

CHAPTER 2

CONSTRUCTION INDUSTRY AND INFORMATION TECHNOLOGY

2.1 Introduction

Information technology (IT) as one of the primary drivers of change in the ways that people work, seek information, communicate, and entertain themselves (Kashorda, 2012; Salin & Abidin, 2011). According to Forrester, nearly 60% of all corporate employees share, access, and manage content outside the office – with their laptops, tablets, and smart phones (Peline, Mines, & Musto, 2011). A report by White (2012) showed that 66% of those surveyed about their remote from work habits and expectations, believe their office will go fully virtual in one to five years time. These indicate that IT continues to change in a rapid pace with no sign of slowing down. The rapid advancement of IT has turned out to be a challenge for construction organizations, instead to be a tool to gain an edge over other competition. Organizations have to select the best IT solutions that may help them gaining competitive advantage. It is very important for construction organizations to cope with this rapidity of IT change to acquire their international credibility by employing advanced IT (Schwab, 2011). Technology change adaptable involves a careful balance between changing the technology to fit the organization, and changing the organization to fit the technology

(Veryard, 2011). Blended aspects should be managed in coping with the rapidity of IT changes, which include the IT infrastructure, people, process, and business environment (Alshawi & Arif, 2011).

The purpose of this Chapter is to understand how the construction industry is managing the rapid pace of IT change in the current economic climate. This Chapter starts with a general overview of IT in the construction industry – it examines current trends of new IT invention within the construction industry as well as the effects on construction management. It continues with discussions on current practices on how construction organizations cope with the technological change, focusing at approaches that support decision-making in developing or procuring IT. The lack of tangible tools and resources for organizations has prompted academic studies on this topic.

2.2 The Construction Industry and IT

What is construction? The purpose of construction activities is to produce artifacts such as buildings, roads, and bridges that involves a process from conception to demolition (Myers, 2001, p. 1). These artifacts are in contrast to other manufactured products; they are located in particular places and need to be constructed on-site rather than in factories. They are one-of-a kind products and it takes a long duration to finish a construction project. The construction process includes the whole life-cycle comprising design, construction, operation and maintenance. During the construction process, manufacturing of the building materials is involved, as well as public planning and activities inspection.

Construction industry is defined as the internal relationships among parties involved, which are formed in their respective economic activities in the entire construction process (Xu, et al, 2005). The concept of a construction market here can be understood as the sum of all purchasing and selling relationships in the construction process in which the parties involved are the main players in the construction market, namely clients, design institutes, construction enterprises, suppliers, and other construction-related companies. This research adopts the definition of construction organizations to be including all parties involved in this market.

Technology is defined as a progressive solutions that have value added to consumer' lives in the form of increased efficiency, security, flexibility or functionality (Woodall, Colby, & Parasuraman, 2007). Hence, the term of 'information technology' refers to any elements where the underlying technological base comprises of computer(s), communications, hardware, software, and network which are brought in from the external environment (Cooper & Zmud, 1990). IT is used to process, transmit, and store information using these technological base (Weill & Olson, 1989).

2.2.1 IT in Construction Context

It is general consensus that IT in construction covers the use of all electronic means of information transfer such as computer networks, local area networks, Internet, mobile phones, faxes, and etc. IT also is seen as the use of latest technology like knowledge-based systems, computer-based decision support system, and object-orientated computer-aided-design (CAD) (Stewart, 2003), while others see it as part of the management strategies and the concepts of concurrent engineering, process re-engineering, and just-in-time production (Galliers & Leidner, 2003). The diversity has

led to a number of different IT definitions in construction. This research adopts an information-centric definition, where IT is defined as *the use of electronic means and programs for the processing, storage, transfer, and presentation of information*. For examples, the use of IT in electronic tendering system, supply chain management, and construction project planning. This demonstrates the key role that IT could play in improving the effectiveness of communication and information exchange between construction partners in the context of managing a construction project from the initial stage to the post-construction phase.

2.2.2 *How IT in Construction is Different?*

In comparing with other industries, there are constraints placed on innovation within construction because of the characteristics of the industry. Adversarial culture and fragmented nature are the main aspect that differs construction and other industries; owing to exclusivity and complexity of each construction project (Alshawi & Faraj, 2002; Brandon & Betts, 1995; Tanyer, 2004). In addition, construction projects involve many parties. The parties engaged in any projects vary in size and carry out distinctive functions where each party has been trained and gained experiences through different educational and professional paths – which makes project integration difficult. On top of that, they work in different organizations and have different value systems and methods of working (Brandon & Betts, 1995; Tanyer, 2004). Also, project teams are almost never the same in different projects. This resulted to different work processes, different computer systems, different skill sets and different individual personalities – each organization has dissimilar level of readiness in adopting IT as each organization has special skills, and different IT capabilities and training procedures (Tanyer, 2004). This situation leads to the separation of life cycle stages of construction projects

between inception, design, construction, and maintenance stages, and it limits introduction of many innovations to the industry (Alshawi & Faraj, 2002).

Construction projects are discontinuous and temporary and there are often poor linkages between project and business processes; even though the purpose of the project is the same from the previous ones, it may differ in terms of engineering design or construction method depending on site's conditions (Bouchlaghem, Thorpe, & Liyanage, 1996). To make matters more difficult, processes are carried out by a myriad of contractors and sub-contractors in different building techniques and methods. This project specific nature within the industry created various issues for rapid assimilation of new ideas within construction firms (Gann & Salter, 2000).

Based on the abovementioned characteristics, construction IT should support products that cannot be described by standardized product models. Construction processes are unique and typically assemble a unique set of partners, and this scenario is totally different from other industries, say banking and manufacturing where they repeat processes millions of times.

2.3 Role of IT in Construction

In the construction industry, IT can be applied to and assist the industry in three main areas; construction management and administration, construction engineering, and automated data acquisition and process control (Underwood & Khosrowshahi, 2012). IT also plays a big role in project management to integrate financial management, human resources, stock management, and machinery maintenance (Chien & Barthorpe,

2010). In construction supply chain, IT is an enabler for a construction business network, from original suppliers of materials, products, and services, to the end users (Deraman, et al., 2011). The use of IT in construction is becoming increasingly sophisticated with virtual reality, knowledge-based systems, and object-orientated approaches among the latest technological advances (Alkalbani, et al., 2012; Stewart, 2003). Construction players also have started to utilize IT as a collaboration tool throughout the whole construction life cycle, as shown in Figure 2.1 (Hore, 2006).



Figure 2.1: Usage of IT tools in construction (Hore, 2006)

2.3.1 Benefits of IT Usage for Construction Organizations

Many researchers have reported the benefits brought by IT to the construction organizations (Ashurst, Doherty, & Peppard, 2008; Ruddock, 2006; UK Contractors Group, 2009). The major advantage of IT is its ability to automate existing work practices without human error. The automation of workflow increases productivity and business turnover, shortens construction cycle time, improves accuracy and consistency of documentation, and increases capacity of an organization to manage larger and more complex construction projects (Gaith, Khalim, & Ismail, 2012). IT also improves quality and usability of information, as well as time and cost saving (Dawood, Sriprasert, Mallasi, & Hobbs, 2001), and this demonstrated a saving of more than 90%

in person per hour (Dawood, 2002). As a result, IT enhances ability of the organizations to satisfy clients' needs on cost and time saving, and transparency of construction information (Lautanala, et al., 1998).

With IT, construction projects can be managed without being on the construction site and provide the possibility of closer collaboration with other remote offices or construction parties. The Extranet, for an example, facilitates contributions from all project team members without the need to meet in one location (Cheng & Kumar, 2012) Communication is improved by using electronic links such as electronic mail, video conferencing, and networks for sharing information (Alaghbandrad, Asnaashari, & Preece, 2012). Additionally, IT can assist in counteracting the problems caused by a lack of integrated project based in this fragmented industry, by supporting exchanges of project information (Atkin, 1999).

