IT PERFORMANCE AND ORGANISATIONAL CHARACTERISTICS IN CONSTRUCTION FIRMS: THE CASE OF TAIWANESE CONTRACTORS

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ABSTRACT

In today's increasingly competitive business climate, information technology (IT) is becoming imperative for business survival. The view that IT expenditures are expected to increase enormously in organisations is now widely accepted in the literature. IT innovation provides construction organisations with the opportunity to improve their business performance and gain competitiveness. According to many surveys such as CICA and KPMG, IT is now becoming widely used in the UK construction industry. There is much evidence to suggest that IT has a major impact on the business performance of construction organisations. However, what is less understood is the interplay between organisational characteristics and IT implementation in construction firms

This research mainly concerns the relationships between organisational characteristics and the outcomes of IT implementation for business improvement in Taiwanese construction organisations. Based on the innovation process and the organisational change literature, an analytical research framework was developed by this research. This framework was used to identify the potential organisational variables which could affect the outcomes of IT implementation for business success in organisations.

After interviewing a total of fifty major contractors in Taiwan, this research firstly explored the current use of IT applications in Taiwan's construction industry and several common IT implementation problems encountered by the contractors. Some possible solutions for the problems are suggested. Secondly, this research found that several organisational variables are statistically correlated with the outcomes of IT implementation from the interviews. Five critical factors for business success through implementing IT were also identified. The results can be used to help contractors manage their IT projects effectively and obtain business success through implementing IT.

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Chapter 1: Introduction

BACKGROUND

In the UK and other industrially advanced countries in the world, the construction industry is known as a mature traditional industry. Utterback and Abernathy (1975) found that in a mature industry, competition is based upon price and that process innovation is dominant. However, Pries and Janszen (1995) argue that due to the relatively stable environment of the construction industry, innovation and management literature have paid little attention to this sector. Moreover, the characteristics and nature of the traditional construction industry have been regarded as the main hindrances for innovation. The segmented organisation of building processes and the uniqueness of each building project are two examples of such industrial disadvantages (Pries and Janszen 1995).

The Technology Foresight Programme launched by the UK government concludes that in the UK's construction industry, sustained profitability flows from innovation in both process and technology (Technology Foresight Panel 1995). The greater the use of advanced business process and technology innovation to improve competitiveness and integration of construction processes, the more opportunities there are for cost reductions and greater profitability.

Pries and Janszen (1995) argue that approximately 40% of building costs are related to the transfer of information and the control of this communication process. Consequently, Information Technology (IT) has the potential to achieve process innovation and thereby reduce costs and improve the efficiency of business processes in the construction industry. Several reports have revealed the successful business process innovations achieved by implementing IT in many sectors; such as the motor industry's supply system and the pharmaceutical industry's automatic ordering system (Betts et al 1991; Davenport 1993; Currie 1995). In the construction industry, various aspects of IT can enhance integration and improve business performance in this sector. Brochner (1990) points out that coordination, automated inspection, data translations and elimination of intermediaries are examples of IT functions that would have positive effects on patterns of integration such as geographic expansion, diversification or subcontracting and integration with material supply in the construction industry. Miozzo et al (1998) have identify the "generic" core and support process in a construction project and outlined a workplan that using IT to help eliminate obstacles in the flows of these processes. Their research works have highlighted the potential opportunities for using IT to support process improvement in the construction industry.

Ward (1986) identifies three particular benefits in the use of IT: (1) to improve the efficiency of operations; (2) to increase the effectiveness of management; and (3) to enhance the competitiveness of the business directly. However, the investment cost in IT is high. There is also no general correlation between the level of investment and the gains in efficiency and effectiveness (Remenyi et al 1993). Much normative literature indicates that IT is most effective when aligned with the core business strategies in organisations. Such emphasis on the links between competitive advantages, core business strategies and IT has been overstated in much of the academic and business literature (Currie 1995). Moreover, new management philosophies such as BPR (Business Process Re-engineering) and outsourcing have emerged and have been applied in conjunction with IT to achieve competitive advantages. Consequently, organisations that are considering the implementation of IT innovation for business improvement are faced with opportunities, as well as challenges.

There are also considerable difficulties in evaluating and judging the value of investments in information technology (Wateridge 1995). Indeed, merely purchasing technology to reduce some direct and indirect costs in business processes may improve competitiveness, but this competitive advantage may be minimal or short-lived since the technology is available to all. Consequently, construction organisations need to manage IT strategically and effectively to obtain significant competitive advantages. In addition, IT should no longer be viewed as a technical tool for traditional business processes, but rather as an innovation agent to provide new and different alternatives for business operations.

