

Review

Application and efficacy of information technology in construction industry

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In the 21st century, information technology (IT) is seen as a tool that assists companies to perform more efficiently and effectively. However, many studies have posed the question whether the benefits outweigh the investments. The issue is more serious in the construction industry where there are factors that limit performance such as inadequate training, ineffective use of IT infrastructures, maintenance inadequacies and less than positive staff perceptions concerning IT implementations by management. Malaysia is a rapidly developing country and IT integration has to be efficient to help accelerate development. This study aims to analyze IT effectiveness in construction companies focusing on small and medium contracting enterprises (SMCE). The study reviewed literature related to IT implementation and its services in the construction industry with the objective of highlighting the appropriate conceptual IT effective model in the context of the Malaysian construction industry. The review was also performed to identify important factors attributed to performance and hindrances of performance of Malaysian construction companies. The paper concludes with tentative implications for IT implementation with the necessity to comprehend operational and process-level changes as well as impact isolation of specific IT application types concerning firm's dynamic capabilities, which mediate IT impacts on firm performance.

Key words: Information technology, construction industry, Malaysia, performance, information technology effectiveness, information technology implementation.

INTRODUCTION

In recent literature, there are many studies of the construction sector, which is increasingly becoming theoretically and empirically important. There is a wide range of literature concerning various areas of industrial applications. The body of literature on the construction sector is very diverse, but it is contingent in the explanation of characteristics and importance. Up-to-date information on construction is a challenging task due to quantity and diversity of new literature in this field of interest. The application of information technology (IT) within construction practices is the area of interest in this study. A review of available information and factors affecting performance in the construction sector will

assist to determine the various elements required for this study. Available literature was used as a guide for a solid foundation on which the theoretical and practical aspects should be investigated and new solutions ought to be built upon. The focus is to identify the general limits in terms of importance for a better understanding of the salient issues to be obtained.

This paper incorporates the relevant elements of literature concerning:

1. Critical IT concepts and definitions in construction domain;
2. Discussion of IT systems, use in construction practices and highlight IT roles and construction applications;
3. Discussion of investment and performance growth in construction;
4. Define roles and IT adoption by small and medium

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- enterprises in Malaysian economic development;
5. Relevant IT models utilized in various industries;
 6. Staff satisfaction and IT perception within companies;
 7. Issues that prevent full effectiveness of IT use in companies;

The information presented in this paper is mostly taken from reviewing the literature. The source materials of the data were obtained from libraries databases of Malaysian universities. Additionally, specialized databases and other information sources available on the Web have been explored. The selected references were selected based on the well-described methodology, and the research results are available and complete.

INFORMATION TECHNOLOGY (IT) AND CONSTRUCTION INDUSTRY

Construction includes the activities involved in the erection, installation or construction of a portion or an entire project. These activities are actually provided on the job site by the contractor, subcontractors, material suppliers and equipment suppliers. This is separate from the production or manufacture of structures and equipment off-site, which is also part of the production. Activities in this phase include site layout and control, foundation construction, forms, structure reinforcement and so on. The construction process is carried out with labor, machinery, equipment, materials, methods and money.

Generally, the construction industry is highly fragmented compared to other manufacturing industries. The extent of this fragmentation is unparalleled in any other sector with considerable impact on productivity and performance (Akinsola et al., 2000; Dawood et al., 2002). The construction industry is defined in various ways. The term construction is usually used to describe the activity of the creation of physical infrastructure, superstructure and related facilities such as buildings, manufacturing plants, roads and bridges (Wells, 1985). Similar to other manufactured products, the construction process is conducted on a job-site, and is usually one-of-a-kind and takes a lot of time to complete. The construction industry is heterogeneous in the nature of its organizations. It operates around projects in which organizations come to work together within the duration of a project. Each project is unique in the sense that there are construction problems that are inseparable from the project (Li et al., 2000).

The key objective of the construction industry, as any other industry (that is, service, manufacturing, and E-business) is to produce its products to satisfy its customers (Akinsola et al., 2000). The construction industry has numerous unique features which distinguish it from other industries, namely, the fragmental nature, one-off projects and multi-participants (Li et al., 2000).

According to Akinsola et al. (2000), the industry production process and the products themselves are unique compared with other industries. However, the products must be produced within the clients' requirements, designer's specifications, assigned time and budget. Unfortunately, the complexity of the construction processes due to industry fragmentation is such that achieving this objective is difficult under the existing delivery processes. However, these have been acknowledged as major causes of performance related problems facing the industry.

The term it has been widely used in existing literature and some definitions of it include the technology side of information systems (IS) (Hollander et al., 1999). Technology includes computer-based information systems (Laudon and Laudon, 2000) and a collection of computer systems used by a body (Turban et al., 2004). However, the following is a more comprehensive definition to elaborate and explain more clearly, what it is:

"Information technology is the technology involved in the operation, collection, transport, taking, reserve, offering access to, and transformation of information in all its forms" (Boar, 1997).

Based on the aforementioned definition and according to (Sarosa and Zowghi, 2003), the term IT is defined as all technologies used by organizations to collect, process and disseminate information in all its forms. Therefore, it covers parts of IT hardware (computers, printers, scanners, etc.), software (operating systems, application development languages, office applications, etc.), and telecommunication devices (modems, hubs, network cards, network interfaces, etc).

THE ROLE OF INFORMATION TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

This section discusses the important role of information technology in the construction industry and provides two related case studies. In addition, this section will discuss the use and implementation of information systems in the construction industry.

The success of the construction industry can also be expected to encourage investment in technology within the field of IT. In the 1980s, the technological revolution made IT an integral part of many core business activities. Current information technology contributes to all the management functions of planning and organization of activities. In addition, IT organizations meet the needs of businesses in order to create value for companies and their customers' projects and this subject remains as a key management task. The use of IT in construction is expected to expand. Organizations are beginning to realize that IT can be used to obtain and maintain a competitive advantage (Li et al., 2000). Therefore, a new

technology is needed that places an increasing demand on design and construction organizations (Ahmed et al., 1995). Despite increased demand, the level of successful implementation is inert to the technological progress. The introduction of IT into an organization is a measure of effectiveness. It is confusing for the construction industry (Choi and Ibbs, 1990; Sanvido and Medeiros, 1990).

Information communication technology provides innovative construction companies with new opportunities to improve the process of collaboration, communication and information (Bowden et al., 2006). Findings from the study by Li et al. (2000) indicated that in addition to construction, architecture also seems to have many benefits from the use of IT. The industry becomes more technology-driven and investment in IT is likely to increase in the near future. A good example is the work of Miyatake and Kangari (1993) who concluded that IT should be viewed as an important resource in today's professional practice and that the automatic flow of vital information in a firm is essential.

According to a study by Akinsola et al. (2000), within the last thirty years or more, business integration and other strategies have emerged from the manufacturing sector. Research reveals their strategies and their successful application in the manufacturing industry. Others have provided researchers with an inspiration in the construction industry to adopt the initiative. Implementation of IT is one of the most strategic and effective management tools to improve productivity and competitiveness. One aspect of IT is to improve the communication and transmission of information among employees of the company or team that describes the design process management and control (Luiten. and Tolman, 1997). Strategic systems when applied give positive impact to the survival and growth of businesses (Cleveland, 1997).

Akinsola et al. (2000) stated that one result of this strategy copied from the manufacturing process is based on the concept of "single point of responsibility" in which, the design and construction of buildings is the responsibility of an organization. The result is a huge cultural change and increasing development of alternatives and variations of existing processes. One of the fundamental aspects of development is the early involvement of contractors in the pre-construction activities as a means to bridge the gap between design and construction. Unfortunately, this approach alone has proven inadequate in addressing the increasing complexity of construction projects and especially without the support of integrated IT.

