

# **A Critical Review on Sustainable Information Technology in the Construction Industry**

**Dr. Brenda Yip**  
**The University of Hong Kong**

This paper investigates the extent of use and management of information technology towards its strategic sustainability by critically reviews on literature. The study focuses on the business firms in the construction industry as efficient and effective information flow is crucial to successful information sharing and learning among internal and external project participants; as well as the development of strategies to meet the requirement of clients. The paper presents the concepts and manner. The review found that it is necessary to determine the applicability of IT to specific construction firms, the selection of the appropriate IT tools and systems to develop (hardware), and the means of managing IT (software) to support the sustainability goal of the business firm. This study suggests that it is necessary to change the perspectives of IT tools and systems from a technical to a strategic perspective. This is necessary to integrate IT into the corporate culture expressed through policies and techniques directed towards sustainability. Comprehensive integration of IT into the various areas of business operation constitutes an effective strategic management of IT towards sustainability.

**Keywords:** construction industry, information technology, strategic management, sustainability

## **Introduction**

Business organizations deal with a number of challenges amidst the globalization of industries. One general challenge is the fast-paced change experienced by business firms brought about by the flow of business activities into and out of industries and the various countries where businesses operate. Complex business flows change the business environment such as international supply and distribution chains including the outsourcing of aspects of operations from one business firm to another or from one country to another. Cross-border business relations need establishing, to take advantage of cost-savings and logistics advantages. Business firms flexible to emerging opportunities and adept at managing change, as core strategies, hold greater potential to succeed when compared to firms operating under systems unyielding to change. Another general challenge is surviving the stringent competition under the three areas of resources access and utilization, competency and skill acquisition, development and retention, and market share expansion. Management of businesses firms cannot neglect these challenges (Moore & Wen, 2007). Strategic management comprises a core aspect of the management task since this involves the determination of decisions and policies to make the business firm succeed amidst all changes in the business environment and stringent competitiveness. Strategic management becomes a necessary process in ensuring the viability or sustainability of business firms. An emerging tool for business firms operating in a complex business environment is IT, which supports knowledge management, operation systems, communications among business units, and other networking or linkage benefits. IT has found close ties with strategic management and sustainability. IT needs management as a strategy to support sustainability. A thriving industry that experienced rapid changes and stringent competition is the construction industry. Although, a number of studies have already focused on IT in the construction industry, there is still need to investigate further IT management within the strategic and sustainability context in the case of the industry. The paper investigates the extent of IT management as a strategic and sustainability concept by looking at literature on the construction industry.

## **Strategic Management**

Strategic management comprises a content as well as a process aspect (Drejer, 2002). In this sense, content pertains to the issues that the parties charged with strategy deal with, while process encompasses the manner of deriving strategic decisions.

As a process, strategic management involved two major perspectives. One perspective considers strategic management as a planning process, while the other perspective deems strategic management as a synthesis process. As a planning process, strategic management follows the scientific method by covering various tasks based on Ansoff's theories. First task is the development of the strategic mission and vision as the framework of the strategic decision-making and planning. Second task is the identification of objectives to direct or guide the strategic implementation. Third task is the development of specific strategies intended to facilitate the achievement of the objectives. Fourth task is the implementation and execution of the specific strategies by assigning specific tasks and managing the contributions of the different industry players. Fifth task is the evaluation and adjustment of strategy implementation to accommodate intervening factors or redirect implementation towards the pre-determine objectives (Coulter, 2007).

These tasks are progressive but flexible to allow business firms to go back to the previous phases for readjustments as needed, based on the results of continuous assessments. Moreover, these tasks could be further broken down into specific sub-tasks to operate according to the needs and objectives context of particular business firms. In addition, the period allocated for each task is also variable since business firms may take more time in the development of specific strategies than other firms due to relative complexities experienced by business firms. Strategic management process involves difficulties and challenges depending upon the characteristics of business firms but recognizing that strategic management is a purpose-driven process should facilitate the completion of the process and the achievement of objectives using the objectives and specific strategies as guides.