IT offers opportunities as strategic method to gain competitive advantage for construction organizations, hence enable new ways of managing, organizing, and developing new business (Bhatt & Grover, 2005). It can be achieved through management efficiency reducing wasted management and administrative energy, as well as providing sophisticated clients with service level improvements (Peansupap, et al., 2003). IT has enabled clients to receive immediate feedbacks that allow organizations to reach fast to clients' demands and let the organization recognize new market niches and positioned them to compete internationally (Apulu & Latham, 2011).

2.4 Understanding Technology Change

Technology is evolving everyday (Lovins, 2012). This rapid change of technology is turning out to be a challenge for many business and industries (Evans, 2011). The words of ‘technology change’ portray the process of technological invention, innovation, and diffusion of technology (Metcalf, 2008). This original model was proposed by Rogers (2005) where he explained that technological process is started with the creation of something new, and it continues by the spread of a technology through a society or industry (please refer Figure 2.2). Rogers (2005) found that the diffusion of a technology generally follows an S-shaped curve as early versions of a technology are rather unsuccessful, followed by a period of high levels of adoption, and finally a dropping off when it will be forgone due to another new technology is created. The Gartner’s Hype Cycle put forward five categories of durations that IT will take to be adopted; some technologies will take less than 2 years whilst many will take 2 to 5 years and 5 to 10 years, not many IT will take longer than 10 years, and few will obsolete before plateau (Gartner, 2010a).

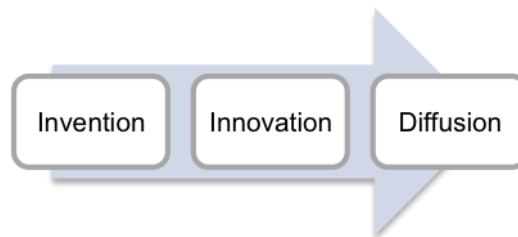


Figure 2.2: Phases of technological change (Rogers, 2005)

2.5 IT Trends in Construction

Historically, personal computers were used only in few construction companies during 1980s (Núria, 2005). Björk (1999) explained that IT was first brought into the construction industry to support activities in creating new information. Björk mentioned that the use of computer-aided design (CAD) in the construction started during the late of 1980's was a significant IT innovation in construction industry, which exclusively used on support for the creation and the viewing of data. In the mid of 1990s, 3-dimensional CAD has established the role of using computer-based building models for design and communication in building projects (Froese, 1999). The introduction of World Wide Web (WWW) in 1993 led to an explosion in Internet usage for commercial uses (Tam, 1999). Virtual Reality (VR) entered construction industry in the early 2000 and was used in the process of design and construction (Li, 2010). Software-as-a-service (SaaS) has becoming accepted in construction industry since 2006 and this technology is used a lot in Cloud Computing – an Internet based development and services, which this technology is still new in the area and it has significant potentials (Gartner, 2008a).

The speculation about the direction of technology rages on daily. As new technologies are experimented, researched and demonstrated, organizations have the difficult task to predict and select the most appropriate technology to be invested. It is expected that computers to become at least as intelligent as humans by the year 2029 (Ford, 2009, p. 2). The Forrester analysts recently predict future IT trends in construction will be in this four categories; “empowered” technology, process-centric data and intelligence, flexible applications, and smart technology management and it is predicted that Software-as-a-service (SaaS) and Cloud Computing will have the greatest

impact on the industry (Leganza, Cullen, & An, 2010b). In addition, other technologies that may continue impacting the industry are Information-as-a-Service (IaaS), Building Information Model (BIM), and next-generation Business Intelligence (BI), and others current technology will be in a mature phase (Erdogan, Abbott, & Aouad, 2010; Gartner, 2011b; McGrawHill, 2009). Forrester (2011) also found that technology areas are most likely to be affected by technology change are applications (37%), production servers (22%), major network infrastructure (19%), database software (12%), and storage (10%).

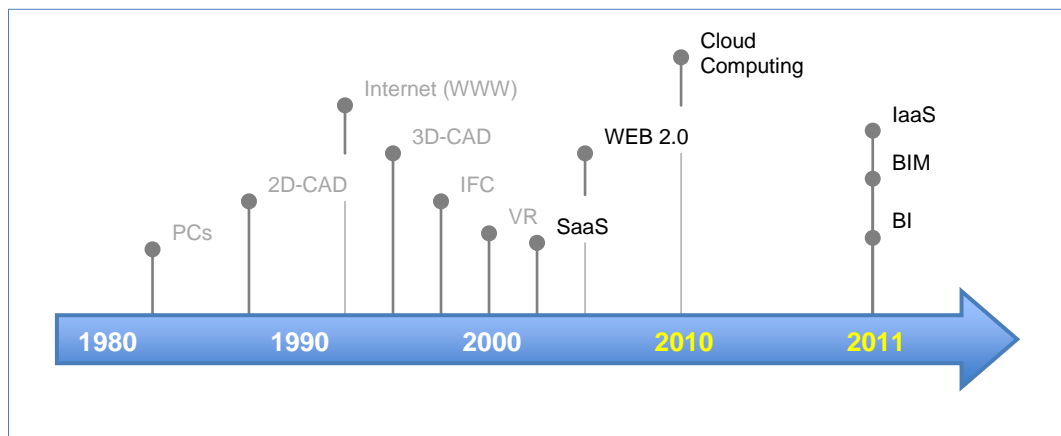


Figure 2.3: Predicted future IT trends in construction industry.

Forrester (2011) found that the IT changes were due to external forces such as changing business conditions, competition, and new regulations. Green (2001) suggested that the main motivation factor for the development of new IT inventions is social; this is divided into four categories, intellectual agenda, economics push, politics, and upgrading existing infrastructure. Mika (2009) suggested that finding and fostering talent as a technology driver. Bossink (2004) found four other factors of IT innovation, which include environmental pressure, technological capability, knowledge exchange, boundary spanning. All these factors are consistent and can be concluded in four categories as below:

- Intellectual agenda – initiatives of leaders and individuals to be better;
- Business competition – influences that force and stimulate organizations to innovate;
- Political agenda – initiatives to co-innovate across the boundaries of departments, organizations, and partnerships, as well as providing financial support at the early stage of new innovation;
- Technological push – technical factors enabling organizations to upgrade and enhance existing technology or develop new innovation products or processes.

2.5.1 The Revolution of IT: How Fast it was?

IT is impacting the advancement of the construction technologies - the more advance the technologies, the more advance IT will be (Omogbadegun, 2010). It is generally believe that the pace of current technology-driven innovation is much faster that it was only seven years ago (Brynjolfsson & Schrage, 2009). Some scholars indicate that the new technologies and inventions are developed and produced everyday (Jurvetson, 2010; Mezo, 2010). Moore's Law stated that the capacity of new technologies doubles every 18 months to 2 years (Mollick, 2006). Internet traffic has been doubling every hundred days (Lovins, 2012). A certainly is that technological change is accelerating and it will continue to impact and reshape the economy, thus, businesses must react quickly to seize the opportunities resulting from any changes. The number of granted patents shows the new inventions has been increasing year by year since the Patent and Utility Innovation Grants¹ were introduced in 1988 (MyIPO, 2011), as shown in Figure 2.4. Up to June 2012, the inventions of new technologies are 1,847 yearly in average, and it marks 5 new technology inventions per day. For the construction industry, it

¹ A patent is an exclusive right granted for an invention, which is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years (WIPO, 2011).

averaged 70 inventions per year (Figure 2.5). This scenario reflects the changing society where new technologies affect everyday life. This further evidence the importance on how to manage the rapidity of IT change becomes a crucial part in most of the organizations that embrace IT.