The role of IT in most industry sectors has changed considerably over the past 30 years. Building practitioners utilize IT to simulate, analyze and evaluate the anticipated performance of the amenity design, the design of the amenities' delivery process and the design of organizations in carrying out the processes. The emphasis is first in the general applications on the data

processing method "of accounting, payroll and analysis of complex numerical calculations, the second-generation applications introduced were related to decision support systems where functions to manipulate and filter information assisted the decision making process, the last and third generation of applications focused on strategic information systems that are critical to company survival in the context of a new paradigm of global competition in the industry as a whole (Michel et al., 2000).

Michel et al. (2000) stated that there is a strong international common ground to enhance the construction industry's reform agenda by implementing IT programs in some key areas, such as emphasizing global business opportunities, supporting a wider informed market place, encouraging technological innovation, generating economical and ecological sustainable environments as well as creating a best practice in a regulatory environment.

The new communication revolution has become critical to organizational success and a key to gaining a competitive edge in the market place. Although IT automates many interactive functions within a company and theoretically boosts productivity, it also produces massive amounts of information often held within complex databases and knowledge repositories (Michel et al., 2000).

The result of a study by Tuman (1998) indicates that information overload eventually leads to communication problems with the data or between teams. However, IT, when coupled with effective network connectivity should bring to light the feasibility of managing projects through a project management team consisting of members who are distributed across buildings, states and countries. Virtual project management teams have demonstrated better control of the design process and design changes as a result of using IT services. Project managers in the construction industry tend to rely heavily on efficient and stable computer networking technology to ensure the success within virtual teams. Traditional project management methods have embraced computer technology for project tracking and reporting. At the same time, virtual project management teams totally depend upon technology and cannot perform without it (Michel et al., 2000).

Information is an essential part in every industry and a valuable investment for a company to succeed. The importance of information is more than ever. The evolution of information technology has greatly assisted the manner in which an organization deals with their operations. Most industries have moved from a traditionally based to a digitally based information exchange (Rivard et al., 2004).

Computer vision is a technology that focuses on providing computers with the characteristics of the function of human vision. It can be used in the formulation of 3D objects from 2D images. An image is automatically scanned and work in progress can be

measured. For example, it is possible to visually measure the construction progress of a superstructure, while some other aspects of measuring progress cannot be fully automated. Thus, the use of a computer vision system is to assist the task of project management to some extent (Zhang et al., 2009).

3D/4D models support the designer of the building element coupled with 3D CAD systems for construction activities of the system of project planning and operation of a graphical interface. In the construction process, the modeller can be framed in the VP system and the user can visually check how the process takes place. 4D CAD systems can help to analyze construction and communication (de Vries and Harink, 2007). Hartmann and Fischer (2007) developed an integrated process concerning how project teams can use 3D/4D models efficiently to support the communication and generation of knowledge required for examination of contractibility on construction projects.

APPLICATION OF INFORMATION TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

Global IT policy in the construction industry has received general recognition in current industrial applications worldwide. IT has been recognized as the primary tool for communication and data exchange schemes. Shen et al. (2004) emphasized that the implementation of IT has become one of the most important factors in determining the success or failure in almost all industry sectors including the construction industry. Gupta and Capen (1996) showed that the impact of IT on organizational productivity differs between small and large companies. However, the research presented by Gupta and Capen (1996) did not ask respondents directly about their company's size in analyzing the differences. The study used other methods in showing the productivity differences. The study also noted that in assessing the impact of IT organizations, many researchers tend to ask respondents to assess the extent to which IT has increased productivity. They observed that there is a large discrepancy between what the manager and other IT users view as improvement and what productivity improvement really is.

As the construction industry becomes more technology-driven, investment in IT is expected to grow in the future. Unfortunately, most IT applications so far have been brought to the industry without proper planning and evaluation. Most of its effects have been allowed to happen just like that without an organizational structure to accommodate changes in business processes (Love and Gunasekaran, 1997). The result is that the 'full' potential of IT to improve organizational efficiency, effectiveness and flexibility have seldom been attained (Love et al. 1996). In the next study, attention should be given to measuring the increase in productivity brought about by

IT and the interaction between IT and business methods, work patterns, employees and organizational culture (Li et al., 2000). The evolution of IT in project management has shifted from project implementation that is based on mere intuition and the analysis approach that is structured to more sophisticated integrated project management systems (Pace and Septelka, 1997; Saad and Hancher, 1998).

Case study 1: Jordan

El-Mashaleh (2007) has reported the discovery to a modified version of the IT barometer survey in the construction industry in Jordan. The researcher has collected data from 207 companies. Thirty-four percent of the companies are general contractors, 37% are architectural and engineering companies, 19% are consulting, architectural and engineering companies and 10% are consulting firms. The companies that participated were involved in the construction of buildings, roads and bridges, water and waste projects and electromechanical projects. Company size in terms of number of employees varies significantly with some companies having only one employee and other companies having more than 150 employees. The study shows that there are 0.46 desktop and laptop computers at the average of 0.024 workers. In the software industry, IT programmes often used are Word, Excel, web browsers and e-mail. AutoCAD tools are used mostly to assist in drawing. In addition, the researcher stated that eighty-two percent of the companies increased IT investment in the last two years. According to 92% of respondents, the demand from customers is a very important motivator for new IT investments.

The perceived benefits of IT adoption by respondents is for better quality work, for work to be done faster, better financial control, better communication, faster and simpler access to public data, greater flexibility to satisfy customers, the possibility of sharing information in general, easier to use a lot of data and the convenience of telecommuting. The main obstacles are the financial cost of using IT, the cost of maintenance as well as ineffective staff training.

Case study 2: Nigeria

Studies conducted by Oladapo (2007) to investigate the IT situation in the Nigerian construction industry highlights IT penetration, the impact of the industry and setting constraints. In addition, this study identified significant factors influencing the level of IT used, classifying them into those internal to the industry and those external to it. The 136 respondents consisted of contractors, consultants and academic researchers were given a survey to provide data for empirical analysis.

Results showed that there are a number of internal factors, the type of business (both contractors, consultants and/or academics), the perception of senior managers, CEO/senior managers and the head of the executive office (CEO) and displayed that the benefits of using IT as well as computer literacy are significantly correlated with the level of IT consumption in the industry. However, none of the external factors significantly correlated with the level of IT usage.

The main use of ICT is in word processing, Internet communication, cost and scheduling. Five major obstacles of ICT are a lack of sufficient regular power supply, high cost of IT software and hardware, lower job orders for the company, fear of virus infection and high levels of obsolescence of IT software and hardware. In addition, a comparison with results of similar studies in some industries in new industrial countries shows that the proportion of companies using computers is high enough for developing countries like Nigeria. It also highlights the huge gap in access to electricity and other communication infrastructure between developed and developing countries. In this section, some definitions of information technology were discussed. In addition, the author discussed the evolution of IT, Information Systems and their usage in the construction industry. Implementation of IT in the construction industry has also been discussed in this study.

INFORMATION MANAGEMENT SYSTEM IN THE CONSTRUCTION INDUSTRY

The information management system for the construction industry is the same as what other industries require. However, these industries may consider IT as a relatively new technological innovation and as a result, managers lack experience and understanding, which makes their task more difficult and decision making more problematic (Li, 1996). The concept of information management involves coordinating information from the time that it is created until it is eliminated and also information management purposes include the creation, capture, entry, manipulation, exchange and storage of information. Information management and Information Technology may be complicated to consider separately since the tools often used to enable information management have been information technologies (Edward and Karen, 2001). Previously, companies have developed paper-based, functionally centered systems to manage information (Huff, 1992).