As a synthesis process, strategic management involves the derivation of practical knowledge from experiences and translating these into operating rules to guide future actions based on Mintzberg's conception of strategic management. This perspective was a reaction to Ansoff's planning concept of strategic management since Mintzberg propounds that managers cannot actually fathom all aspects of strategic management through the planning process. The application of strategic management involves the process of collating everything that managers learn from different experiences of the business firm and synthesizing these lessons into visions of the area and direction that business firms should pursue in the future (Harrison & St. John, 2007).

As a synthesis process, strategic management takes on the form of a learning process where strategies depend upon the specific experiences of the business firm. This means that managers need to embody receptive skills for learning such as recognizing problem and success areas, determining alternative options or actions, and identifying a course of action and direction based on the future needs and objectives of the business firm. In this sense, the strategic management process greatly relies on the competencies of managers. As content, strategic management involves various issues or aspects that business firms should focus on including product-to-market strategies and the development of competencies (Drejer, 2002). Strategic management encompasses a broad scope including human resource management, customer service provision, marketing, product development, and supply chain management. This means the need for the development of collaborative relationships among managers handling these various aspects in order to ensure that the derivation of lessons encompass all these areas.

## **Strategic Management of IT**

Strategic management involves learning and translation of lessons into specific strategies. Learning constitutes the common factor of strategic management and IT since IT constitutes the process of collecting, collating and sharing information to various parties involved in the business firm using innovative technologies. IT encompasses communication tools such as email and mobile phone technology together with linkage tools such as intranet systems and Internet tools such as firm websites and online advertising channels. All these tools offer the benefits of easing the derivation of learning to support the development of specific strategies directed towards sustainability (Betz, 2001 & Willcocks, Feeny & Islei, 1997). Although the methodological soundness and factual veracity are

suggested to be the two criteria in evaluating the 'design school' of strategic management (Mintzberg, 1990), current practice of management has failed to address these two factors in presenting strategic behavior (Ansoff, 1991).

These benefits are classified under four categories (Thorp, 2003). First category is improvements in productivity performance on a number of aspects including cost reduction, process and systems upgrades, and increased channels of product or service delivery. IT influences the reduction of costs through the processes of automation and dematerialization. Shifting from manual to automated task completion, as long as the developed automation process captures the pre-determined objectives, would minimize mistakes or errors that lead to wastage of raw materials and delays in production or service delivery. In addition, various IT tools have achieved popularity leading to the derivation of various processes and systems for different business firms and industries. Due to the accessibility of IT tools to business firms, automation comprises a cost-effective alternative for most business firms. Moreover, the shift from IT tools has also eliminated the use of materials such as paper in communication with the popularity of emails and audio-visual communications. Second category is the enhancement of the business results of firms measured through financial and non-financial measures. Financial measures include rates of profitability and revenue generation, risk assessments, financial leverage ratios, and rate of investment. Non-financial measures involve the development of competencies and retention of employees, derivation of intangible assets, and achievement of intended business values. IT tools facilitate the easy derivation of results from financial and non-financial measures to provide the company with data to support the derivation of lessons necessary in the development of specific strategies directed towards the achievement of business sustainability. Third category is the improvement in the performance of individual employees and business units or departments. Although the development of performance measures or standards does not necessarily involve IT tools and systems, IT enhances the implementation of these measures through the provision of ways of collating, organizing and analyzing data on individual and group performance for comparison purposes as well as the effectiveness of existing policies to support generalizations on strategic direction such as whether to continue or change the implemented work performance and goal achievement policies. Fourth category is the reliability of IT project delivery through various IT tools. Most IT tools and systems have received recognition through the ability to meet intended results such as IT transformation of business firms expressed through the placement of communication channels for members of the organization as well as for customers.

IT tools and systems enhance strategic management at the same time that the management of IT also supports the development of better strategies. Either way, the links between IT and strategic management supports business sustainability by using IT to improve measures and networking and the effective selection of IT tools and systems appropriate for the particular context of the business firm. Nonetheless, IT needs integration into strategic management in order to support learning and strategic planning. Further investigation of this relationship continues with a look into the case of the construction industry.

