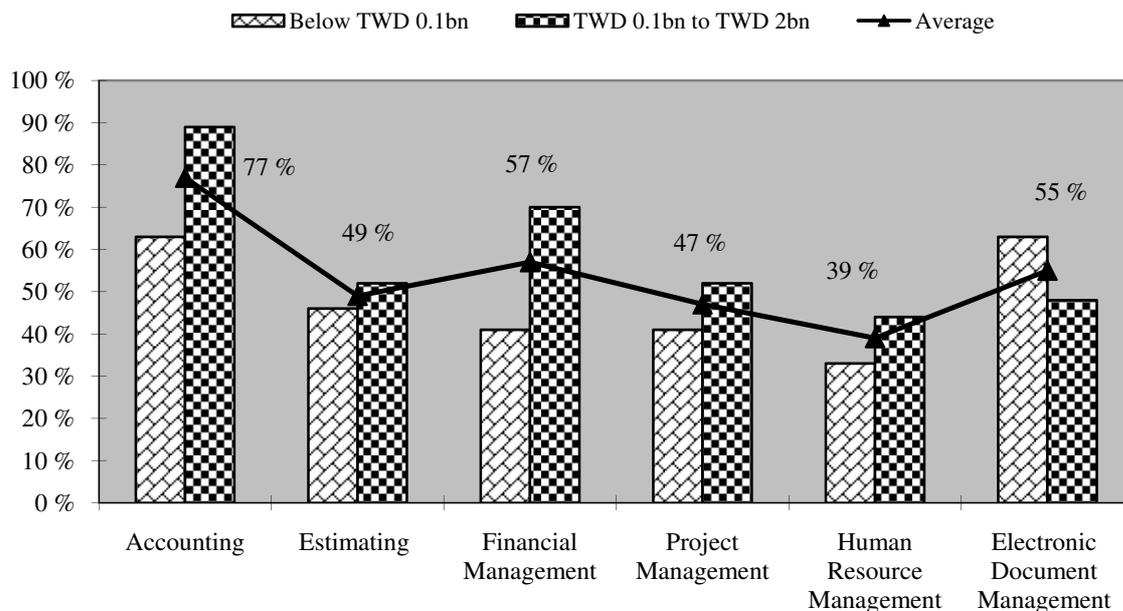


FIG. 1: ICT applications by Taiwanese construction companies

TABLE 2: ICT application used by Taiwanese construction companies

ICT applications	Below TWD0.1bn	TWD0.1bn to TWD2bn	Average
Accounting	62.5%	88.9%	76.5%
Estimating	45.8%	51.9%	49.0%
Financial Management	41.7%	70.4%	56.9%
Project Management	41.7%	51.9%	47.1%
Human Resource Management	33.3%	44.4%	39.2%
Electronic Document Management	62.5%	48.1%	54.9%

Furthermore, the respondents were invited to rate the level of usefulness in improving the effectiveness of construction management from the various ICT applications. Mean ratings on the level of usefulness were calculated, (on a scale of 1-5) which revealed that Accounting (4.28), Financial Management (4.10) and Electronic Document Management (3.71) were considered to be the most useful in improving the effectiveness of construction management. The applications of Human Resource Management (3.70) and Estimating (3.68) ranked fourth and fifth respectively.

3.3. Current Use of CAD Software

The use of CAD (Computer-Aided Design and Drawing) has become commonplace throughout the professional services sector within the construction industry. The authors' survey was designed to determine the level of CAD software used by small and medium Taiwanese construction companies. The results revealed that almost all of the respondents (92.2%) used CAD as a product design tool. However it was surprising to note that 87.5% of firms with a turnover below TWD 0.1 billion had CAD systems installed.

The authors' survey respondents were invited to rate the level of usefulness in improving the effectiveness of product design in using Computer-Aided Design and Drawing (CAD) software. The results established that CAD software was considered to be 85.6% ($4.28 \div 5 = 85.6\%$) one of the most useful tools in improving the effectiveness of product design and drawing. It is also interesting to note that the construction companies with turnovers between TWD 0.1 billion and TWD 2 billion were very positive in their opinion (4.31) that CAD software was considered to be 86.2% ($4.31 \div 5 = 86.2\%$) of the most useful tools in improving the effectiveness of product design and drawing.

3.4. Virtual Reality

Virtual Reality (VR) is an emerging technology that enables interactive real-time viewing of three-dimensional data and as such it is also a state-of-the-art communication tool. The authors' survey results revealed that 37% of construction companies with turnovers between TWD 0.1 billion and TWD 2 billion and 33.3% of construction companies with turnovers below TWD 0.1 billion used VR to communicate with designers and non-designers, both inside and outside their company.