According to a study by Kingman et al. (1990), approximately 1% of a corporation's data is in the computer system and available for processing while 99% is non-coded in the form of paper, microfiche, or other media. As a means of improving project performance, many businesses, companies and industries have implemented various technologies. Efforts to use IT have been

fragmented (Keen, 1991) and many of these technologies have been implemented to automate isolated functions within a business work process rather than within the company or enterprise as a whole (Haeckel and Nolan, 1993). Huff (1992) indicates that IT has been primarily implemented as functionally focused computer systems that automate the pre-existing functionally focused paper-based systems.

In many instances, implemented technologies have been sufficiently advanced to carry out the required tasks, but there has been no set of standard conventions for enabling them to work together (Koulopoulos, 1995). The practice is that technologies are resting on increased networks with incompatible computer programs (Haeckel and Nolan, 1993; Coussens, 1995). According to Najafi (1991), computer technology in the 1980s changed drastically. Microcomputers perform functions that only large and expensive mainframe computers performed a decade ago. They are being used today by a rapidly growing majority of construction firms. Najafi (1991) has investigated computer applications in various aspects of the construction industry, such as planning, surveying, designing, graphics, pre-bidding, budgeting, scheduling, quality and cost control and equipment management. The study also includes the results of a questionnaire directed at the construction industry concerning the types of construction, the company's annual dollar volume of work, types of computers used, usage of commercial software and percentage of usage for various activities within the construction industry as well as to what extent has computer utilization advanced the construction industry. In the construction industry, the use of small and personal computers dominate in the types of computers used.

According to Fereig et al. (1989), the developments in the computer field and the evolution of powerful and affordable personal computers which out-perform old minicomputers have created a great potential for their use in the construction industry. The advancement of personal computers not only makes the computers personal, but they are also mobile, faster, more flexible, secure and more effective. In addition, the proliferation of construction-related software has resulted in the development of more efficient decision-support systems for the management of the construction company and its construction site applications in different administrative areas, like payroll, accounts payable and receivable, inventory control, general ledger and word processing. The use of microcomputers and related software is now widespread in construction companies. Moreover, engineering applications are used in a considerable number of companies activities related to the site, such as scheduling, job progress management, purchasing and procurement, cost control, and equipment management (which can now be performed using microcomputer software on-site). Fereig et al. (1989) investigated the extent of computer usage in such applications in the

Kuwaiti construction industry. According to his study, the problems associated with computer usage are presented. His study reveals that more than fifty percent of construction companies registered in Kuwait are using computers and these users believe in the importance of computers to their company's operation. According to Fereig et al. (1989), administrative applications and accounting tools rank as the most frequently used applications followed by general ledger and word processing, while estimation and developing a cost database are the main applications in the engineering area. Scheduling applications in the project planning area are also widely used.

The general purpose of information management is to make available the right information at the right time and at the right place (Schlögl, 2005). To achieve this purpose, technology-oriented information management and computer-based information systems are the principal methods. Information management emphasizes the significance of information technologies. This is essential through the high IT integration level considering the complexity of its application and its strong value for an organization.

According to Schlögl (2005), technology-oriented information management includes data management, information technology management and strategic information technology management. The main emphasis of these approaches is the effective and efficient use of information technology on performance.

INVESTMENT IN INFORMATION TECHNOLOGY (IT) AND FIRM PERFORMANCE

Studies to-date can be categorized into two levels that are firm level and industry level. Measuring the impact of IT on performance is the subject domain of Management Information Systems (MIS) research, Organizational Theory and Business Strategy.

Impact of information technology on firm performance

Firm or company performance is a composite score of several metrics of performance such as cost performance, schedule performance, safety performance, customer satisfaction and profit. Performance measurement is used as a business tool for evaluating management performance, managing human resources and formulating corporate strategy. Studies on the forms and concepts of a framework that can effectively carry out a firm's performance measurement have been conducted since the early 1990s (Yu et al., 2007).

There is no relationship established between IT use and customer satisfaction, safety or profit (El-Mashaleh et al., 2005). The research to identify IT benefits at the firm

level started in the 1980s. Bakos and Treacy (1986) categorized the research of the impact of IT on the performance of companies into three levels: the impact on individual users, departments or groups and on the company itself. The study suggested that the impact could also be categorized according to areas of impact. The results showed that the impact of a single application (23%), the impact of a portfolio of applications (31%) and the impact of all applications used (36%) (Benameur, 1999). Strassmann (1985), Roach (1988), and Ahituv and Giladi (1993) studies have largely been put to rest by studies of Brynjolfsson and Hitt (2000) Jorgenson and Stiroh (2000), Oliner and Sichel (2000) Dedrick and Kraemer (2001) and Jorgenson (2001), and not all studies have demonstrated a clear payoff from IT investment.

McKeen and Smith (1993) stated that analyzing the firm level is an appropriate unit of examination for interpretation of the relationship between IT and performance. Decisions about the investment in IT are also made at this level. If the level of analysis is based on the country or industry, much of the organization level activity is obscured. On the other hand, if the unit of analysis is at the individual information system, then the problem is reversed. In this case, it is extremely difficult to separate the individual effects of a single information system from those of other systems. Furthermore, the benefits of each individual information system cannot explain performance benefits at the firm level.

POSITIVE AND NEGATIVE RELATIONSHIP OF INFORMATION TECHNOLOGY INVESTMENT AT FIRM LEVEL

A number of researchers have investigated the impact of IT investment on performance at the firm level. Nevertheless, there is still no clear evidence of a consistent relationship between IT investment and firm performance. Some studies show a positive relationship while others display a negative relationship. Cron and Sobol (1983) studied the relationship between computer utilization and the performance of 138 medical wholesalers. They measured computer utilization by the number of computer applications. They measured firm performance by return on assets, return on net worth, five year sales growth, and pre-tax profits. The results of their study demonstrated that firms with intense computer utilization were either very strong or very weak performers.

Weill (1992) collected six years of historical data from 33 U.S. valve manufacturing companies to investigate the impact of IT on firm performance. The study categorized IT investment by management objectives such as strategic, informational and transactional IT investment. He used four performance measures including sales growth, return on assets and two measures of labor productivity and found that only transactional IT

investments had a positive impact on firm performance while strategic and informational IT did not. Further, the researcher found that conversion effectiveness which includes the quality of management and commitment to IT is a significant moderator between strategic IT investment and performance.

Mahmood and Mann (1993) measured the organizational impact of IT investment with the financial data from 100 U.S. firms. They chose five measures for IT investment variables such as annual IT budget as a percentage of revenue, value of an organization's IT as a percentage of revenue, percentage of IT budget spent on IT staff, percentage of IT budget spent on training IT staff and the number of PCs and terminals as a percentage of total employees. The study used six financial ratios as organizational performance measures: return on investment, return on sales, growth in revenue, sales by total assets, sales by employees and market to book value. The study found that although individual IT investment variables were only weakly related to performance variables they were significantly related to the performance when combined. The results show that investment in IT benefits the company in many areas.

According to Dedrick et al. (2003), from about the early 1990s, stronger research with large samples have been conducted and many succeeded in finding the positive impact of IT investment on the firm's productivity. Harris and Katz (1991) studied the impact of IT on insurance companies which had been a leading industry in the usage of IT. They investigated the data of IT investment and firm performance from 40 U.S. life insurance companies for four years. In their study, firm performance is measured by the operating cost efficiency ratio, which was the ratio of total operating expense to premium income. IT investment was appraised by the IT expense ratio, which was the ratio of IT expense to total operating expense and the IT cost efficiency ratio, which was the ratio of IT expense to premium income. They concluded that firm performance was related to the level of intensity of IT investment.