## **Characteristics of the Construction Industry**

The construction industry is turbulent because of the greater number of international players expanding their operation to domestic markets and the emergence of new issues in the business environment such as the shift towards service orientation by the industry and the need for specialized skills with the sophistication of the demands of clients (Zeng, Lou & Tam, 2007). Due to these developments in the construction industry, many existing construction companies found it difficult to compete with global construction companies that have developed competitive competencies these use in ensuring their leadership or top position in the global industry and in achieving their business objectives. Construction firms seeking competitive positions in the domestic and international market need to enhance value creation through the quality of their services and the levels of productivity.

The construction industry can be described as complex requiring firms to manage various aspects such as overseeing the scope of the construction project, controlling the cost incurred during construction activities, keeping tabs of the schedules of the project phases, and handling the different issues arising in the course of construction (Schwegler et al, 2001). Moreover, construction projects usually involve a long period segmented into different phases, different internal and external parties, different skills and competencies, various levels of expectations, and different standards. Managers need to understand these complexities and take control of these areas in order to ensure that the ensuing activities of the business firm all contribute to the achievement of objectives including the completion of the

construction project to the satisfaction of the client and the achievement of the intended level of performance and productivity. Commonly, performance measures covering both financial and non-financial aspects are useful in assessing the project completion process. Planning, assessment, and learning all fall under strategic management so that this concept applies in the construction industry by enabling business firms to recognize all the areas of complexity and work through these based on lessons from previous experiences as bases for plans and readjustment of plans. A way of dealing with complexity and the continuous improvements of practices is the utilization of quality as framework of operations.

The core business value of the construction industry is quality because of the implications of quality work to the satisfaction of clients and the performance of the construction company (Oakland, 2006). Many construction firms apply for ISO quality certifications as evidence to their clients of their adherence to quality standards. Quality standards applicable to the construction industry include ISO 9000:2000 focusing on quality management. Construction organizations awarded this ISO certification have to comply with certain obligations including: 1) meeting the quality requirements of clients; 2) adhering to other industry and government regulatory requirements; 3) ensuring the satisfaction of clients; and 4) achieving the continuous flow of performance improvements as a means of meeting these quality standards. Many construction companies sought ISO 9000:2000 certification since the introduction of the standard in 1987 (Zeng, Lou and Tam, 2007). Another ISO standard adhered to by the construction industry is ISO 9001:2000 that identifies the specific requirements needed to ensure the establishments of systems of quality management (Oakland, 2006). The system of quality management of individual construction firms should express the firm's capability of meeting the requirements of clients in a consistent manner and the commitment of the construction firm in continuing performance improvements. ISO 9000:2000 constitutes the guide for quality management while the ISO 9001:2000 contains the auditing kit for construction firms adhering to ISO quality management standards (Oakland, 2006). Studies on the impact of applying management standards show that these contribute to improvements in process control, systems efficiency, enhanced productivity, as well as improved customer service. Registrations for ISO 9000:2000 certifications have increased to half a million. Out of this number, construction firms receive one third of the certifications (Zeng, Lou and Tam, 2007).

A core element of quality management is information flows to support the derivation of learning and the development of strategies to meet the requirements of clients (Oakland, 2006). Information sharing involves knowing the quality requirements of clients, the expectations of project supervisors, the performance and project management measures, the potential contributions of subcontractors, and the availability of suppliers and skill resources. In addition, construction firms also require information sharing on internal aspects with bearing on the completion of construction projects such as the structure of the organization determining the communication channels, the plan for quality management, the extent of knowledge about existing construction equipment and technology, and the sharing of necessary information to draw the cooperation of workers in contributing to the completion of the construction project (Zeng, Lou and Tam, 2007). All internal and external information need to be organized, processed and analyzed before translation into policies on quality management objectives and strategies intended to ensure the achievement of these objectives. IT tools and systems aid in the processing of information for learning and strategic planning in the construction industry.