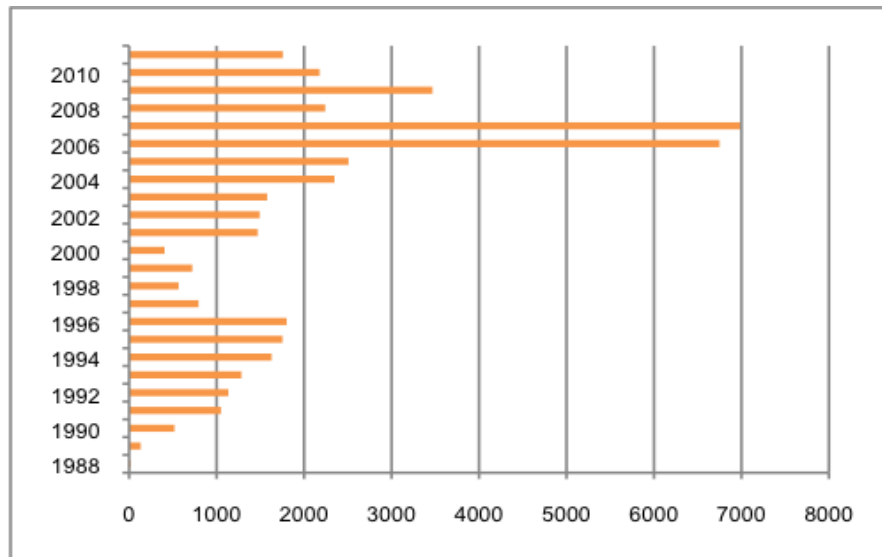


Figure 2.4: Total numbers of Patents granted in the world (MyIPO, 2011)

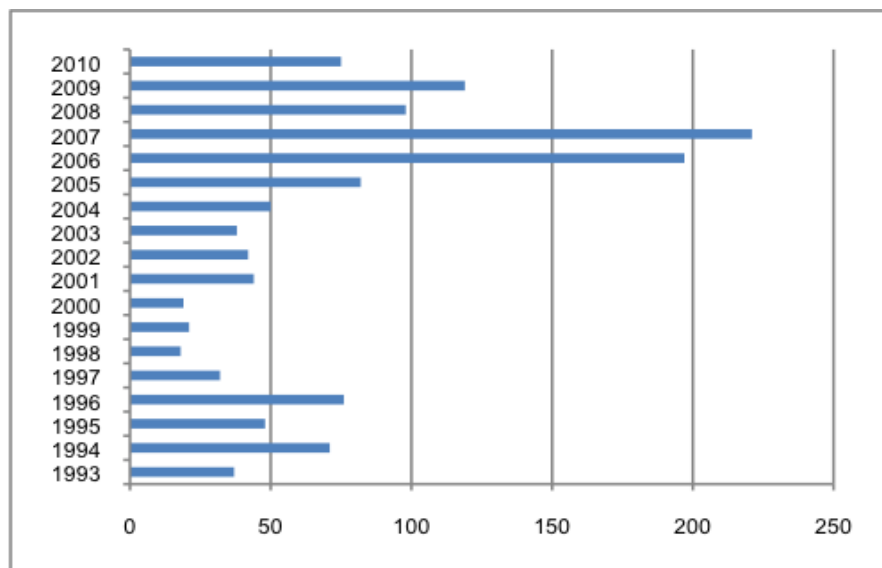


Figure 2.5: Patents granted for the construction sector 1993-2010 (MyIPO, 2011)

2.5.2 IT Investment Trends

In a context of IT investment trends, Salleh (2007) found 6 stages of maturity (please refer Figure 2.6). At the least matured stage, an organization start with ad-hoc investment where IT system are developed or purchased based on what the management sees taking place within other external organizations. In the next level, the organization increases number of IT applications in its IT development plans. Then, short-term development of IT starts to appear with management welcoming user involvement to define needs and requirements, followed by long-term development of IT with an attempt to align business strategy and IT strategy. When the organization becomes more mature in IT, the organization will use IT for adding value of products or services, for supporting supply chain activities, and for supporting strategic and innovative business objectives.

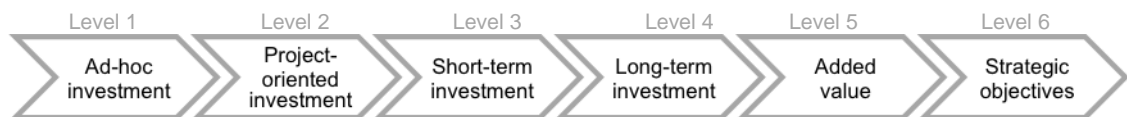


Figure 2.6: IT investment maturity model (Salleh, 2007)

2.6 IT in Malaysian Construction Industry Perspective

The recent Tenth Malaysia Plan 2011-2015 (2010) reported that the Malaysian construction industry's share to gross domestic product (GDP) to be approximately 2.9% with an estimated growth of 3.7% per annum. The report accounted that construction GDP in 2009 was USD5.69 million, and mentioned that the construction industry is expected to employ around 777,000 people or 5.9% of total employment in

year 2015. Based on this projected growth, the Malaysian Construction Industry Master Plan (CIDB Malaysia, 2007) has outlined IT as one of the critical success factors of the industry to accommodate the growing complexities of construction project information and its resources.

Historically, Shahrudin et al. (2010) reported that advanced applications such as digital modeling, global-positioning system, and Internet are incidentally applied in the Malaysian construction industry. Heavy usage of IT was found in three aspects. Firstly, in administration, where the common activities involved are production, editing, and storage of the written word in the form of letters, memos, reports, and documents. Secondly is for communication by using local area networks (LANs) for sharing information and the use of electronic mail. The third is for producing construction specific activities, for example to generate construction drawings using CAD applications, estimations and tender analyses, and project planning. Various software has been created specifically for each profession within the industry to accelerate work processes – rather than with pen and paper.

Bernama (2012) reported that Malaysia was expected to spend USD8.04 billion by year-end of 2012 for IT expenditure, which the amount represents a year-on-year growth of 10.1%. From the total amount, USD7.15 billion was allocated for IT infrastructure (88.7%), and USD0.91 billion was for IT services (11.3%). In previous years, Malaysia's total IT spending in was USD7.35 billion in 2011, and USD5.9 billion in 2010, according to data by International Data Corp (Chin, 2011).

IT was started to get attention with the launch of a long-term project (1995-2020) of the Multimedia Super Corridor (MSC) project in 1996, which the industry

recorded IT expenditure of USD49.6 million (Kaliannan, Raman, & Dorasamy, 2009). The construction industry spent about 4% of the total IT spending in Malaysia for year 1996, and was far behind from other major industries such as banking and finance (27%) and manufacturing spent (13%) in the same year.

IT in Malaysian construction industry is led by the Construction Industry Development Board (CIDB) Malaysia. In 2000, the construction industry spent USD36.5 million on IT, USD41.1 million in 2005, and is expected to increase to USD44 million in 2010 (New Straits Time, 2007). This is reflected by many IT projects under the e-Government initiatives that benefit the Malaysian construction industry. Among these are the electronic tendering, electronic procurement, Project Monitoring System, Land and Property Application System, the G2E portal, the Local Government system and the Integrated Financial Management System. However, these IT systems have been tried in selected local authorities but faced numerous problems such as technical issues, e-readiness, and standardization (CIDB Malaysia, 2007). Notwithstanding, the large-size private construction companies in Malaysia have demonstrated competitive IT implementation within their territories through a recognition of the Malaysian Construction Industry Excellence Awards by CIDB Malaysia, for instance Sunway Construction, Juru Ukur Bahan Malaysia (JUBM), and MK Land. However, by looking the construction industry as a whole, the industry is still lagging behind in term of IT investment as opposed to other industries such as manufacturing and banking (Shaharudin, et al, 2010).