Floyd and Wooldridge (1990) studied a specific interrelationship among strategy, IT and firm performance. They surveyed data from 127 U.S. banks and classified the utilization of Information Technology into two categories; product IT and process IT. Product IT included automated teller machines and home banking systems. Process IT included online transactions, PCs for managers and decision support systems. They chose average return on assets over 3 years and deposit growth rate as firm performance variables. They used seven variables to measure the firm's competitive strategy such as human resource differentiation and product differentiation and so on. The study found that strategy had a direct effect on IT and IT had direct effect on the return on assets. The study concluded that IT could play a meaningful role in the relationship between strategy and return on assets.

Barua et al. (1995) considered intermediate variables between input and output variables to identify the benefits of IT for sixty business units among large corporations in the U.S. and Europe. The study used IT capital and IT purchase as input variables and market share and return on assets as output variables. The study chooses inventory turnover, relative price (the weighted average of three largest competitors), relative inferior quality (the percentage of products that are inferior to those of three competitors), new products and capital utilization (the ratio of actual output to maximum output) as intermediate level variables. In his empirical analysis, the researcher found that IT related factors had significant positive effects on intermediate level variables but failed to identify that IT had an important effect on firm performance variables.

Hitt and Brynjolfsson (1996) considered three different benefits of IT: productivity improvement, consumer benefits and firm profitability. The researchers collected data from 370 large U.S. firms to determine relationships between IT investment and these three benefits. IT investment was calculated by a broad definition of IT, which included hardware and software expenses, support and complementary costs such as training costs or the costs of business process redesigns relevant to IT. The measure of IT investment consisted of two variables such as computer capital and information system labour. Computer capital is the total dollar value of central processors as well as the value of all PCs owned by a firm. Information system labour is the labour portion of the central information system budget. The study used three profitability measures such as return on assets, return on equity and total shareholder return. The study suggested that IT induced productivity enhancement and created considerable value for customers. However, the study did not find the evidence that those benefits had resulted in business profitability. Chari et al. (2007) noted in their study that performance impact could be significantly positive for firms with high IT investment.

The precise and up-to-date measurement of work in progress on construction sites is fundamental for project management functions such as schedule and cost control. Presently, the job takes place with the aid of traditional building surveying methods and visual inspections (Zhang et al., 2009). Measurement of the work in progress is considered as one of the most challenging problems faced by project management.

Digital imaging has been used enormously nowadays in order to support the visual inspection task by several construction companies (Navon, 2007; Navon and Sacks, 2007; Tsai et al., 2007; Zhang et al., 2009). A regular capturing of images on the construction site can be used in the assessment of work progress, which consequently minimizes the need of site visitation.

The development of innovative technologies has always played a crucial role in increasing the global competitive advantage for the firm's performance (Ma

and Wang, 2006). Even when IT spending is shown to improve intermediate variables of organizational productivity such as improved communication leading to the need for reduced inventories (Dudley and Lasserre, 1989), it does not necessarily lead to improvements in productivity (Barua et al., 1995).

Loveman (1994) examined 60 manufacturing business units within the U.S. and Western Europe. Despite disaggregating the use of IT according to IT intensity, industry and market share, the study found no significant impact of IT investments on productivity at the firm level. Hu and Plant (2001) argued that there is causality between IT investment in the preceding years and performance of a firm in the subsequent year. Instead, the study found that improved financial performance of preceding years resulted in an increase in IT investments in the subsequent year.

Menon et al. (2000) investigated IT productivity in the healthcare industry and categorized capital investments into three types: IT capital, medical IT capital and medical (non-IT) capital. Labour was categorized as IT and non-IT. Their study indicated that non-IT labour showed the highest positive impact on productivity, IT labour and medical IT capital contributed to high productivity, IT capital contributed to a low average productivity, but non-IT capital showed a negative impact on productivity. Shao and Lin (2002) found that IT has a positive effect on technical efficiency in the production process, whether IT investments are treated as a firm-specific factor or a production factor. Kudyba and Diwan (2002) compared their empirical results to three previous studies with similar methodologies and concluded that the increase in productivity from IT increased over time. Kudyba and Vitaliano (2003) investigated the relationship between IT and profitability and found that IT enhances firm level profitability. Lee and Kim (2006) found a positive relationship between IT investment and firm performance considering the effects of information intensity and time lag.

POSITIVE AND NEGATIVE RELATIONSHIP OF INFORMATION TECHNOLOGY AT THE INDUSTRY LEVEL

Studies dealing with IT benefits at the industry level attempted to identify whether there are significant differences of IT benefits according to the industries. Stiroh (2001) compared labour productivity growth for 61 U.S. industry sectors during the 1990s. The study found that the IT intensity of the industries and productivity growth was significantly related to each other. IT intensive industries, whose level of IT capital as a share of total capital was higher than average, had a higher productivity growth than other industries (Dedrick et al., 2003).

In the Asia-Pacific region, Valida et al. (1994) studied

IT utilization among 230 business organizations in Malaysia. They concluded that the use of IT in Malaysian organizations was strategic in order to gain competitive advantage. Thong and Yap (1995) developed an IT adoption model for small businesses and they concluded that small businesses that had innovative Chief Executive Officers (CEOs) possessed more positive attitudes toward IT adoption.

Another study in Singapore by Ang and Koh (1997) explored the relationship between user information satisfaction and job satisfaction by developing two constructs to measure the relationship and found them to be correlated. In Hong Kong, Burn (1990) studied the strategic use of IT in Hong Kong in small and medium sized organizations. The researcher surveyed three medium sized organizations and found that IT strategy was related to the Porter and Millar (1985) model of competitive advantage.

In Australia, Sohal et al. (1998) studied the role and impact of IT in 530 Australian Business Organizations and found IT usage was positively related to organizational performance. Fink (1998) studied 280 Australian small and medium business organizations and identified 10 IT adoption factors in the business firms. The study concluded that IT holds considerable potential for the SME industry because it facilitates and manages the exchange and management of information. A case study was also conducted to show how IT could be used successfully in construction projects.

Several statistical data have shown that adoption of the internet among Canadian firms in the recent past has grown rapidly (Charles et al., 2002). According to Rivard et al. (2004), the public sector is completely connected to the Internet and the size of firms does matter when Internet adoption rates are included. This is similar to the findings by Gupta and Capen (1996). Almost all medium and large firms are connected to the Internet. Internet usage among Canadian construction industries was registered at 76% in 2002.

The study done by Seyal et al. (2000) in Brunei has identified and assessed the degree of IT usage among participating small and medium business organizations in Brunei Darussalam. The study has further identified the factors that influenced the use of IT. The use of IT is influenced by the organizational factors such as sales and type of business. The research has also identified that most of the surveyed organizations are avid users of IT; however, it does not confirm the turnaround and strategic support from IT applications.

The study concluded that in order to build an IT based culture; IT should be used not only to support management functions but also to support the operational functions. However, the study by Seyal et al. (2000) still recommended that the results should be used with caution and can further be improved with revised research methodologies in future studies. Their study does not measure the specific nature and level of use of

Table 1. Summary of empirical studies in information technology by industry level.