The authors' survey results also indicated that the virtual reality application is considered to be 76% (3.83) of the most useful tools in improving the effectiveness of marketing and communication. The results found in the authors' survey concur with those of Whyte & Bouchlaghem (2001), Whyte et al. (1999) and Construction News (2003) and confirm that only a few organisations within the construction industry currently use VR technology.

Many researchers have demonstrated the benefits of using VR as architectural design, training, sales and marketing tools (Whyte & Bouchlaghem, 2001; Construct IT for Business, 2002; Construction News, 2003). In particular, a survey conducted by Construction News (2003) revealed that marketing, communication with planners and refining the design idea were seen as the areas in which VR techniques had the most to offer. Seventy-six percent of Construction News (2003) respondents reported that they thought that it would take less than 5 years to see VR techniques used in their company.

3.5. Communication systems and procedures

Construction is one of the most information-dependent industries. Timely and accurate information is therefore important for all project participants as it forms the basis on which decisions are made and physical progress is achieved. Table 3 and Figure 2 reveal that almost all of the respondents (96.1%) used e-mail as a communication tool. A further 58.8% indicated that they used an Intranet for internal communication and only 33.3% reported that they used videoconferencing as a communication media. The authors' survey results compare with an earlier study carried out by Rivard (2000) who identified that 87% of the companies surveyed used e-Mail and 90% of the companies surveyed are connected to the Internet. The industry has therefore quickly jumped on the Internet bandwagon since it first became popular in 1995.

The respondents were also invited to rate the level of usefulness from the various communication tools. Mean ratings on the level of usefulness were calculated, (on a scale of 1-5) which revealed that e-mail (4.39) and the Intranet for internal communication (3.71) were considered to be the most useful in improving the effectiveness of communication between the different parties engaged in the construction process.

TABLE 3: Communication tools used by Taiwanese construction companies

Communication tools	Below TWD0.1bn	TWD0.1bn to TWD2bn	Average
e-Mail	91.7%	100.0%	96.1%
Video Conferencing	33.3%	33.3%	33.3%
Intranet for internal communication	50.0%	66.7%	58.8%

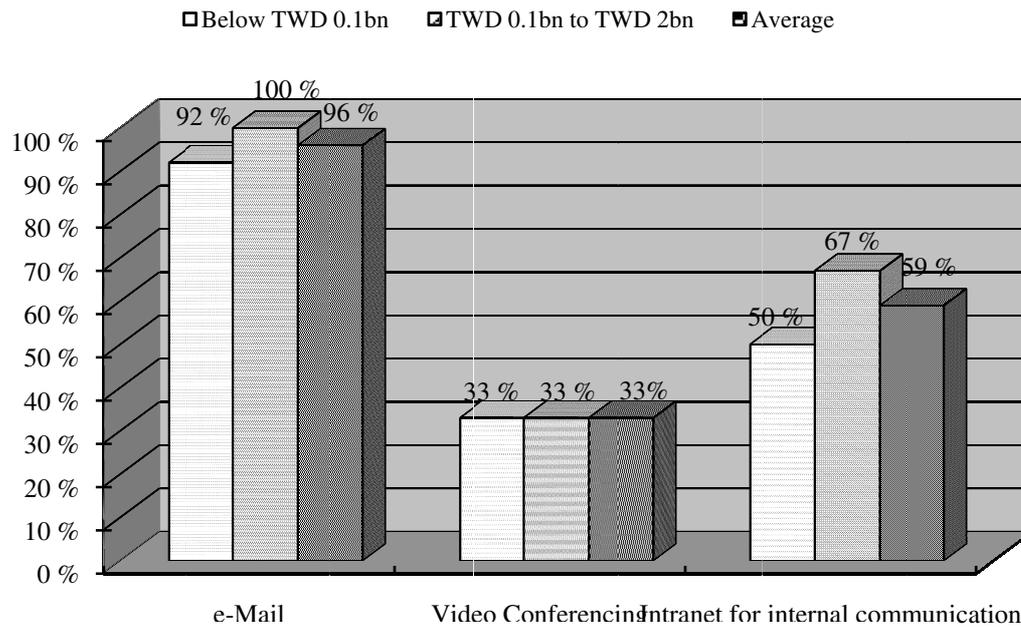


FIG. 2: Communication tools used by Taiwanese construction companies

3.6. Tendering Online

Traditional tendering can be a protracted process, with plenty of time and paper wasted. Tendering online (e-tendering) is likely to gain wider adoption as clients and contractors become more aware of its potential. The Taiwanese government issued the Regulations Governing Electronic Procurement Operations in July 2002 to serve as the basis for electronic procurement by government agencies. In addition, to simplify procedures for small government procurement projects and reduce government disbursement operations, the Taiwanese government has also planned the implementation of a government procurement card system and rules suited to the domestic environment to make the execution of small procurement cases more efficient. An expanded trial operations plan was completed in June 2002 and 37 agencies have disbursed procurement payments in excess of TWD 43 million using government procurement cards (PCC, 2003).