2.7 Implications of Rapid IT Change for Malaysian Construction

Industry

The rapid introduction of new IT has benefited the world in many ways such as upgrading people's lifestyle, provided a myriad of working methods and introduced new skills and job opportunities. The information transfer is now shared more quickly than ever before and this enabled companies to invest in a wide range of ventures around the world. At the same time, the inter-relations between industries become closer (Wangwe, 1995). Furthermore, technological changes increases people interest in knowledge discovery and developing new ideas and this creates healthy environment for future generation.

Despite the advantages of IT, it was reported that rapid technology, policy, and management changes contributed to the IT project failures in Malaysia (Samah, et.al, 2010). When IT changes were not properly managed, it will be a burden to any organizations. The advancement of IT leads to more complex IT system, and it will be more vulnerable to the obstruction of just one part of the system, consequently, the risk and cost of procuring new IT are highly increased (Mukelas & Zawawi, 2012). New skills, knowledge, abilities, and other capabilities are needed in facing IT change. IT operation has become so specialized as to be obscure for majority of organizations (Afuah & Werner, 2007). Technological change also increases staff resistance as new ways of job-done is proposed every time changes are required (Akintoye, Goulding, & Zawdie, 2012). The implications of the rapidity changes in IT can be referred at Table 2.1.

Table 2.1: Implications of the rapidity change in IT

Factor	Positive impacts (Benamati & Lederer, 2001; Shakantu, Zulu, & Matipa, 2002)	Negative impacts
Technology	<ul style="list-style-type: none"> • Information flows faster through all aspects of the construction industry (design, construction, finance, marketing etc.) • Effective communication worldwide. • Real-time communication and monitoring. • Reduce transactions costs. • Marketing improved. 	<ul style="list-style-type: none"> • Increase a risk of overhead if the new IT failure. Increase turnover in investing new IT and send staffs for training. • New IT can become obsolete before its initial use due to lengthy duration of IT acquisition. • Difficulties in knowing the differences between new IT and choosing most appropriate.
Nature of market	<ul style="list-style-type: none"> • Construction companies know more about latest construction product and can recognize new market niche. 	<ul style="list-style-type: none"> • Customers have become more demanding about price and quality. • Customers have a free market from which to choose contractors from.
Globalization	<ul style="list-style-type: none"> • International contractors enter the local market. • Interconnectedness between sectors grows (Wangwe, 1995). 	<ul style="list-style-type: none"> • Increase competition for local contractors. • Local contractors require an international credibility.
People	<ul style="list-style-type: none"> • Number of workers involved in knowledge discovery and application grows. • New and varied IT requires IT professionals continuous training. 	<ul style="list-style-type: none"> • IT managers have difficulties to be experts on all emerging IT. • Turnover generates additional training demands (Benamati & Lederer, 2001).

2.7.1 Current Practices in Coping with Rapid IT Change

For many years, the ability of most industries to manage IT change has been the subject of controversy and debate (Shakantu, et al., 2002). In coping with the rapidity of IT change within the organization, Benamati & Lederer (2001) found five ways that have been used by organizations: 1) training and education, 2) vendor support, 3) endurance, 4) internal procedures, and 5) consultant support. On top of this, product benchmarking is also useful for organizations to help them choosing the appropriate IT solution by making comparison of different IT platforms (Brewer, et al., 2003). Even though proactive action is getting popular, the organizations are still coping the rapid technological change in deterministic way – which means react only when changes occur (Björk, 1999).

Unfortunately, academic research is short of literature in reporting about the current practices used by Malaysian construction organizations in handling the rapid IT changes. To further clarify and understand how the Malaysian construction industry would cope with IT change, interviews with experts in this field were conducted. The experts were Senior Managers from the two construction agencies of the Malaysian government that have had more than 10 year experience in chairing and leading the IT implementation strategic committee in the Malaysian construction industry. Among the projects they have involved include National Electronic Tendering Initiative (NeTI), National Construction Industry Portal, and Modular Coordination Checker. In addition, another experts participated are the Chief Information Officer and the Senior General Manager of Technical, both from the private large construction-property groups in Malaysia that have involved in this construction IT more than 10 year, and they have managed to achieve the Malaysian Construction Industry Excellence Awards due to their advancement in IT implementation among the private construction organizations in Malaysia. Current practices undertaken by the Malaysian construction industry is summarized in Table 2.2:

i. Ad hoc decision-making

By definition, ad hoc is described as "...for the particular end or case at hand without consideration of wider application" (Merriam-Webster, 2011). From a management context, ad hoc decision-making is done only when needed for a specific purpose, without planning or preparation (Macmillan Dictionary, 2011). It is task-oriented problem solving. The Stanford University (1995) reported that construction organizations respond to conditions as they arise, often in an ad hoc fashion and do whatever is necessary to implement change. Changes made in response to external forces such as changing technological

aspect and institutional requirements tend to be the most difficulties. In addition, Howes (2000) emphasized the implementation of IT on the business processes in the construction industry have happened in an unplanned fashion and not through conscious reengineering or preceded by extensive research.

Table 2.2: Different approaches undertaken by construction organizations in coping with technological change.

Approach	Focus	Purpose	Approach Characteristics	Strengths	Weakness
Ad hoc	No focus	Use for IT projects with time constraint and lack of information required.	Case by case basis	<ul style="list-style-type: none"> • Less expensive if properly structured • Amendable based on situations 	<ul style="list-style-type: none"> • No information about the cause-effect relationship • Difficult to review and critic the conclusions of every decision • No continuation in decision-making • Ignore critical issues such as organizational readiness. • Promote change resistance – lack of motivation among IT users.
Outsourcing	Expertise, IT infrastructure.	When no-expertise and manpower in-house to develop IT.	<ul style="list-style-type: none"> • Bind a contract with a third party • The third party provides service of IT development, maintenance, and training. 	<ul style="list-style-type: none"> • Puts failure risks to a third party • Easy to catch up with latest technology 	<ul style="list-style-type: none"> • Expensive. • Lack of control on the desired IT system • Information security will be at risk
Benchmarking	IT infrastructure	Help to define which technologies are used most, based on best practices.	Make a comparison with other industries, or other organizations in the same industry.	<ul style="list-style-type: none"> • Continuous improvement • Knows the existence of present technologies 	<ul style="list-style-type: none"> • Incorrect comparisons may lead to meaningless results • Reluctant to share information limits the result of benchmarking • Best for others does not mean best for everybody

Source: Zainon, et al., (2011)

From the expert interviews, it was found that the management of the Malaysian construction organizations does not structure their problems; hence, it makes ad hoc decision-making more amenable to systematic analysis. Decision making through an ad hoc manner does not have any implementation guideline, thus its flexibility enables the organizations to decide the resolution procedure themselves. The construction organizations perceive to perform this approach because it offers fewer burdens to organize and administer the problem. Usually, organizations prefer to use experts' decisions in every event or technological changes occur, which are based on a unique combination of experience, training, and intuition. It goes the same when other changes arise such as legislation, policy, and customer needs. Ad hoc decision-making is often used to deal with unforeseen problems, especially when the organizations are facing time constraints and lack of information,

The common problem appeared in this approach is that it depends upon the willingness of the parties to agree upon procedures at a time. It requires a greater degree of effort, cooperation, and expertise from the parties. Failure of one or both parties to cooperate can result in an undue expenditure of time in resolving the problems. Hence it often has a risk of increasing costs. In addition, Carrillo et al. (2012) suggests that ad hoc decision making does not promote continuation in decision-making, and styles of decision-making may differ in different organizations Thus decisions made tend to achieve goals, which are limited for short-term objectives.

ii. Outsourcing

According to Gartner (2008b), outsourcing accounted of 8.1% growth in 2008. Outsourcing is not a new concept, its origin can be found in the practice of subcontracting activities (James & Weidenbaum, 1993). Outsourcing is defined as one of allocation or reallocating business activities from an internal source to an external source (Schniederjans, et al., 2005). The external source could be a third party, or from other division or subsidiary of a single corporate entity. By outsourcing, a service provider develops and maintains an IT system, as well as, proving training for its clients.