No.	Author	Level of Analysis	Findings
1	Weill (1992)	Firm and industry	Positive relationship between transactional IT and performance No relationship between (Strategic IT or informational IT) and performance.
2	Loveman (1994)	Firm and industry	No relationship between IT investments and productivity.
3	Menon et al. (2000)	Firm and industry	A positive relationship between medical labour, IT labour, IT capital, medical IT capital and productivity. A negative relationship between Non-IT capital and productivity.
4	Kudyba and Diwan (2002)	Firm and Industry	IT investments increase productivity and this increase in productivity increases over time. High IT-intensive industries increase returns to IT capital.
5	Ko and OseiBryson (2004)	Firm and industry	IT has a positive impact but it is conditioned by both IT Stock and Non-IT capital. The impact of IT is positive only under a certain condition. Complementary relationship exists between IT and non-IT investments
6	Hu and Quan (2005)	Industry	A causal relationship exists between IT investments and productivity at the industry level. IT investments contribute positively to the Manufacturing and Transportation industries. Finance industry did not show significance.
7	Lee and Kim (2006)	Firm and industry	IT (or a lag effect of IT) increases performance. The effects of IT are larger in the high information-intensive industries than in the low information-intensive industries. A lag effect of IT is larger than an immediate effect of IT.

IT in business.

Although the study is pioneering in its nature, it has not provided valuable information on the nature of IT use in Brunei, especially the influencing factors. Based on the experience gained from the study, an expanded survey is being planned where a more detailed research instrument will be used on a wider sample of organizations.

This would provide a richer picture of IT use in business practices in Brunei Darussalam that may provide the basis for comparison with other Asian countries.

Michel et al. (2000) highlight the effective use of protocols to support the integration and collaboration process between teams. His study also explores the capability of typical IT tools to assist in the collaboration and integration of design information, such as intelligent agents (knowledge-based expert systems), neural networks, 3D, Computer-Aided-Design (CAD), Electronic Data was to select a set of these tools for incorporation within the Integrated Facility Engineering (IFE) system, which can assist in automatic processing and integration

of design information.

Lee and Kim (2006) found that the effect of IT and a lag effect of IT on performance are greater for firms in high information-intensive industries than in low information-intensive industries and a lag effect of IT investment is larger than an immediate effect. Kudyba and Diwan (2002) indicated that IT-intensive industries (that is, banking and financial services, computers and electronics) have greater returns on IT capital. Kudyba and Vitaliano (2003) found no relationship between IT impact and profitability of firms in service industries, but found a positive relationship of firms in manufacturing industries. Hu and Quan (2005) investigated the IT investment impact at the industry level and found a causal relationship between IT investments and productivity in six out of eight industries. However, their results show that IT investments have no significant impact on productivity among the construction and finance industries, which are somewhat different from the findings of Kudyba and Diwan (2002). Table 1 includes a summary of previous empirical studies on IT.

INFLUENCE OF FIRM'S CONTEXTUAL FACTORS

One of the other main research efforts of firm-level studies is to find the reasons for the variance of IT benefits among individual firms. Kauffman and Weill (1989) emphasized the importance of the role of the firm's contextual factor for firm level IT benefit studies. Weill (1992) identified four contextual factors: Top management commitment to IT, previous experience with IT, user satisfaction with systems, and political turbulence.

Powell and Dent-Micallef (1997) developed a resource based theoretical framework to explain variance among U.S. retail companies using the same IT's. They identified three resources of a firm such as human resource, business resource and technical resource. Human resource included CEO commitment to IT, open communications, consensus etc. Business resources included IT training, process redesign, benchmarking etc. Technology resources included computer hardware, software, linkages of the home office and stores. The study suggested that a firm's resources: Human, business, and technology relevant to IT, produced advantages that explained significant performance variables among firms.

In their follow-up study, Brynjolfsson and Hitt (2000) documented the influence of decentralized organizational structure on the IT benefit of firms. They found that firms having decentralized organizational structure and work structure had higher benefits of IT on firm's productivity growth and market value. Devaraj and Kohli (2000) investigated the combined effect of IT and business process redesign on organizational performance. They collected data over three years from eight U.S. hospitals. Their study showed that IT and business process redesign had impacts on performance separately and that their combined effects, affected performance. The impact of IT on performance is higher in firms where there are high degrees of business process redesign implementation.

Tam (1998) investigated the relationship between IT investment and firm performance for 106 firms in Hong Kong, Singapore, Malaysia and Taiwan. The author used computer systems capital as input variables and shareholder return, return on equity, return on assets, and return on sales as output variables. The study found that shareholder's return was not associated with IT investment for firms from all four nations. However, as for the profit ratios, their relationship with IT investment was mixed for the four nations/territories. For example, regarding return on equity, Hong Kong had a positive relationship with IT investment, but Singapore and Malaysia did not have any significant relationship.

Interchange (EDI), multimedia and visualization. The objective Dewan and Kraemer (2000) examined the relationship between IT capital investments and productivity for two separate groups of countries, 22 developed and 14 developing countries. Their study

found significant differences regarding their return from IT investment between developed and developing countries. Developed countries received positive and significant returns from their IT capital investment. On the other hand, there was no significant relationship between IT capital investment and returns in developing countries. This could be explained by many reasons such as the difference of the level of IT infrastructure and the difference of IT enhancing complementary factors between the countries. Andersen (2000) argued for the necessity of research for measuring the benefit of IT in the construction industry in its overall business performance improvement is beyond task-oriented benefits. Although there is sufficient literature on IT and its potential benefits in the construction industry (Bjork, 1993; Li et al., 2000), there has been no significant research effort towards evaluating its performance (Li et al., 2000). Li et al. (2000) investigated the relationship between IT investment and the performance of professional consulting firms from the Hong Kong construction industry. Although Li's study is meaningful due to the fact that it is one of the first attempts to measure the impact of IT on the performance of construction contracting firms, the research was done at a very simplistic level. It considered a few IT investment indexes such as number of personal computers, annual IT budget and IT value as a percentage of total assets. It also considered only one performance variable, the net profit for the employee. The variables of IT investment and firm performance are too simple and do not consider internal and external environmental factors of a firm, which can influence the relationship between IT investment and firm performance. Several studies investigated the benefits of IT spending at a national level since 1970, but most of the early studies until the early 1990s found little or no productivity improvement in spite of heavy investment in IT (Dedrick et al., 2003).

Roach (1988) investigated the contributions of IT investments of the service industry which owned about 84% of the total IT capital share in the U.S. in 1985. When the author estimated information technology capital of the service sector, he considered all the information processing equipment including computerized office machinery, communication equipment and so on. As an output variable for his study, he used productivity indexes published by the American Productivity Centre. According to his study results, technology empowerment was the share of each industry's total capital stock that could be accounted for by information technology products and this had increased 33% from 1970 to 1985. The U.S service sector had experienced a clear slowdown in productivity growth between that period.

INTERNET USAGE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Shi (2007) stated in his study that with the rapid

development of Internet technologies, inter-organizational systems (IOS) based business-to-business e-commerce has been booming since the late 1990s. Like other industries, the Malaysian construction industry has also started to use Internet as much as other industries. Though the main use for internet is limited to emails and information searches, there are also minimal uses related to online bidding and e-meetings. Internet users are blessed with time and cost savings as well as increased efficiency. Even then, there are also certain drawbacks like downloading delays, virus problems and frequent internet connection cut-offs etc. To utilize the full potential of the Internet and not just implementing the basic automation, aspects that are more serious need to be considered so that the Internet and automation would benefit this industry a lot more. Mui et al. (2002) concluded that in recent years in Malaysia the construction industry seems to be using the Internet as much as other industries, which poses two questions. What is the actual level of Internet usage in the construction industry? What are the perceived benefits and disadvantages experienced by the users? Based on the survey, it was found that the respondents have accessibility to the Internet comparable to much more developed countries such as the United States.

It was in 1990 that the Internet Service Provider (ISP) JARING was launched by MIMOS Berhad and Malaysia was connected to Internet. In 1996, the country's second ISP, TMNet was launched by Telekom Malaysia (Rahmah and Yusof, 1999). The Construction Industry Development Board (CIDB) had launched an e-Construction Portal Exchange which is an IT infrastructure to provide maximum and effective means of interaction among the industry actors (Abdul, 2000). Besides this, various portals like Binaonline.com, Buildcom.net, icfox, etc. have emerged as active construction portals in recent years.