## **Strategic Management of IT in the Construction Industry**

Strategic management of IT in the construction industry captures the turbulence and complexity of the construction industry and highlights the importance of the specific area of quality management and the broader sphere of strategic management in achieving sustainability. Succeeding discussions focus on the areas of operation of construction firms where IT is used, the extent and manner of IT utilization, benefits and problems experienced in managing IT as a strategy, and the means of dealing with these issues. These reflect the strategic management of IT in the construction industry.

### *IT Use and Management in the Construction Industry*

The use of IT in the construction industry is discussed by dividing into IT use in the processes of construction projects and in the management areas of construction firms (Lautanala et al., 1994). IT finds use in the two general

process categories of operative and supporting processes. The operative processes directly relate to the stages of the commencement up to the completion of construction work. Processes during the commencement of the construction of the project includes information-sourcing, analysis of the needs of the clients, documentation, design of the construction plan and strategies, logistics, and marketing design to the client. During the course of construction up to completion, the operative processes that use IT include project management, documentation, logistics, and performance measures. IT tools and systems, especially computer-aided design (CAD), has become a standard among construction firms covering the operative processes of design and planning. Derivation of information and communication with the client involves the use of electronic channels such as email, video conferencing, and SMS or MMS mobile technology. The supporting processes refer to the areas intended to aid the accomplishment of the operative processes. The supporting processes that find IT useful include intra-firm communications, administrations of day-to-day activities, management of personnel, office transactions, and other systems of management. IT tools such as email and other IT tools facilitate the daily activities of construction companies with people in the field especially so in large multinational companies handling projects in different countries, from where the main office is located. IT tools help construction companies manage projects by enabling firms to transcend the issue of time zone and geographic distance issues so that business units or field personnel connect with the main office through an intranet site or other forms of linkages in real time. IT also enables construction firms to develop linkages with external parties such as suppliers through an extranet system.

Apart from the use of IT in the process areas of construction companies, IT also finds application in different management areas including the encompassing field of project management and the sub-areas of designing and engineering, contracting and sub-contracting, and supply chain management. IT facilitates control in these management areas by providing communication tools, information organization and analysis tools, standards assessment measures, and equipment or facilities for automation. IT tools and systems ease the complexities of management by providing accessible means of deriving bases for understanding problems and making decisions (Lautanala et al., 1994).

Love and Irani (2003) describe the application of IT in the construction industry as the area of quality cost control. IT tools such as cost and quality analysis software supports the determination of quality costs that allows decision-makers to determine the merit of the construction designs and completion plans that meet the cost limitations as well as the quality expectations of the business firms and its clients. IT also supports the achievement of quality assurance to derive information on performance tracking and quality cost matrix. At the least, IT tools and systems applied to quality management allow construction companies to assess the merits of designs and plans. At the most, in the case of construction companies engaging in advanced IT tools, these could enable construction firms to make predictions on the effect of intervening factors to the construction process to allow the construction firm to identify alternative action in case the intervening factors happen.

The extent of IT use in the construction industry varies depending upon the scale of operation of construction firms. Small construction firms usually operate on a limited market and with limited capital. The organizational structure of small construction companies is simple and the relationships created are limited only to suppliers and a small number of sub-contractors for specialized skills and materials needed in meeting the specific demands of clients. Since there are less people to coordinate, small construction firms engage in basic IT tools such as computer-aided design and email or other online communication channels. The primary consideration in engaging in IT for this scale of operation is cost and return on investments. Medium construction firms have a larger and more complex organizational structure with network relations to a greater number of external parties and taking more construction projects. With this scale of operation, IT engagement ranges from the use of basic IT tools and systems to advanced IT equipment and functions.