Within the construction industry, outsourcing is a popular solution for IT (Mahmud, 2008; Sattineni, 2008). The main reasons of outsourcing are cost savings, gain outside expertise, to improve services, focus on core competencies, and to gain access to latest technology (Underwood & Khosrowshahi, 2012). Gartner (2008b) estimated cost savings of 25 to 40% from outsourcing. It is believed that outsourcing can deliver cost reductions for both operations and applications maintenance, as well as improving the value of IT investment (Lacity & Willcocks, 2012). It also shortens cycle times of IT product delivery whilst fulfilling customer needs (Carpenter & Agrawal, 2007).

Outsourcing involves comparatively low initial investment and overhead cost, and it is convenient for keeping up with cutting-edge technology (Khosrowpour, et al., 2011). Therefore, it is a practical solution especially for small and medium-sized companies that do not have enough resources to maintain an in-house IT department and/or a sophisticated networking infrastructure (Chang, et al., 2012). From the experts interview, the Malaysian

construction organizations usually hire IT experts from the outsourced service provider under short-term contracts. The service provider provides knowledge input and technical information and support all the new and existing IT functions and allowing organizations could focus on their core business activities. Therefore, organizations do not have to put extra effort on developing and maintaining IT systems and staff. In addition, outsourcing brings IT systems together and avoiding political problems within the construction organizations (Manmohan, 2010). Despite of its advantages, the IT outsourcing clients has started to realize that outsourcing risks can cause project to fail with greater costs incurred and poorer quality than expected (Lee, Yeung, & Hong, 2011)

iii. Product benchmarking

In order to choose the best technologies in market, findings from the expert interviews revealed that benchmarking approach is practiced in the Malaysian construction organizations. Benchmarking is a process of comparing an organization's performance, processes, or solutions against recognized leaders for the purpose of determining best practices that lead to superior performance (Horta, et al., 2012). The benchmarking approach promotes a culture of continuous improvement (Baggen, Schill, & Visser, 2010). It identifies the best organizations where similar processes exist, and comparing the results and processes of those studied, and usually comes with key performance indicators (KPIs). The KPIs present measurements about the current state of business at the particular milestone (Syuhaida & Aminah, 2007). Further, this approach is capable in detecting changed conditions and potential problems that might arise from the changed situation (Syuhaida & Aminah, 2009).

In the context of IT change, the benchmarking method could help construction IT managers to find the appropriate IT solution by allowing them to make a comparison of different IT systems, as well as, providing an outlook for future performance levels (Brewer, et al., 2003). The experts revealed during the interview that, Singapore and United Kingdom has become the most favorable IT benchmark in the public and private sectors in the Malaysian construction industry. Hence, benchmarking becomes a method to monitor the organization's improvements whilst at the same time to identify the best practice against which organizations can compare and learn (Horta, et al., 2012). Through objective competitor analysis, benchmarking allows construction organizations to measure IT products or services against competitors and best-in-class companies (Brewer, et al., 2003).

However, the experts claimed during the interview, that this approach is done in ad-hoc manner. Different department, different project, and even different construction IT project managers have been using different product benchmarking. Thus this encourages discontinuation in decision-making. In addition, the benchmarking method, however, has its downsides – if used wrongly, it may mislead the organization. What is best for one organization may not be the best for another organization, and comparisons must be made on a similar level. It is important to compare 'an apple with an apple', and not 'an apple with an orange'. Poorly defined benchmarks are wasted effort and provide meaningless results.

2.7.2 Other Proposed Models in Literature

Several attempts have been made to deal with rapid IT change. Literature also proposed other well-described methodology and the research results are presented in Table 2.3. Orlikowski & Hofman (1997) have developed a model for managing technology-based changes for open-ended, customizable technologies or for complex and unprecedented change. This model is an improvised version from the traditional Lewin (1952)'s three-stage change model of “unfreezing, change, and refreezing”. The model distinguishes between *anticipated changes* – changes that are planned ahead of time and occur as intended, *emergent changes* – changes that arise spontaneously which are not predicted, and *opportunity-based changes* – changes that are not anticipated ahead of time but are introduced purposefully and intentionally during the change process in response to an unexpected event. The model spells three interdependent dimensions; the technology, the organizational context, and change model used to manage technological change. This model pre-defines each step to be taken and then controlling events to fit the plan, thus it creates an environment that facilitates improvisation.

The Priority Matrix proposed by Gartner (2010a) helps organizations in prioritizing emerging technologies by looking beyond the hype and assesses technology opportunities in terms of their relative impact on the enterprise and the timing of that impact. The vast majority of technology innovations do make it through the hype cycle (Raskino, 2010).

Koehn & Adler (2010) developed a Change, Adaptation and Learning Model (CALM) that focuses on measuring and addressing organizational readiness to accept and respond to technological changes. The model provides a checklist for formulating,

validating, and executing strategies to enable transformational change. The development of CALM was facilitated by Delphi techniques to estimate values for CALM metrics on a scale 1 to 100. The respondents were from teams of leaders and senior workers drawn from all organizational levels.

Using Cultural Theory derived from Anthropology as a theoretical lens, Jackson & Philip (2010) investigated the role of culture in the management of technological change. They examined the relative effectiveness of the three approaches in the management of technological change, namely, technological determinism, cultural determinism, and techno-cultural emergence. Through case studies and multiple methods such as in-depth interviews, documentary analysis, and observations, the model promotes ongoing attention to unanticipated cultural and technological issues arising over time and space.

Among all the models proposed, Gartner's Priority Matrix is the most popular tools among all, and has been used widely by many industries (Raskino, 2010). This model, however, has limitations where it focuses only at IT application issue, and does not provide information for administering human infrastructure and the business environment managing technological change. After all, none of this tools address the issue of managing technological change problem specifically. The tools are more concern about assisting the right technology and managing people resistance to cope with new technology.

Table 2.3: Proposed models found in literature that cater the issue of coping with technological change.

Tool/Model	Focus	Purpose	Assessment Criteria	Model Methodology	Strengths	Weakness
Model of Change Management Orlikowski & Hofman (1997)	Technical issue in project level	Predicting changes that will occur during system implementation.	<ul style="list-style-type: none"> Anticipated changes Emergent changes Opportunity-based changes 	<ul style="list-style-type: none"> Literature review A case study 	<ul style="list-style-type: none"> Empirically studied. Help in controlling the project plan. 	<ul style="list-style-type: none"> Does not discuss about any unforeseen changes during the IT implementation.
The Gartner's Hype Cycle's Priority Matrix Gartner (2010a)	Management in organization level.	As a guideline in choosing right technology to be adopted in an organization.	Duration of adoption	Not stated.	<ul style="list-style-type: none"> Useful to assess any new technologies. Clearly stated how many years the technology could be adopted. 	<ul style="list-style-type: none"> Neglect people and management issues.
CALM Koehn & Adler (2010)	People and management in organization level.	Measuring and addressing organizational readiness.	<ul style="list-style-type: none"> Organizational mindset People mindset Infrastructure 	<ul style="list-style-type: none"> Delphi technique. Metric values 1 to 100. Respondents were leaders and seniors workers. 	<ul style="list-style-type: none"> Empirically studied Focuses on tangible factors Reduce risks of people resistance 	<ul style="list-style-type: none"> Neglect intangible factors especially on infrastructure
Cultural Theory Jackson & Philip (2010)	Technical and work environment in organization level.	Continuation in upgrading the infrastructure and setting mindset.	<ul style="list-style-type: none"> Techno-cultural emergence 	<ul style="list-style-type: none"> Interviews Documentary analysis Observations 	<ul style="list-style-type: none"> Investigate the role of culture in managing technological change 	<ul style="list-style-type: none"> Does not provide a framework or guideline derived from this theory.