According to the findings in the survey of Mui et al. (2002), about 94% of survey respondent firms had Internet access. Among these respondents, only 14% believed that Internet was not important to their firms. Primarily, the reason for accessing Internet is for email whereas the second most popular activity is research or obtaining business information and then comes marketing purposes, etc. Usage of the Internet for designing and estimating purposes is usually carried out only by the firms that work in collaboration with other firms from foreign countries. Concerning the benefits obtained via Internet usage, saving time, cost saving in business deals due to reduction in postal, fax, courier, and other documentation services, business expansion and obtaining new projects, etc. are noted (Mui et al., 2002). Most of the construction companies own their own company websites, which facilitate their advertising needs, company reputation, information of their services and employees, feedback from their clients, e-commerce, online contracting, sharing information, etc.

INFORMATION TECHNOLOGY ADOPTION WITHIN THE CONSTRUCTION INDUSTRY

During recent years, information technology has received a great deal of attention not only from the academic field but also from the business world because of its implementation in an increasing number of companies (Gargallo-Castel and Galve-Górriz, 2007). It has proven to be an integral part of personal life as well as part of daily business activity. The existing studies have documented some of the drivers and barriers of IT adoption within different types of firms including SMEs (Thong and Yap, 1996; Dutta and Evrard, 1999; Thong, 1999; Walczuch et al., 2000; Utomo and Dodgson, 2001; Duxbury et al., 2002; Drew, 2003). Drivers are the positive influences for IT adoption while barriers are negative influences for IT adoption. The drivers and barriers may come from two different sources, those from within the internal SMEs and those from outside SMEs (Sarosa and Zowghi, 2003). Because of the benefits in utilizing IT, many organizations do employ IT in one form or another to manage their knowledge and as such, IT is being used primarily to store and transfer clear-cut forms of knowledge. Furthermore, IT can also be used to support the collaboration and co-operation between people and an instrument to aid the transfer of knowledge and information between project teams, enabling the development of new knowledge for innovation. However, the construction industry has been slow to recognize the benefits of IT as a major communication tool Egbu et al. (2001).

The fact that IT contributes greatly to the convenience and performance of a business has been documented in several studies by Lichtenberg (1995), Brynjolfsson and Hitt (1996), Greenan and Mairesse (1996), Brynjolfsson and Hitt (2000) and Mairesse et al. (2001) that confirm the positive contribution of computers on productivity by using company-level data. Brynjolfsson and Hitt (2000) briefly summarize these microeconomic researches and conclude that IT positively contributes to company productivity.

Some studies showed IT to be beneficial to a company. The study of Fink and Kazakoff (1997) clearly explains the extensive potential benefits that an organization could obtain when it utilizes IT in addition to efficiency gains (for example, the automation of clerical procedures), increased management effectiveness (for example, in decision-making) and improved business performance (for example, by entering into strategic alliances with other firms). Technological developments present potential adapters with the means to solve problems and create opportunities. The falling costs of computer hardware, software and telecommunications and associated performance improvements have enabled organizations to re-examine the way that they conduct business and come up with more cost-effective practices. An evaluation should therefore be made of the IT that is available to a

firm by considering its features, benefits and cost.

As pointed out by Fink and Kazakoff (1997), in the small business domain, IT systems would prove to be invaluable in tracking customer orders, correspondence, delivery and payments. Bonk (1996) has correctly pointed out that in today's global economy even the larger high-technology companies are finding that technical leadership, by itself, is not enough to meet global competition. The most important factor seems to be the ability to deliver a quality product, on time, at a competitive price, anywhere in the world.

The idea of IT importance is further supported by Bonk (1996) who concluded that in the electronic arena, small and large companies alike can combine appropriate resources from anywhere in the world to reach target markets anywhere. These shared resources may include products, marketing, sales, distribution, research engineering, technology transfer, finance and various mutual support services. This ability to share resources is especially important to SMEs that previously lacked the complementary resources to participate in global markets. In reference to Globerman et al. (2001), the Internet has dramatically reduced the costs of point to multipoint communications, making it easier for brokers and other information providers to supply information to their customers. In addition, the relatively low cost of opening a website has made it easier and less costly for those in possession of information to make that information accessible to all, in one well-known (electronic) location. Sarosa and Zowghi (2003) stated that the SMEs need to evaluate the need for IT more comprehensively in terms of why they need IT and explore the relative advantages of IT for their organisations. In other words, SMEs must consider the costs and benefits of using IT. SMEs should find out the foreseeable impact of IT on their business, their customers and suppliers, as well as competitors. The purpose is to measure the effectiveness of the investment and profit gains. At the same time, SMEs need to consider what kind of external assistance such as consultants, government agencies and vendors are available to help them in adopting IT. Last, but not least, SMEs need to consider compliance to the current government policies regarding the use of IT.

SMEs also need to define general requirements for IT solutions (Nikula and Sajaniemi, 2002). The goal at this stage is to determine what kind of IT solution is needed immediately and define the essential features desired. Nowadays, various engineering requirements control the systems available to support organizations in shaping their IT needs. In general, the processes to define the requirements are elicitation, analysis and validation (Hay, 2002). Even though IT has been broadly used for communication in SMEs, the use of IT as a knowledge capture tool is still weak. This may be possibly due to the lack of awareness of knowledge management in the SME. It is their financial and knowledge capture

limitations as well as their weakness in education and training which hinders their IT skills.

Overall, results from past studies indicate that IT adoption has grown tremendously within different types of firms including SMEs (Cragg and Zinatelli, 1995; Thong, 1999). More studies by Bridge and Peel (1999) and Foong (1999) further confirmed that computers in SMEs are mainly used for administrative and operational tasks rather than for strategic planning. Fuller (1996) argued that the key problem of the lack of strategic IT usage in SMEs relates to the relatively poor fit between what the software tools are offering and what is needed, with neither the users nor the suppliers in a strong position to communicate with each other. Malaysian Ninth Malaysia Plan (RMK9) emphasized that the principal SME policy is the development of a competitive, innovative and technologically strong SME sector, which will be able to compete in the global market. Strategies are piloted through the acquisition of technology to move the SMEs up the value chain in the manufacturing, services and agriculture sectors. The Third Industrial Master Plan (IMP3) outlines five clear strategies focused on strengthening the economic foundation of SMEs in the manufacturing, agriculture and service sectors. These are enhancing competitiveness, capitalizing on outward investment opportunities, focusing on technology innovation, providing cohesive and supportive regulatory and institutional frameworks and nurturing the service sector. Muneswari (2008) showed in his study that there are many issues and challenges that the Malaysian SMEs face in their attempt to move forward like a low-level of technology and lack of innovation, financial constraints, lack of international exposure and experience as well as a lack of management experience, etc.

SMEs must actively move forward and look for new opportunities to enhance their competitiveness through strengthening their capability and capacity. Little research has been done in Malaysia to gather information from small and medium sized industries on how and why IT can be applied to business (Ibrahim and Minoi, 2005). Table 2 depicts an elaboration of the importance of IT in relation to the construction industry, which has gained the interest of many researchers all over the world.

SMALL AND MEDIUM CONTRACTING ENTERPRISES (SMCE)

This study defines SMEs differently than earlier studies of construction or other industries. Normally, researchers define SMEs by the number of employees or total assets (Norris, 1984). However, this definition is not practical for the Malaysian construction industry. As a result, construction companies rarely have the number of employees and assets that match their project volume. The same definition is used in other countries like Thailand (Ganeson, 1982). In the construction sector in

Table 2. Summary of previous studies on it adoption in the construction industry in various countries of the world.