Medium construction firms operate with the objective of expanding their clientele and market reach to be at par with large construction companies. There is pressure on the part of the medium construction firms to engage in IT investments, if these constitute a key determinant of competitiveness in the construction industry. Large construction firms operate by taking on different construction projects requiring multi-level knowledge and skills for implementation in different countries. The operations of large construction companies reflect the greatest degree of complexity and turbulence in the industry. It is in this scale of operation that IT becomes most important. The organizational structure of large construction firms is multi-tiered and complex including subsidiaries in different countries, contractors and sub-contractors, various supply networks, and diverse clientele. The geographic distance and time differences including the need to communicate with many parties at the same time requires IT tools such as

email, video conferencing, and mobile services to facilitate coordination. The diverse knowledge and skills involved in the operation of large construction firms require IT tools and systems in coordinating the flow of information from the different experts located in the field or reporting in different business units to support the skills needed in the various projects engaged in by large construction firms. Intranet and extranet systems support collaborative relationships among the various parties involved in construction projects. Apart from information flows, large construction companies also engage IT tools for 3D and 4D designs for exploration and testing, through simulation programs such as Building Information Model (BIM).

Apart from the scale of operation, the extent of IT involvement of construction companies also depends upon the range of intended outcomes that could be short, medium or long-term. Short-term IT involvement pertains to the use of IT tools for specific aspects of projects such as computer-aided design but the implementation and evaluation remains manual so that the use of IT is limited only to the commencement stage of construction projects. Medium-term IT use involves performance measures and design assessments. Long-term IT use focus on goals such as collaboration, enhancement of business values, and reduction of risks through multi-level networking, change in corporate culture towards an accepting and cooperative IT values, and determination of the relative merits of various policy direction through lessons derived from documentations. (Schwegler et al, 2001).

The differing extents that construction firms engage in IT use reflect the variances in the manner of strategically managing IT. Construction firms considering IT tools and systems as key to competitiveness hold greater tendency to perceive IT as a strategy requiring efficient management. By considering IT use as a strategy, the management of IT happens with the intention to achieve long-term results extending beyond the completion of construction projects to cover the market retention and expansion, industry competitiveness, and firm sustainability. Construction firms considering IT as merely an alternative solution or system would likely not consider IT as a strategy and allot minimal management efforts towards IT projects. At this low level of IT management, construction firms would not achieve long-term benefits of IT involvement such as ensuring sustainability. Construction firms need to consider two factors in determining the strategic management of IT. One is the future direction of the construction industry towards IT investments and second is the IT adjustments that individual construction firms need to make to achieve the common goal of competitiveness and sustainability.

### *Benefits and Issues of IT Strategic Management in the Construction Industry*

The benefits of the strategic management of IT in the construction industry can be classified into the three categories of strategic, tactical and operational benefits (Love and Irani, 2004). These benefits encompass the advantages of engaging in IT tools and services by construction firms according to their needs and objectives. Greater strategic management of IT also enhances the benefits experienced by construction firms. The extent of benefits experienced by construction firms depends on the manner and extent of managing IT.

Strategic benefits of strategically managing IT include: 1) firm growth; 2) reduced marketing costs; 3) technology leadership; 4) market share improvement; 5) leadership in the market; 6) customers and supplier satisfaction improvement; 7) customer relationship improvement; 8) competitive advantage enhancement; and 9) organizational and business process flexibility improvement (Love and Irani, 2004). Through IT management, construction firms experience greater control of the various processes, systems and relationship through information processing, communications, and other strategic benefits.

Tactical benefits of managing IT in the construction industry include: 1) change response improvement; 2) service quality improvements; 3) teamwork improvement; 4) pro-active culture promotions; 5) business function integration improvement; 6) planning period improvements; 7) time reductions in the compilation of tenders; 8) time reductions in the preparation of cost plans; and 9) contract administration improvements (Love and Irani, 2004). IT management allows construction firms to enhance process flows and system networking.

Operational benefits derived by managing IT in the construction industry include: 1) data management improvement; 2) communication improvements; 3) decision-making improvements; 4) paperwork minimization; 5) bottleneck problems minimization; 6) labor cost minimization; 7) rework minimization; 8) output quality improvement; 9) data exchange improvement; 10) response time enhancement; 11) forecast and control improvement; 12) cash flow control improvement; and 13) lead time in financial planning minimization (Love and

Irani, 2004). IT management enables construction firms to organize day-to-day aspects of operations through assessment software and documentation.