The authors' survey is intended to investigate the degree of influence by SMEs for growth in using e-tendering and furthermore to identify the main factors that create the barriers to online tendering. Table 4 and Figure 3 reveal that the majority of respondents (13.7%+43.1%=56.8%) agree that they will lose out on tendering opportunities and will be less competitive if they do not participate in online tendering.

TABLE 4: Tendering online - response analysis

Categories	Below TWD 0.1bn	TWD 0.1bn to TWD 2bn	Average
Strongly agree	12.5%	14.8%	13.7%
Agree	41.7%	44.4%	43.1%
Undecided	16.7%	7.4%	11.8%
Disagree	29.2%	25.9%	27.5%
Strongly disagree	0.0%	7.4%	3.9%

Furthermore, the respondents were invited to indicate which barriers discourage the growth of construction industry online tendering. The author's survey results show that the three of the most significant barriers are:

- Data may be altered in transit
- Software problems
- Employees unfamiliar with the system

The results found in the authors' survey concurred with studies carried out by Rivard (2000), Barthorpe & Chien (2003), Martin (2003) and Bowden et al., (2006) who also identified that safety concerns and software problems are a significant issue in using e-tendering.

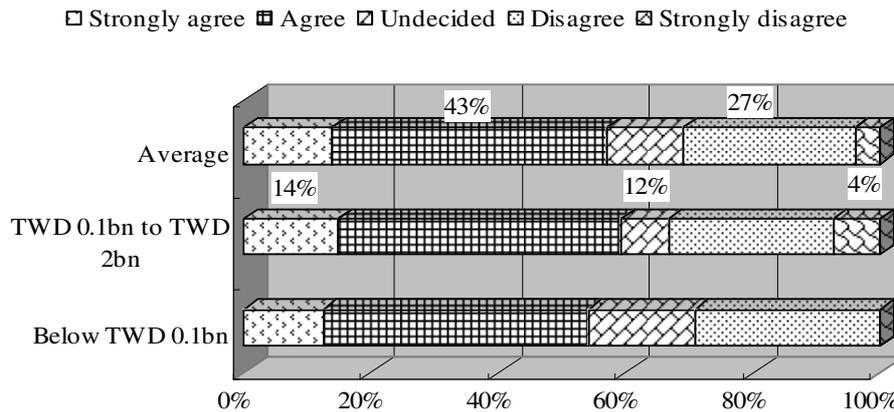


FIG. 3: Tendering online – response analysis

3.7. Knowledge Management

Knowledge Management (KM) has received a great deal of attention in recent years. It is also one of the current significant issues in the world of ICT (Hamilton, 2002). This issue is considered in the authors' survey and is intended to examine the level of usefulness in improving the effectiveness of knowledge management of small and medium Taiwanese construction companies.

The authors' survey results reveal that only 29.4% of respondents used KM software to manage their company's knowledge. Furthermore, the respondents were invited to rate the level of usefulness in improving the effectiveness of knowledge management from existing KM systems. Mean ratings on the level of usefulness were calculated, (on a scale of 1-5) which revealed that knowledge management was considered to be 67% ($3.33 \div 5 = 67\%$) of the most useful in improving the effectiveness of knowledge management.

ICT analysts, the Butler Group (2003) stated that KM was the only growth area in ICT investment. Speakers at the Construction Plus conference also predicted that construction firms would increasingly need to treat KM as an integral part of the way they work (Russell, 2003).

Indeed, KM is not simply a matter of putting the ICT in place – people have to want and need to use the systems provided. In addition, the application of a KM solution requires an enormous change in culture, discipline and training (McCrea, 2003a). However, there is no single approach to KM that can suit every construction organisation; each application will need to be tailored to their particular mix of people and procedures. It is therefore necessary to investigate all kinds of technology to enable the construction industry to enhance its management of knowledge (McCrea, 2003b).

The need for KM software and infrastructure will grow in the next few years. Construction companies also believe that a value can be attached to business knowledge, with McCrea (2003b) suggesting that organisations must do three things effectively; find and capture the knowledge they have, share it and exploit it to some commercial benefit.

4. THE ONE-WAY ANOVA ANALYSIS

An analysis of variance (ANOVA) exercise was undertaken to test the null hypothesis that there is no significant difference between the mean values of the groups. This enabled the authors to clarify whether or not the opinions of the separate construction organisation groups were the same on the various issues dealt with in the survey.

Table 5 shows 'F statistics' (F-ratio) and 'F significant' (Sig.). A probability value (Sig.) below 0.05 indicates that the null hypothesis can be rejected, suggesting that there is a high degree of difference of opinion between groups in relation to that factor. For example, in Table 5, in relation to the 'Accounting' application, the F-ratio is 5.23 and the observed significance level is 0.027 (below 0.05), indicating that the null hypothesis can be rejected. This suggests a significant difference of opinion between below TWD 0.1 billion and TWD 0.1 billion to TWD 2 billion in relation to the 'Accounting' application.