Source: Zainon, et al. (2011)

2.8 Towards Flexible IT Infrastructure

The KMPG survey (2010) shows that organizations are now moving towards having IT infrastructure that is able to react to changes. As organisations spends 70% to 80% of IT budgets on IT infrastructure, it essential to ensure the infrastructure is implemented successfully (Forrester Research, 2009; Gartner, 2010b; Gray, 2009). Upgrading or adopting new technology consumes large investment and risk to the organisation (Hewage, Ruwanpura, & Jergeas, 2008). Hence, this study proposes the concept of IT

infrastructure of being flexible and the idea is further explained and developed in following chapters.

2.9 Conclusion

This chapter summarizes about the trend of new IT inventions in the construction industry and its implications to construction management. Literature review shows that IT can change very quickly and this raised the awareness of importance of organizational IT to be more adaptable to technological changes. However, finding the best tool to cope with the rapid technology change is not easy as the industry is lacking available tools. Based on literature reviews, there are tools available to assist organizations in selecting the right technology, but there is a lack of existing tools specifically for construction organizations; and also to provide insights into factors such as infrastructure, people, and business environment. This chapter demonstrates the significance of proposing a model that can be used by the construction organizations to cope with such situation. The new framework is further explained in the next chapter.

Reference

- Afuah, A., & Werner, R. (2007, June 18-20). *Technological change and the negative effects of embeddedness*. Paper presented at the DRUID Summer Conference on Appropriability, Proximity, Routines, and Innovation, Copenhagen, CBS, Denmark.
- Akintoye, A., Goulding, J., & Zawdie, G. (2012). *Construction Innovation and Process Improvement*. West Sussex: Wiley-Blackwell.
- Alaghbandrad, A., Asnaashari, E., & Preece, C. (2012). Problems and Barriers of ICT Utilization on Iranian Construction Sites: Case Study on the Successful Use of ICT in Remote Construction Sites. *Journal of Information Technology in Construction* 17, 93-102.
- Alkalbani, S., Rezgui, Y., Vorakulpipat, C., & Wilson, I. E. (2012). ICT adoption and diffusion in the construction industry of a developing economy: The case of the sultanate of Oman. *Architectural Engineering and Design Management*.
- Alshawi, M., & Arif, M. (2011). *Cases on e-readiness and information systems management in organisations: Tools for maximizing strategic alignment*. United Kingdom: IGI Global.
- Alshawi, M., & Faraj, I. (2002). Integrated construction environments: technology and implementation. *Construction Innovation*, 2(1), 33-51.
- Alshawi, M., & Underwood, J. (1999). *The application of information technology in the management of construction*. London: Royal Institution of Chartered Surveyors.
- Apulu, I., & Latham, A. (2011). An evaluation of the impact of information and communication technologies: Two case study examples. *International Business Research*, 4(3), 3-9.
- Ashurst, C., Doherty, N. F., & Peppard, J. (2008). Improving the impact of IT development projects: the benefits realization capability model. *European Journal of Information Systems*, 17(4), 352-370.
- Atkin, B. (1999). *Innovation in the Construction Sector*. Brussels: European Council for Construction Research.
- Baggen, R., Schill, K., & Visser, J. (2010, March 15). *Standardized code quality benchmarking for improving software maintainability*. Paper presented at the 4th International Workshop on Software Quality and Maintainability (SQM 2010), Madrid, Spain.
- Benamati, J., & Lederer, A. L. (2001). Rapid IT change, nine IT management challenges. *INFOR* 8(4), 336-358.
- Bernama. (2012, Feb 9). Malaysia's ICT spending to touch RM24.65 Bln by year-end. *Bernama Media*. Retrieved from <http://my.news.yahoo.com/malaysias-ict-spending-touch-rm24-65-bln-end-093611004.html>
- Bhatt, & Grover, V. (2005). Types of information technology capabilities and their role in competitive advantage: an empirical study. *Journal of Management Information Systems*, 22(2), 253-277.
- Björk, B.-C. (1999). Information technology in construction: domain definition and research issues. *International Journal of Computer Intergrated Design and Construction*, 1(1), 1-16.
- Björk, B. C. (1999). Information technology in construction: domain definition and research issues. *International Journal of Computer Intergrated Design and Construction*, 1(1), 1-16.
- Bossink, B. A. G. (2004). Managing drivers of innovation in construction networks. *Journal of Construction Engineering and Management*, May/June, 337-345.

- Bouchlaghem, N., Thorpe, A., & Liyanage, I. G. (1996). Virtual reality application in the UK's construction industry. Retrieved 24 February, 2011, from http://docs.google.com/viewer?a=v&q=cache:P3411GCGroAJ:itc.fgg.uni-lj.si/bled96/papers/bouchlag.pdf+VR+in+construction+industry&hl=en&gl=my&pid=bl&srcid=ADGEEShAd5kjjiaU38RF-34mE5tF79ofDxry1bz-GMZrqLNmU0J4pRCKVl-J5eZulaD2i9n1v-LoXrunNs-7euFu-G-F176Bz8PtA-My-2i9gdMEDUEna0p1dbWia95GQIbnwlfSanhJk&sig=AHIEtbSA2jD3qu3ubb0_MUXNi dqRpIX2iQ
- Brandon, P., & Betts, M. (1995). The field of integrated construction information: an editorial overview. In P. Brandon & M. Betts (Eds.), *Integrated construction information* (pp. xxv-xxx). London: E&FN Spon.
- Brewer, G., Gajedran, T., McCann, J., & Chen, S. E. (2003). Creating a benchmarking service to measure ICT uptake for the Australian construction industry. *Construction Informatics Digital Library*.
- Brynjolfsson, E., & Schrage, M. (2009). The new, faster face of innovation. *2011*(1 March). Retrieved from <http://sloanreview.mit.edu/executive-adviser/articles/2009/3/5139/the-new-faster-face-of-innovation/>
- Carpenter, D. A., & Agrawal, V. K. (2007). Why, when and what to outsource. In M. Schniederjans, A. M. Schniederjans & D. G. Schniederjans (Eds.), *Outsourcing management information systems*. Hershey, USA: Idea Group Publishing.
- Carrillo, P., Ruikar, K., & Fuller, P. (2012). When will we learn? Improving lessons learned practice in construction. *International Journal of Project Management*, Available online 7 November 2012.
- Chang, S.-I., Yen, D. C., Ng, C. S.-P., & Chang, W.-T. (2012). An analysis of IT/IS outsourcing provider selection for small and medium-sized enterprises in Taiwan. *Information & Management*, *49*(5), 199-209.
- Cheng, J. C. P., & Kumar, B. (2012). Cloud Computing Support for Construction Collaboration. In C. J. Anumba & X. Vang (Eds.), *Mobile and pervasive computing in construction* (pp. 237-253). West Sussex, United Kingdom: John Wiley & Sons.
- Chien, H.-J., & Barthorpe, S. (2010). The current state of information technology and communication technology usage by small and medium Taiwanese construction companies. *ITcon*, *15*, 75-85.
- Chin, W. C. (2011). *Malaysia IT spending, 2011-2015: A view from industry and company size segmentations spending*. Kuala Lumpur: International Data Corporation.
- CIDB Malaysia. (2007). *Construction Industry Master Plan Malaysia 2006-2015*. Kuala Lumpur: Construction Industry Development Board.
- Cooper, R. B., & Zmud, R. W. (1990). Information technology implementation research: a technological diffusion approach. *Management Science*, *36*(2), 123-139.
- Dawood, N. (2002). Development of automated communication of system for managing site information using internet technology. *Automation in Construction*, *11*(5), 557-572.
- Dawood, N., Sriprasert, E., Mallasi, Z., & Hobbs, B. (2001, 4-5 October). *Development of an integrated information resource base for 4D/VR construction processes simulation*. Paper presented at the AVR II and CONVR2001, Chalmers, Gothenburg, Sweden.
- Deraman, R., Salleh, H., Beksin, A. M., Alashwal, A. M., Abdullahi, B. C., & Abdullah, A. A. (2011). The roles of information and communication technology (ICT) systems in construction supply chain management and barriers to their implementation. *African Journal of Business Management*, *6*(7), 2403-2411.
- Erdogan, B., Abbott, C., & Aouad, G. (2010). Construction in year 2030: developing and information technology vision. *Philosophies Transactions of The Royal Society*. Retrieved from <http://rsta.royalsocietypublishing.org/content/368/1924/3551.full>
- Evans, R. (2011, February). Technology creates ever-changing leadership challenges. Retrieved November 14, 2012, from <http://www.cpoagenda.com/previous-articles/winter-2010-11/features/technology-creates-ever-changing-leadership-challenges/>
- Ford, M. (2009). *The lights in the tunnel - Automation, accelerating technology and the economy of the future*. United States: Acculant Publishing.