The issues faced by construction firms are diverse and multifaceted because of the differing extents of engagement and management of IT together with the varying business environments and contexts that construction firms experience.

Construction firms have trouble in using and managing IT because of direct and indirect costs (Love and Irani, 2004). Direct costs refer to the material or non-material aspects of IT engagement. These include the acquisition of hardware, software and accessories, upgrade of existing IT systems, outsourcing of consultants, engineers and other IT experts, development of networking linkages, increase in overhead costs, addition of training costs for employees to learn to use new IT tools and systems, and addition of maintenance costs. Direct costs become management issues by requiring the construction firms to reallocate funds and managers to engage in new areas of management, new management tools, and innovative styles to facilitate the experience of benefits by the construction firm. Managers need to become flexible and develop the necessary competencies to handle IT engagement effectively.

Indirect costs incurred by construction firms in engaging and managing IT comprise the other costs emanating from the direct costs accruing to construction firms investing in IT. The indirect costs include the change in the management of human resources to ensure the integration of IT tools and systems in administrative work and work performances; time and effort in supporting and troubleshooting IT operations; shifts in salary or wage rates because of the acquisition of new skills by the staff; turnover of staff because of the changes in the human resource needs of the construction firm; organizational restructuring; and resource strains (Love and Irani, 2004). Indirect costs become management issues because they increase the level of investment and commitment of construction firms to the use of IT tools and systems that adds to investment cost and increases the investment risk. The decision of the construction firm to commit to the management of IT engagement amidst the costs, based on rational decision-making, determines whether the construction firm would experience the benefits of IT engagement and the extent of benefits that the firm would experience.

Apart from cost as a management issue, another issue experienced by construction firms in strategically managing IT is standardization, in the area of design. Achieving standardization in design systems is difficult because design tools address specific design needs making it difficult to integrate or link different design tools as innovations develop. Since previously developed design tools still have not been fitted with information exchange capabilities, this would constitute management problems when design needs require the integration of one or more IT design tools. This also constitutes a drawback of existing IT design tools so that meeting the needs of business firms require manual work for different aspects of the design or limited use of design tools.

Another issue arising in the strategic management of IT is security since the proliferation of IT tools has also created security issues. This constitutes an important issue for construction firms since design and techniques constitute valuable products and tools in the industry. Construction firms create value by coming up with exclusive innovative designs for clients and developing efficient techniques in project construction. Security becomes important in keeping designs exclusive and techniques as sources of business values. Moreover, the smooth flow of information is crucial to the successful completion of construction projects and the derivation of performance data. Peer-to-peer computing comprises a networking system that allows the flow of information online. This is important in decisions involving the completion of the construction project but this is also susceptible to security breaches that hinders and corrupts information and data flow. Construction firms have to invest in security systems to support the use of IT tools and systems.

These issues need resolution if business firms expect to achieve the potential benefits of IT integration including the long-term goal of business sustainability. Rationalization of direct and indirect costs of IT integration is necessary to determine whether IT engagement is appropriate to the construction firm, what IT tools and systems to acquire and develop, what IT issues to address, and what techniques to apply to experience IT benefits. Other issues require changes in the perspectives of managers toward IT tools and systems. In addition, there is also need for a concurrent change in corporate culture to recognize the importance of IT tools and systems when the construction firm requires IT engagement and effectively use IT tools by selecting the tools appropriate to the needs of the firms and

determining the advantages and disadvantages of IT tools and systems. Overall, IT tools and systems offer potential benefits accruing to construction firms based on business context.