No.	Author(s)	Country	Research problem	Research findings
1	Doherty (1997)	New Zealand	A survey was conducted to measure computer use in the New Zealand building and construction industry.	1) Large minority did not use computers or used them only casually. 2) Strategize to change attitudes of those not accepting computer applications.
2	Howard et al. (1998)	Scandinavia	The IT barometer survey summarized in this paper compared results from Denmark, Finland and Sweden on the use of computer hardware, software and communications.	1) Major IT development projects were under way in Finland and Sweden and it was proposed to measure their progress at the half-way stage by surveying the construction industries in about year 2000. 2) Denmark needed more promotion of its IT initiatives and measure awareness of these in the year 2000.
3	Clark et al. (1999)	United Kingdom	To benchmark the use of IT within ten major UK construction companies.	1) The construction industry still had a significant gap to bridge each best practice in its use of IT to support supplier management. 2) The internal exploitation of IT within contractors was more advanced than between the separate legal entities of contractor and supplier.
4	Rivard et al. (2004)	Canada	A survey about the current and planned use of IT and its impact on the Architecture, Engineering and Construction (AEC) industries in Canada had been conducted.	Many business processes were almost completely computerized with tendency toward greater computerization of remaining processes.
5	Andresen et al. (2000)	United Kingdom	The paper presented a new framework for measuring the benefits of IT in construction.	Framework presented subjected to testing and application within UK construction organizations. The results suggested a number of improvements in the benefits realization process.
6	Arif and Karam (2001)	South Africa	A survey was conducted to identify the extent of IT applications in the building construction context of South Africa.	1) The survey revealed major dependency on CAD software. 2) Computer use was clearly concentrated in administration, communication and the core activity of construction drawings production.
7	Samuelson (2002)	Nordic Countries	The paper presented the most significant results from the Swedish survey and a few selected results from the comparison between the three countries (Sweden, Denmark and Finland) regarding the use of IT in the Nordic construction industry.	1) The survey produced knowledge about the use of computers, hardware and software, communications and plans and strategies for IT use. 2) The comparison between Sweden, Denmark and Finland showed that Finland and Denmark had a greater extent of IT adoption.

Malaysia, contractors must register with two government bodies namely the Construction Industry Development Board (CIDB) and Pusat Khidmat Kontraktor (PKK) to

translate the Contractor Service Centre. Before the establishment of the CIDB in December of 1994, contractors had to register with the PKK. However, these two

Table 2. Contd.

8	Mui et al. (2002)	Malaysia	A survey was conducted to measure the actual level of Internet usage and to find the perceived benefits and disadvantages experienced by the users in the Malaysian construction industry.	<p>1) Respondents have accessibility to the Internet comparable to countries such as the US.</p> <p>2) The main use of the Internet is for emails and information searches.</p> <p>3) Provision relevant parties in the industry should look into sufficient infrastructure and IT skills training to enable the workers in this industry to fully utilize the potential of the Internet.</p>
9	Ruthankoon and Ogunlana (2003)	Thailand	This study tested the two-factor theory on Thai construction engineers and foremen following Herzberg's interviewing procedure and compared the results to Herzberg's.	<p>1) Responsibility, advancement, possibility of growth and supervision contribute to job satisfaction.</p> <p>2) Working conditions, job security, on-site safety and relationships with other organizations contribute to job dissatisfaction.</p> <p>3) It was concluded that Herzberg's theory was not entirely applicable in the Thai construction setting. Some factors should receive attention to motivate employees effectively.</p>
10	Rivard et al. (2004)	Canada	Eleven case studies were gathered from across Canada to define an initial compendium of best practice in the use of IT in the Canadian construction industry.	<p>1) The following technologies were demonstrated: 3D CAD, custom Web sites, commercial Web portals and in-house software development.</p> <p>2) The industry could achieve substantial benefits from widespread adoption of IT.</p>
11	Goh (2005)	Singapore	This paper investigated the levels of general adoption of IT in the construction industry.	<p>1) To avoid the "technology for the sake of technology" trap.</p> <p>2) To develop standards, integrated databases and interactive applications.</p> <p>3) Business strategy must support investments in information systems.</p> <p>4) To focus on people, their IT needs and ability to manage change.</p>
12	Peansupap and Walker (2005)	Australia	This paper examined Information and Communication Technologies (ICT) implementation in construction organizations with a specific focus using results from a study of a small but indicative sample of Australian ICT literate construction organizations.	A list of 46 essential variables was developed from integration of three main theories: innovation diffusion, change management and knowledge management.

bodies have similar registration criteria required to be met by contractors. In short, the CIDB contractor classifies grades G1-G7, while the PKK by the classes F- A as shown in Table 3. However, for contractors who wish to

tender for projects in the public sector, they must register with both the PKK and CIDB, but, for private projects, they only have to register with CIDB.

As discussed above, the link between foreign assembly

Table 2. Contd.

13	El-Mashaleh et. al. (2006)	United States	This paper examined the impact of IT on construction firm performance based on data collected from 74 construction firms.	<p>1) Analysis provided empirical evidence that IT was positively associated with firm performance, schedule performance and cost performance.</p> <p>2) No relationship was found between IT usage and customer satisfaction, safety performance or profitability.</p>
14	Zhu and Wang (2007)	China	This paper discussed the categorization, classification, management and revision of information standards for the Chinese construction industry.	A systematic introduction of the system of organization and major issues related to the development and implementation of the system were provided to have better understanding towards the standardization efforts in the Chinese construction industry.
15	El-Mashaleh (2007)	Jordan	This paper reported the findings of conducting a modified version of the IT barometer survey. It benchmarked the current IT usage, availability, and perceived impact in the construction industry in Jordan.	<p>1) The perceived benefits of IT adoption according to the respondents were mentioned.</p> <p>2) The main obstacles of IT use were high investment costs and more knowledge required from staff.</p>
16	Tas and Irlayici (2007)	Turkey	A survey about the current and planned use of IT and its impact on the construction industry in Turkey has been conducted to help in the selection of acquiring building products.	<p>1) The current level of usage and the future expectations for building product information systems have newly become widespread in Turkey.</p> <p>2) The development of building product information systems was said to be an important step to solve many problems in construction industry field.</p>
17	Scheer et al. (2007)	Brazil	The main objective of this paper was to foster a greater understanding of IT and its application in the Brazilian construction industry.	<p>1) Important improvements of international investors' participation in the Brazilian construction market were noticed and consequently more credit availability.</p> <p>2) One of the most important steps to be undertaken was academic research and professional educational efforts that would continually increase IT use in undergraduate civil engineering courses.</p>
18	Oladapo (2007)	Nigeria	Investigate the state of ICT in the Nigerian construction industry; identify its impact in the industry and the constraints to its adoption.	<p>1) The main uses of ICT were identified.</p> <p>2) The top five constraints to the use of ICT were stated.</p> <p>3) A comparison with results of similar studies indicated that IT usage is quite high for a developing country like Nigeria.</p>
19	Samuelson (2008)	Sweden	Describe the development of IT use in construction and facility management sectors during a nine-year period by presenting the most significant results from the Swedish IT-Barometer 2007 survey, with comparisons with the situation in 1998 and 2000.	<p>1) There has been a clear increase in the use of IT in the last few years.</p> <p>2) The possibility of making use of IT to support new ways of working and to make processes more efficient is increasing.</p> <p>3) Contractors have used IT least of all.</p>

Table 3. Contractors' classifications according to total paid up capital.