Previous literature on the impact of using IT in construction has shown a considerable change in industry structure (Brochner 1990). However, Alty (1993) argues that the application of information technology has been applied with limited success within the construction industry and that it has not fully produced the benefits which are found in other sectors. Tucker and Mohamed (1996) also indicate that although the impact of information technology (IT) on the design process has been acknowledged by designers for many years. However, its impact on construction management applications such as estimating, planning, decision-making, etc. has been rather low. The impacts of IT innovation in construction have also been delayed compared to other sectors (Betts et al 1991).

A number of reasons are highlighted by Alty (1993), Tucker and Mohamed (1996) and Miozzo et al (1998) to account for the low success and diffusion of IT implementation in the construction industry. These reasons are primarily related to the unique characteristics of the construction industry such as site-specificity of the product, longevity and the need for durability, traditional craft demarcation, codes of practice, separation of the design and the construction process, the fragmented nature of construction activities and the use of multiple parties such as sub-contractors in the construction process.

The above perspective was also shared by Winch (1998). He regarded construction as a complex systems industry and in particular, distinguished between the role of the innovation superstructure, innovation infrastructure and system integrators. The fragmentation of the professional bodies within the complex systems has also lessened the opportunities for innovation due to potential conflicts of interest among these bodies.

Betts at el (1991) have also argued that the real benefits of IT are yet to be realised in the construction industry either. The main reason they highlighted was a lack of strategic planning at individual and organisational levels for the management of IT in such a fragmented industry. Consequently, it is imperative to create an IT strategy tailored specifically to the nature and needs of the construction industry, so that it can join the IT bandwagon and progress into the twenty-first century with the other industrial sectors. As Davenport (1993, p.300) succinctly states,

> "*Although it is theoretically possible to bring about widespread process innovation without the use of computers or communications, we know of no such examples.*"

THE NEED FOR THIS RESEARCH

There is much evidence to suggest that IT has had a major impact on organisational practices and structure over the past decade. Indeed, technological advances have revolutionised the way that organisations conduct their operations and have provided considerable avenues in which they can gain an advantageous edge over their competitors. Much of the innovation literature (e.g. West and Farr 1990, Rogers 1995, King and Anderson 1995) has described the importance of individual and organisational characteristics as the antecedent of organisational innovation. However, what is less understood is the relationship between these characteristics and IT performance in construction organisations. The challenge facing IT/IS researchers is the pervasive nature of IT innovation.

IT can permeate most or even all levels and functions of an organisation. However, the organisation's culture and characteristics may pose as possible barriers to the successful implementation and systemic integration of IT within the organisation. Moreover, the external context from which the organisation operates such as its business environment may also influence its IT implementation. Consequently, it is necessary to investigate the interactions between organisational characteristics and IT innovation.

In recent years, the construction market in Taiwan has captured the attention of many international organisations due to major construction projects such as rapid transit systems, new harbour and airport construction and nuclear power station sites. Competition in Taiwan's construction market has grown with the participation of many leading contractors from all over the world. Faced with this and coupled with a heightened awareness of IT potential, local contractors in Taiwan have started to consider adopting IT innovation as a means of increasing business competitiveness. Consequently, the aim of this research is also to investigate the current diffusion and implementation of IT innovation in Taiwan's construction organisations.

The main objectives of this research are summarised as follows:

1. To investigate the nature and characteristics of Information Technology and its current strategies, applications, appraisal approaches and risks for IT innovation.
2. To investigate the benefits of IT and barriers (if any) to IT innovation in the construction industry and the current development of IT projects in this sector.
3. To identify the possible variables (if any) which could influence IT innovation in construction organisations.
4. To investigate the current use of IT innovation in Taiwan's construction industry and identify common problems (if any) encountered by contractors in Taiwan.

5. To explore the interplay between these variables and IT innovation and how this interaction can affect the performance of IT innovation for business success in Taiwan's construction industry.

An analytical framework was developed in this research to facilitate the investigation. The results can be used as an analytical tool by construction organisations seeking to analyse how their IT innovation projects can contribute to greater business success. The results can also provide a basis for further research in the field of IT innovation in the construction industry.

THESIS STRUCTURE

In order to set the scene for the research objectives above, a review of contemporary literature relating to IT and its implementation is provided. The second chapter discusses IT and innovation concepts. Two groups of literature are reviewed. Firstly, the definition, benefits and constraints of IT are analysed. Secondly, the literature associated with the strategic use of IT is covered. Some techniques and tools for strategic information system planning (SISP) are also introduced.