## Conclusion

A number of lessons emerge from the strategic management of IT in the construction industry. One lesson revolves around understanding the importance, purpose and role of IT tools and systems in the construction industry and to individual construction firms. This is necessary to determine the applicability of IT to specific construction firms, the selection of the appropriate IT tools and systems to develop, and the means of managing IT to support the sustainability goal of the business firm. Key to understanding the role of IT and IT management in the construction industry is recognition of the differing needs, objectives and issues faced by individual construction firms so that these also perceive the importance of IT to the firm. IT engagement depends upon the need of construction firms but if construction firms adopt IT tools and systems, these require effective management in order to facilitate the achievement of the multi-faceted potential benefits of IT use.

In effectively managing IT tools and systems, construction firms need to consider two general lessons. One is the necessity of changing perspectives of IT tools and systems from a technical to a strategic perspective. This is necessary to integrate IT into the corporate culture expressed through policies and techniques directed towards sustainability. IT cannot operate effectively without necessary changes in the manner that individual construction firms operate. Comprehensive integration of IT into the various areas of business operation constitutes an effective strategic management of IT towards sustainability. Another lesson is considering IT as a continuous investment through innovations on existing tools to customize it to the context-based needs of the firm and upgrading systems with the introduction of new system.

Future research could refer to the finding in this paper and design a longitudinal study to investigate the causal relationship between strategic management of information technology and its contribution towards sustainability.

## References

- Ansoff, H. I. (1991). Critique of Henry Mintzberg's 'The design school: reconsidering the basic premises of strategic management'. *Strategic Management Journal*, 12, 449-461.
- Betz, F. (2001). *Executive Strategy: Strategic Management and Information Technology*. New York: Wiley & Sons.
- Coulter, M. K. (2007). *Strategic Management in Action*. Upper Saddle River, NJ: Prentice Hall, p. 10.
- Drejer, A. (2002). *Strategic Management and Core Competencies: Theory and Application*. Westport, CT: Quorum Books, p. xx-xxi.
- Harrison, J.S., & St. John, C. H. (2007). *Foundations in Strategic Management*. Mason, OH: Thomson South-Western Educational Publishing, p. 4.
- Lautanala, M., Enkovaara, E., Heikkonen, A., & Taiponen, T. (1994). *Potential Benefits of Information Technology in Construction in Finland*. Proceedings CIB W78 Workshop on Computer Integrated Construction, Finland: Helsinki [WWW document]. URL [http://cic.vtt.fi/vera/document/timi\\_eng/TIMI\\_CIB\\_W78.doc](http://cic.vtt.fi/vera/document/timi_eng/TIMI_CIB_W78.doc).
- Lautanala, M., Enkovaara, E., Heikkonen, A., & Taiponen, T. (1994). *Potential Benefits of Information Technology in Construction in Finland* [WWW document].
- Love, P. E. D. & Irani, Z. (2003). A project management quality cost information system for the construction industry. *Information & Management*, 40, 649-661.



- Love, P. E. D. & Irani, Z. (2004). An exploratory study of information technology evaluation and benefits management practices of SMEs in the construction industry. *Information & Management*, 42, 227–242.
- Moore, S. & Wen, J. J. (2007). Strategic management in Australia and China: The Great Leap forward or an Illusion? *Journal of Technology Management in China*, 2(1), 10-21. p. 11.
- Oakland, J. S. (2006). *Total Quality in the Construction Supply Chain*. Oxford: Butterworth-Heinemann, p. 75.
- Schwegler, B.R., Fischer, M.A., O'Connell, M.J., Hänninen, R. & Laitinen, J. (2001). Near-, Medium-, & Long-Term Benefits of Information Technology in Construction. CIFE Working Paper #65, p. 1-19.
- Thorp, J. (2003). *The Information Paradox: Realizing the Business Benefits of Information Technology*. New York: McGraw-Hill, p.3.
- Willcocks, L., Feeny, D. & Islei, G. (1997). *Managing IT as a Strategic Resource*. Berkshire: McGraw-Hill, p. 44-45.
- Zeng, S.X., Lou, G.X. & Tam, V. W. Y. (2007). Managing information flows for quality improvement of projects. *Measuring Business Excellence*, 11(3), 30-40.