Registration grade (CIDB)	Registration class (PKK)	Minimum paid up capital (RM)	Minimum project price (RM)	Contractors category (Size)
G1	F	5,000	< 100 000	Small
G2	E and EX	25,000	< 500,000	Small
G3	D	50,000	< 1,000,000	Small
G4	C	150,000	< 3,000,000	Medium
G5	BX	250,000	< 5000 000	Medium
G6	B	500,000	< 10, 000,000	Medium
G7	A	750,000	No limit	Large

firms and local SMEs are relatively limited because of low levels of technology to local SMEs. Entering the year 1990, Malaysia began to fully support industry efforts to further strengthen the promotion of local small and medium enterprises (Karikomi, 1998). SMEs are an integral part in the economic development of a country. At present, Information Technology accelerated the speed of management systems in small and medium enterprises. This section includes the definitions of small and medium enterprises and the role of SMEs in economic development. Additionally, Contractors' Classifications based on CIDB registration have been discussed.

MODELS BRIEF FROM PREVIOUS RELATED STUDIES

There are several research models for the impact of IT on performance at both the organizational and building levels. Weill (1992) showed that all of the important variables that influence the relationship between IT investments and company performance could not be stated with certainty. On the other hand, Trice and Treacy (1988) suggested that linking IT investment in the role of theory without use would not present a clear picture about the impact of IT organizational performance.

Trice and Treacy (1988) concluded that the use of the system, the intervening variable between IT investments and organizational performance could not affect performance, unless it is used in one way or another. Furthermore, they found that most studies have subjective measures, such as reported use, frequency of use or plans to use. Few studies have used unobtrusive and objective measures, such as machine usage statistics, although these are routinely recorded and easily accessible to computers. Such statistics because they do not fall prey to the usual challenges of psychometric validation, present a better picture of IT efficiency than subjective statistics. They further contend that the lack of standardized measures lead to a considerable error.

On the other hand, Trice and Treacy (1988) ignore the

fact that the amount of IT investments is not the efficiency of that use in the plant. In contrast, Kauffman and Weill (1989) in their model aim directly at IT investments and financial performance of a company. They ignore the fact that the impact of IT on the performance of an enterprise may be influenced by many other factors.

Kauffman and Weill (1989) localized IT effectiveness as an important intervening variable that has been ignored by researchers in the relationship between IT investments and organizational performance. McKeen and Smith (1993) proposed a refined model that modeled IT effectiveness as an important moderating variable in the relationship between IT and organizational performance.

Delone and McLean (1992) reviewed 180 articles on the factors contributing to the success of identifying information. The satisfaction of users and IT usage is affected by quality systems and the quality of information affects the individual use of IT, which will be reflected in the performance of the organization. Their research examined IT usage and user satisfaction and that they are complementary variables that play important roles in the studies on the impact of IT.

The model proposed by Weill and Olson (1989) resulted from a review of contingency theory and information system performance. They reviewed 177 articles for the use of contingency theory in the field of Management Information Systems (MIS). This model assumes that a range of factors can affect the performance of IT. Benameur (1999) agree with Weill and Olson (1989) that the better the relationship between these variables, the greater the impact they have on performance.

Based on a previous study by Weill and Olson (1989), another was proposed by Weill (1992). His model was based on contingency theory and important variables that affect the relationship between IT investments and organizational performance. According to his model, IT investment decisions were influenced by activity of the company's strategy. The relationship between IT investment and performance was influenced by many internal factors of a company such as power and politics, the suitability of the structure and size; conversion efficiency that is the ability to convert IT investment in

improving the performance as well as external factors such as the state of the economy and industry. He identified four components of conversion efficiency: Top management commitment to IT, previous experience with IT, user satisfaction with systems and environmental factors.

Lucas (1993) is concerned with how it enhances the performance of companies. He proposed two conditions, which are in the right order that leads to performance results. The first condition necessary should be to design in a way that fits the company's role effectively. No matter how effective IT design is, alone, it is insufficient for organizational performance because technology cannot improve organizational performance, unless technology is used properly. Therefore, the proper use of an effective new technology is a prerequisite for improved organizational performance in Lucas' model.

Lucas (1993) recognized that factors other than the correct use of effective technology developed might affect the performance of a company (for example, competitor reactions). However, the Lucas model considers the appropriate relationship between IT use and performance of a firm as essentially a necessary and sufficient type of relationship if all else remains unchanged. More effective use of technology leads to better performance. This is particularly the case when performance outcome is closely linked to technology. In summary, Lucas' model splits into two sub-models, the first process is an appropriate theory to explain IT usage and the second is a variance theory linked to the use of appropriate IT business values.

Building on Weill's (1992) concept of "conversion effectiveness," Markus and Soh (1993) argued that there cannot be a necessary and sufficient relationship between spending on information technology and improved performance of an organization because some of the investment might be wasted by poor internal IT management processes, such as not implementing the right IT projects or not selecting effectively. Markus and Soh (1993) proposed an interim result that they call "IT assets" between IT investments and organizational performance. IT assets are described as the result of a conversion process where IT spending is a necessary condition. Moreover, like Lucas, they argue that "structural factors" such as company size and industry information intensity affect the ability of an organization to transform IT assets into business value impact.

In summary, this model is divided into two sub-models, processes and theories. The first explains how IT investments may or may not become IT assets. The second explains how IT resources may or may not improve organizational performance efficiency.

Paopun (2000) studied the relationship between IT investments and organizational performance of 249 Thai retailers. IT investment was considered as a percentage of total sales. Five financial ratios were used for the performance of the organization (for example, return

on investment, return on assets, return on equity, change in sales and return on sales). He also analyzed the relationship between IT investments and a number of conditional variable environmental uncertainties (i.e. size and structure of the firm, business strategy and business and human resources). Although no significant association was made between IT investments and financial performance, there was a significant relationship between IT investments and increased IT performance. He also found a number of meaningful relationships between IT investments and business contextual factors. IT investments had positive relationships with environmental uncertainties, the degree of decentralized organization, business strategies such as product innovation and cost. A positive correlation between human resources and financial performance was also found.

CONCLUSION

The review of literature concluded that many studies have been conducted to assess the correlation and impact of IT and related services to companies' performance. There are few issues that are left unanswered, for example, the different degrees of IT between large and SMEs, the areas that IT benefit the most, the ways that IT can be utilized fully and the ways to overcome the hurdles identified in the previous studies.

The purpose of reviewing literature is to gain comprehension of the factors that contribute to the performance of a construction company. The literature showed the relevant definition of terms and detailed discussion of important aspects that gave some empirical background, which will help in carrying out additional study.

The results and conclusions of the previous studies analyzed lack consistency. There is no clear causal relationship between investing in IT and the overall performance of a given company. There need to be more studies that identify the specific type of investment and not just overall cost on the benefit gained. The IT impact was studied in various cases as to its importance for the success of IT rather than the overall performance. The methodologies used were as different as the objectives sought. However, the main and commonly used method for data collection was the questionnaire. Most of the studies were conducted in manufacturing, business, insurance and retail firms in different countries and most of the companies were from developed countries especially in the United States (US). Thus, because construction companies are most active in developing countries, thus, there need to be more studies on the contribution of IT in these countries.

The key purpose of the review is to explore IT effectiveness in previous literature and the impact of preceding studies that described IT impact and to develop a

conceptual model for IT implementation in the Malaysian Construction industry. Models which have been reviewed in this literature are based on the previous studies from holistic theoretical models suggested by Markus and Soh (1993) IT Assets Model, Lucas (1993) appropriate use of IT, McKeen and Smith (1993) IT effectiveness model and Paopun (2000) the relationship between IT investment and organizational use in Thailand retail firms. Each of these studies had contributed to the development of the conceptual model. Unfortunately, none of the reviewed studies provided a comprehensive approach to the issue of IT effectiveness in the Construction Industry especially in a Malaysian context with firms' limited tendering (that is, G3, G4, and G5).

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