Chapter Three discusses the concepts of innovation and organisational change. The literature regarding the diffusion and implementation of innovation is reviewed. Pettigrew's three elements of organisational change are discussed. These elements are brought into the analysis of the adoption and implementation of IT innovation in construction organisations by this research.

The next three chapters focus primarily on Pettigrew's three elements of organisational change. Chapter four discusses the "context of change" and reviews the literature regarding the antecedents of organisation innovation and change. This includes both internal (e.g. organisational and individual characteristics) and external factors (e.g. the fragmentation of the professional bodies in the construction industry).

Moving on to IT practices in the construction industry, the fifth chapter focuses on "the content of change" and reviews the literature of IT projects in construction. Firstly, the management of IT and barriers to IT innovation in the construction industry are discussed. Secondly, some current applications of IT in construction are introduced. Lastly, some models that can be used for the strategic exploration of IT investments for the construction industry are discussed.

Chapter Six focuses on "the process of change". Firstly, the concepts and criticisms of the stage-models for the implementation of innovation are discussed. Secondly, four different implementation models for both general and IT innovation are introduced. In particular, attention is drawn to the recursive model developed by Winch (1994) which avoids the traditional equilibrium analysis and emphasises continuous change and learning.

In Chapter Seven, the existing approaches for IT project appraisal are introduced. The "traditional assessment approaches" and "modern assessment approaches" are reviewed and critiqued. An IT benefits assessment model developed by Construct IT for the construction industry is highlighted. Some general literature on the risk assessment of IT projects is also reviewed in this chapter.

Chapter Eight proposes the methodology of this research. Firstly, an analytical framework to facilitate the research is deployed. This framework is used to identify potential organisational variables which could influence the outcome of IT performance in construction organisations. Secondly, the main research questions, proposed variables and hypotheses are stated. Thirdly, a debate between quantitative and qualitative methods for data collection is discussed. Finally, the contents of the structured research instrument developed in this research are reviewed. This instrument was used in the interviews with 50 contractors in Taiwan to facilitate and ensure uniformity in data collection of variables for statistical analysis.

Chapter Nine reports the descriptive statistics resulting from the interviews in Taiwan. The answers from the structured research instrument derived from the interviews are firstly reviewed. Secondly, the current implementations of IT systems by fifty contractors in Taiwan are discussed. With the exception of VR, all the IT systems stated in the research instrument are found to be used by the contractors interviewed. Lastly, particular emphasis is placed to some common problems encountered by the contractors in the interviews. These problems are explored and examined in detail and some suggestions for solving these problems are also provided.

Chapter Ten presents the results of the statistical analysis performed on the interview data. The relationship between organisational characteristics and IT performance for business success are investigated and discussed. The analysis shows that certain organisational variables are significantly correlated with achieving business success through implementing IT. A model is developed accordingly to show how the organisational characteristics can influence each other and the outcome of IT performance. Five further critical factors for business success through IT implementation are identified. Statistical evidence suggests that these five factors are important for the contractors in Taiwan to achieve business success through implementing IT.

The concluding chapter reviews the discussion and findings of this research. Firstly, some general implications and significant findings that have resulted from this research are elaborated. Secondly, the limitations and contributions of this research are discussed. Finally, some related questions and problems for further research are suggested.

Chapter 2: Information Technology and Strategic Advantages

2.1 Introduction

Information Technology (IT) is the term that describes the disciplines encompassing computer systems, telecommunication networks, and multimedia applications Frenzel (1996). Monk (1987) defines IT as machine-based technology and tools that actively process information, not only transferring or storing it. IT is becoming increasingly important in the operation of organisations. According to Willcocks and Lester (1996), the IT/IS expenditure by UK companies in 1995 was estimated as exceeding £ 33 billions, equivalent to an average of over 2 % of annual turnover, and was expected to rise in subsequent years. The size and continuing growth in IT investments show an increased awareness among organisations of the benefits and opportunities brought by IT.

Peppard (1993) contends that IT/IS can offer new management and strategy and can be applied strategically in at least four different ways: (1) to gain a competitive advantage; (2) to improve productivity and performance; (3) to facilitate new ways of managing and organising; and (4) to develop new business. Davenport (1993) also suggests that IT provides numerous opportunities to bring about business changes and can be viewed as an enabler for process innovation. In other words, IT can convert the way business is done, stimulating the redesigning and re-engineering of various business processes. The change enablers, however, not only provide opportunities, but also bring constraints to the organisations. Thus, a good understanding of IT is required.