- Forrester Research. (2009, 29 June). US and global IT market outlook: Q2 2009. Retrieved 9 November 2009, from <http://www.forrester.com/Research/Document/Excerpt/0,7211,48356,00.html>
- Froese, T. (1999). Interwoven threads: Trends in the use of information technologies for the construction industry, *A white paper prepared for the Berkely-Stanford CE&M Workshop*.
- Gaith, F. H., Khalim, A. R., & Ismail, A. (2012). Application and efficacy of information technology in construction industry. *Scientific Research and Essay*, 7(38), 3223-3242.
- Galliers, R. D., & Leidner, D. E. (2003). *Strategic Information Management - Challenges and strategies in managing information systems*. Oxford: Butterworth-Heinemann.
- Gann, D., & Salter, A. (2000). Innovation in Project-Based, Service-Enhanced Firms: the construction of complex products and services. *Research Policy*, 29, 955-972.
- Gartner. (2008a). Gartner says Cloud Computing will be as influential as e-business. Retrieved from <http://www.gartner.com/it/page.jsp?id=707508>
- Gartner. (2008b). Gartner says worldwide outsourcing market to grow 8.1 percent in 2008. Retrieved April 11, 2011, from <http://www.gartner.com/it/page.jsp?id=578307>
- Gartner. (2010a). Gartner's Hype Cycle Special Report for 2010. In J. Fenn, B. Gammage & M. Raskino (Eds.): Gartner Group.
- Gartner. (2010b, 18 May). IT spending to rise 4.1% in 2010, Gartner says. Retrieved 19 July, 2010, from <http://www.networkworld.com/news/2010/051910-gartner-it-spending-rise.html>
- Gartner. (2011). Predicts2011: Gartner's predictions for the year ahead. Retrieved 24 February, 2011, from <http://www.gartner.com/technology/research/predicts/>
- Gray, M. (2009). The NHS Infrastructure Maturity Model (NIMM).
- Green, L. (2001). *Technoculture*. Crows Nest: Allen&Unwin.
- Hewage, K. N., Ruwanpura, J. Y., & Jergeas, G. F. (2008). IT usage in Alberta's building construction projects: Current status and challenges. *Automation in Construction*, 17, 940-947.
- Hore, A. (2006). Use of IT in managing information and data on construction projects - a perspective for the Irish construction industry. *Information Technology in Construction Project Management*.
- Horta, I. M., Camanho, A. S., Johnes, J., & Johnes, G. (2012). Performance trends in the construction industry worldwide: an overview of the turn of the century. *Journal of Productivity Analysis* Retrieved November 15, 2012, from <http://repositorio-aberto.up.pt/bitstream/10216/62520/2/30770.pdf>
- Howes, R. (2000). Making governance mechanisms effective in a coordinated industry: the case of construction in the United Kingdom. *International Journal of Technology Management*, 20(1), 194-213.
- Jackson, S., & Philip, G. (2010). A techno-cultural emergence perspective on the management of techno-change. *International Journal of Information Management*, 30, 445-456.
- Jafari, S. M., Yusuff, R. M., & Tang, S. H. (2006). ERP Systems Implementation in Malaysia: The Importance of Critical Success Factors. *International Journal of Engineering and Technology*, 3(1), 125-131.
- James, H. S., & Weidenbaum, M. (1993). *When business cross international borders*. Westport: Praeger.
- Jurvetson, S. (2010). The pace of innovation never falters. *Technology Review by MIT*. Retrieved from <http://www.technologyreview.com/business/24562/>
- Kaliannan, M., Raman, M., & Dorasamy, M. (2009). ICT in the context of public sector service delivery: a Malaysian perspective. *World Scientific and Engineering Academy and Society (WSEAS) Transactions on Systems*, 8(4).
- Kashorda, M. (2012, September 19). *ICT innovations changing lives in Kenya*. Paper presented at the 2nd OECD Global Forum on Knowledge Economy, Seoul, South Korea.
- Keen, P. (1991). *Shaping the future: Business design through information technology*. Boston: Harvard Business School Press.
- Khosrowpour, M., Subramaniam, G. H., Gunderman, J., & Saber, A. (2011). Managing information technology with outsourcing: An assessment of employee perceptions. *Journal of Applied Business Research*, 12(3), 85-96.

- Kline, R., Dolene, M., & Turk, Z. (2009). *Possible benefits of Web 2.0 to Construction Industry*. Paper presented at the International Conference on Information Technology in Construction, Santiago, Chile.
- Koehn, D. J., & Adler, R. (2010). CALM (change, adaptin, learning model) - Dealing with change holistically and dynamically. Retrieved from <http://www.articlesbase.com/management-articles/calm-change-adaptation-learning-model-dealing-with-change-holistically-and-dynamically-2463039.html>
- KPMG IT Advisory. (2010). From cost to value: 2010 global survey on CIOs agenda: KPMG International.
- Lacity, M., & Willcocks, L. (2012). Outsourcing business and IT services: the evidence of success, robust practices and contractual challenges. *Legal Information Management*, 12, 2-8.
- Lautanala, M., Enkovaara, E., Heikkonen, A., & Taiponen, T. (1998). Potential benefits of information technology in construction in Finland. *Exchange*, 60, 80.
- Lee, C. K. M., Yeung, Y. C., & Hong, Z. (2011, June 27-30). *Managing the risks of outsourcing in supply chain networks*. Paper presented at the IEEE International Technology Management Conference (ITMC), San Jose, California.
- Leganza, G., Cullen, A., & An, M. (2010a). The Top 15 Technology Trends EA Should Watch: 2011 to 2013. *Forrester Research*.
- Leganza, G., Cullen, A., & An, M. (2010b). The top 15 technology trends EA should watch: 2011 to 2013. *Forrester Research*.
- Lewin, K. (1952). Group decision and social change. In E. Newcombe & R. Harley (Eds.), *Readings in Social Psychology* (pp. 459-473). New York: Henry Holt.
- Li, M. (2010). *Applications of virtual reality technology in construction industry*. Paper presented at the 2nd International Conference on Computer Engineering and Technology (ICCET) 2010.
- Lovins, A. B. (2012). Response. In J. Wilsdon (Ed.), *Digital Futures: Living in a Networked World* (pp. 69-71). London, United Kingdom: Earthscan Publications Ltd.
- Macmillan Dictionary. (2011). Ad hoc. Retrieved April 12, 2011, from Macmillan Publishers Limited: <http://www.macmillandictionary.com/dictionary/british/ad-hoc>
- Mahmud, K. H. (2008). *Outsourcing in Construction Industry*: Fraser Milner Casgrain.
- Manmohan. (2010). Keepmoat CIO Andrew Newton: Outsourcing is natural to construction trade. Retrieved 9 February 2011, from <http://www.theoutsourcemap.com/2010/07/keepmoat-cio-andrew-newton-outsourcing-is-natural-to-construction-trade/>
- McGrawHill. (2009). SmartMarket Report, the business value of building information modeling: getting building information modeling to the bottom line.
- Merriam-Webster. (2011). Ad-hoc. Retrieved April 12, 2011: <http://www.merriam-webster.com/dictionary/ad+hoc>
- Metcalf, S. (2008). Technical change. *The New Palgrave Dictionary of Economics*, 2nd Ed.
- Mezo. (2010). Amazing technology: New amazing technologies. Retrieved 1 March, 2011, from <http://hubpages.com/hub/Amazing-technology>
- Mika, S. (2009). The four drivers of innovation. Retrieved Mar 29, 2011: <http://gmj.gallup.com/content/26068/the-four-drivers-of-innovation.aspx>
- Mollick, E. (2006). Establishing Moore's Law. *Annals of the History of Computing, IEEE*, 28(3), 62-75.
- Mukelas, M. F. M., & Zawawi, E. A. (2012). *Theoretical framework for ICT implementation in the Malaysian construction industry: Issues and challenges*. Paper presented at the International Conference on Innovation Management and Technology Research (ICIMTR).
- Myers, D. (2001). *Construction Economics: a new approach*. New York: Spon Press.
- MyIPO. (2011). Intellectual Property Corporation of Malaysia: Patent Statistics. Retrieved 1 March, 2011, from http://www.myipo.gov.my/index.php?option=com_content&view=article&id=160&Itemid=327
- New Straits Time. (2007, December 5). Leverage on ICT in construction industry. *New Straits Times*.