TABLE 5: One way ANOVA analysis

		Sum of Square	df	Mean Square	F	Sig.
ICT investment	B. G.	1.30	1	1.297	5.62	0.022
	W. G.	11.29	49	0.230		
	Total	12.59	50			
Accounting	B. G.	0.89	1	0.885	5.23	0.027
	W. G.	8.29	49	0.169		
	Total	9.18	50			
Financial Management	B. G.	1.05	1	1.047	4.48	0.040
	W. G.	11.46	49	0.234		
	Total	12.51	50			
Knowledge Management	B. G.	3.60	1	3.601	6.05	0.029
	W. G.	7.73	13	0.595		
	Total	11.33	14			

In order to identify the reason for the difference of opinion between the groups in relation to the various factors, structured interviews were undertaken with ICT managers of two companies (turnovers below TWD 0.1 billion and TWD 0.1 billion to 2 billion). The findings from the two structured interviews are summarised below:

- Both companies' ICT managers agreed that the Taiwanese construction industry is very challenging, due to the increasing globalization of products and services.
- A significant factor that discourages the small Taiwanese construction companies from utilizing ICT applications is due to the very thin margins of 1% to 2% currently made on construction projects. The result found in the authors' survey was also confirmed by a separate survey conducted by Bowden *et al.*, (2006) where one respondent stated that "There are no company profits from developing a system which everyone else can benefit from and most companies are too small to do their own bespoke development."
- The ICT managers of both company's agreed that the barriers for implementing ICT are cultural more than technological. The culture barrier is generally coming from the older employees who still remember using the more traditional paper-based system. The finding in the authors' survey has also concurred with a study carried out by Hewage *et al.*, (2008) who indicated that they have experienced resistance from 'older' workers whenever a modern technology has been implemented.
- "I personally believe that ICT applications are not useful for small construction companies," one ICT manager stated. "Construction generally is a one-off product and physical environment, and

all we worry about is building the building as cheap as we can.” Bowden et al., (2006) agreed and further commented, “It is relatively easy to implement new technologies in a manufacturing product line where it is a clean, stable environment and the work travels to the worker. However, on a construction site the worker has to travel to the work and takes the technology with him/her and is subject to the natural elements.”

- Technology solutions cannot be forced onto KM, if information is not incorporated in the electronic database. In particular technologies that they are not getting the best value out of are those based on the knowledge that is in people’s heads.

5. LIMITATION OF THE SURVEY

According to Samuelson (2008) three criteria were set up for the ‘IT – Barometer 2007 survey’ tool. It should:

1. Be repeatable and comparable over time.
2. Be comparable between countries.
3. Cover all categories in the construction industry.”

Although the purpose of this survey is to examine the current state of ICT usage by small and medium Taiwanese construction companies, there are several limitations and constraints which have influenced the response obtained in this survey:

- Unfamiliarity of ICT applications: ICT is a relatively new technology, particularly by small and medium Taiwanese construction companies and therefore some respondents were unfamiliar with the ICT applications available or even the esoteric terminology used.
- Constraints of conducting structured interviews: Although a substantial empirical study was conducted using the questionnaire survey, the expense and time-consuming nature of conducting structured interviews limited the number which could be carried out. However although two structured interviews can in no way be considered to be representative of the industry as a whole they do provide important indications.
- Analysis constraints: Some difficulty was experienced in analysing some of the survey respondent’s comments, due to their subjectivity.

6. CONCLUSIONS

The Taiwanese construction industry faces a number of challenges as customers become more demanding, procurement methods change and new construction technologies are introduced. Recently there has been a rapid growth of ICT use in the industry, especially the Internet. This paper has presented the findings of a questionnaire survey conducted by the authors among a sample of 100 construction organisations based in Taiwan. The survey results, received from 51 respondents demonstrate that an appropriate ICT investment is less than TWD 1 million (roughly less than 0.1% of the respondents’ annual turnover). Other major conclusions that can be drawn from this survey, are summarised below:

- Almost all of the respondents used e-mail as an internal and external communication tool and 58.8% of the respondents used an Intranet for internal communication.
- 92% of the respondents used CAD as a product design tool, which is significantly higher than the 73% observed by Barthorpe & Chien in 2003. It can be predicted therefore that construction companies would increasingly use CAD software in the future.
- 56.8% of the survey respondents agree that they will lose tendering opportunities and competitiveness if they refrain from tendering online. It was also revealed that the three most significant barriers to online tendering in the Taiwanese construction industry are; ‘data may be altered in transit’, ‘software problems’ and ‘employees unfamiliar with the system’.

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