- Núria, F. M. (2005). *Life cycle document management system for construction*. University Politechnic of Catalunya, Catalunya.
- Omogbadegun, Z. O. (2010, July 13-22). *ICT & Property Networking*. Paper presented at the Information Communications Technology and Real Estate Property Networking Workshop, Ota, Nigeria.
- Orlikowski, W. J., & Hofman, J. D. (1997). In improvisational model of change management: The case of Groupware Technologies. *Sloan Management Review, Winter*.
- Peansupap, V., Walker, D. H. T., Goldsmith, P. W., & Wilson, A. (2003). *Developing within-company information and communication technologies (ICT) innovation diffusion networks: a study of three Australian major contractors*. Paper presented at the 19th ARCOM Conference.
- Peha, J. M., & Strauss, R. P. (1997). A primer on changing information technology and the firm. *Department of Engineering and Public Policy, 37*. Retrieved from <http://repository.cmu.edu/epp/37>
- Peline, M., Mines, C., & Musto, S. (2011). The rise of wannabe and maverick mobile workers. *Forrester Research, February 16*.
- Raskino, M. (2010). Google Wave is following the Gartner Hype Cycle. Retrieved Mar 28, 2011, from Harvard Business Press:
- Rogers, E. M. (2005). *Diffusion of Innovations* (5th Edition ed.). New York: Free Press.
- Ruddock, L. (2006). ICT in the construction sector: computing the economic benefits. *International Journal of Strategic Property Management*.
- Salin, A. S. A. P., & Abidin, Z. z. (2011). *Information and communication technologies (ICT)s and a Smart City in Malaysia*. Paper presented at the 2010 International Conference on Business and Economics Research, Kuala Lumpur, Malaysia.
- Salleh, H. (2007). *Measuring Organisational Readiness Prior to IT/IS Investment*. University of Salford, Salford.
- Salman, A. (2009). ICT, the new media (internet) and development: Malaysian experience. *The Innovation Journal: The Public Sector Innovation Journal, 15*(1), Article 5.
- Samah, B. A., Shaffril, H. A. M., D'Silva, J. L., & Hassan, M. A. (2010). Information communication technology, village development and security committee and village vision movement: a recipe for rural success in Malaysia. *Asian Social Science, 6*(4), 136-144.
- Sattineni, A. (2008). Outsourcing and off-shoring: Options for the US construction industry. *International Business & Economics Research Journal, 7*(5), 59-66.
- Schniederjans, M. J., Schniederjans, A. M., & Schniederjans, D. G. (2005). *Outsourcing and insourcing in an international context*. Armonk, New York: M. E. Sharpe.
- Schwab, K. (2011, September 7). *Country Highlights of the Global Competitiveness Report 2011-2012*. Paper presented at the World Economic Forum, Geneva, Switzerland.
- Shaharudin, M. W., Ibrahim, I. F. C., & Ismail, N. A. (2010). *ICT Usage in Malaysia Construction Market*. Universiti Teknologi Mara, Shah Alam.
- Shakantu, W., Zulu, S., & Matipa, W. (2002). *Global drivers of change: Their implications for the Zambian construction industry*. Paper presented at the CIB W107 1st International Conference: Creating a sustainable construction industry in developing countries, Stellenbosh, South Africa.
- Stanford University. (1995). New information technology slowly transforming construction industry. *Stanford University* Retrieved from <http://news.stanford.edu/pr/95/950829Arc5107.html>
- Stewart, R. A. (2003). *Lifecycle Management of Information Technology (IT) in Construction*. Griffith University.
- Syuhaida, I., & Aminah, M. Y. (2007, August 28-29). *Developing the deliberative key performance indicators (KPIs) in assessing the performance of public infrastructure provision via private finance initiative (PFI) in Malaysia*. Paper presented at the MICRA 2007 6th Conference and Annual Meeting, Shah Alam, Malaysia.
- Syuhaida, I., & Aminah, M. Y. (2009). Benchmarking the performance of Malaysia's construction industry. *Management Research and Practice, 1*(1), 1-13.

- Tam, C. M. (1999). Use of the internet to enhance construction communication: Total Information Transfer System. *International Journal of Project Management*, 17(2), 107-111.
- Tanyer, A. M. (2004, 18-21 February). *Developing evaluation criteria for computer integrated construction: a usability analysis with end users*. Paper presented at the The World IT Conference for Design and Construction (INCITE), Langkawi, Malaysia.
- Tenth Malaysia Plan 2011-2015. (2010). Tenth Malaysia Plan. Retrieved April 18, 2012
- UK Contractors Group. (2009). *Construction in the UK Economy: The Benefits of Investment*. London: L.E.K Consulting.
- Underwood, J., & Khosrowshahi, F. (2012). ICT Expenditure and Trends in the UK Construction Industry in Facing the Challenges of the Global Economic Crisis. *ITcon*, 17, 26-42.
- Veryard, R. (2011). Technology change management. Retrieved Mar 29, 2011, from <http://www.linkedin.com/in/richardveryard>
- Vouk, M. A. (2008). Cloud computing - issues, research, and implementations. *Journal of Computing and Information Technology*, 16(4), 235-246.
- Wangwe, S. M. (1995). New technologies and the implications of changing technological conditions *Exporting Africa: Technology, trade and industrialization in Sub-Saharan Africa*. London: Routledge.
- Weill, P., & Olson, M. H. (1989). An assessment of the contingency theory of management information systems. *Journal of Management Information Systems*, 6(1).
- White, C. (2012, March 11). Survey: Telcommuting becoming more prevalent [infographic]. Retrieved 2012, October 18, from <http://mashable.com/2012/03/11/telecommuting-infographic/>
- WIPO. (2011). World Intellectual Property Organisation. *Intellectual Property - some basic definitions* Retrieved 1 March, 2011, from http://www.wipo.int/about-ip/en/studies/publications/ip_definitions.htm
- Woodall, R. D., Colby, C. L., & Parasuraman, A. (2007). "E-volution" to Revolution. *Marketing Management*, 16(2), 29-34.
- Zainon, N., Rahim, F.-A., & Salleh, H. (2011). The information technology application change trend: Its implications for the construction industry. *Journal of Surveying, Construction & Property (JSCP)*(Special Issue), 6-20.
- Zainon, N., Salleh, H., & Rahim, F.-A. (2011). Coping with the Rapidity of Information Technology Changes - A Comparison Review on Current Practices. *World Academy of Science, Engineering, and Technology*, 80, 427-433.