2.2 Definition of IT

Before any further discussion, it is necessary to distinguish between the terms, "information technology" and "information system". According to Fidler and Rogerson (1996), the former is concerned with the fundamental technological tools, whereas the latter is concerned with the application of these technological tools to support business activity. Willcocks and Lester (1996) indicate that IT is taken to refer to hardware, software and communication technologies- the essential equipment; while IS is a wider concept referring to how the designed information flow attempts to meet the information needs of the company, which is more or less IT based.

Earl (1989) makes an easy distinction between the terms 'IS' and 'IT' strategy. He suggests that the **former be best used to define what should be done with technology and the latter to define how it is done.** IS strategies are therefore focused on business and aim to identify the systems which support priorities and plans relevant to a particular business activity. On the other hand, IT strategies are technology focused and show how a given set of requirements is to be met. However, Frenzel (1996) contends that with the discovery of infrastructure fragmentation and system incompatibility in the 1980s due to the flourishing telecommunication and networks, firms have increasingly recognised the advantages provided from the development of information systems and searched for competitive advantages through IS developments. Consequently, this subject became to be called information technology (IT) after telecommunications merged with computers into a single discipline.

Among the many varied definitions for the term IT, one definition is favoured by the British Advisory Council for Applied Research and Development for information technology (Zorkoczy 1990, p.12):

> *The scientific, technological and engineering disciplines and the management techniques used in information handling and processing; their applications; computers and their interaction with men and machines; and associated social, economic and culture matters.*

Electronic information processing has been used in business operations for over four decades. In the late 1950s, the low-powered and huge computers executed electronic data processing predominantly for financial or accounting functions only. Typically, the EDP (Electronic Data Processing) departments at that time were isolated from the remainder of the core business, devoid of any role in tackling problems on the business front (Frenzel 1996).

A decade later, mainframes and database management were introduced as large quantities of business data accumulated. Decision support systems and end-user computer terminals came into fashion and information infrastructure began to emerge. Frenzel (1996) suggests that this was the era of management information systems (MIS) although many managers still failed to comprehend what MIS was about. However, the effectiveness of MIS attracted a lot of attention and interest from many organisations.

Since the late 1980s, IT has come to substitute earlier terms such as electronic data processing (EDP), management information system (MIS) and information system (IS), though the latter is still in use (Frenzel 1996). At the same time, the introduction of networking and telecommunication, as well as the availability of personal computers and office systems have made the business world aware of the importance of using IT to gain valuable competitive advantages. Since then, many organisations have begun to utilise advanced technology in strategic planning, organisational learning and gaining business competitive advantage.

Now in the 2000s, due to the swift advancement of technology, firms are using IT to streamline their structure and enhance the relationships among customers and suppliers. Business process re-engineering, outsourcing and downsizing are implemented by firms to achieve quicker response and more flexible infrastructures (Frenzel 1996). Furthermore, the increasing IT/IS expenditure levels, coupled with the global economic and competitive climate which the organisations face today, have made the measurement of IT/IS effectiveness, cost justification and containment issues of top priority to most industries (Ballantine et al 1996).

2.3 The impacts of IT in organisations

Scott Morton (1991) concludes six major implications of IT impacts in organisations from their MIT research programme. These six implications are as follows:

(1) IT is enabling fundamental changes in the way work is done

IT is capable of radically changing the structures of a wide variety of jobs in organisations, especially for those based on information. Scott Morton (1991) indicates that three kinds of works can be changed by IT: production work, coordinative work and management work.

The potential impact of IT on production work is evident when considering the changes made by the use of IT in physical production and information production, but does not seem to be easily exploited in the field of knowledge works (production). Scott Morton (1991) contends that this could explain why organisations are slow to exploit and utilise technology to increase the effectiveness of knowledge production.

Communication networking, as one element of IT, permits a change in economics and functionality of the coordination process. Changes can be seen in various areas: (a) distance can be shrunk toward zero and become irrelevant as far as information flow is concerned; (b) time can be shrunk toward zero or shift to a more convenient point, and (c) organisational memory can be exemplified by a common database and become available to all parts of the organisation.

The third IT-enabled change in work is relevant to manager's jobs. Business direction setting and management control process are the two principal dimensions of management work that can be fundamentally affected by the use of IT. Examples of such IT systems are sophisticated strategic planning systems, executive support systems and customer feedback systems.

(2) IT is enabling the integration of business functions at all levels within and between organisations

IT is capable of providing the means for organisations to create a significant enterprise-level infrastructure by electronically connecting people and tasks within and between firms. Boundaries of organisations become more permeable. This integration enabled by IT can take four forms:

- Within the value chain- such as integrating design, engineering and manufacturing processes by connecting relevant personnel within a local area networking system.
- End-to-end links of value chains between organisations: such as connecting a supplier's shipping department to the buyer's purchasing department. This integration is a powerful way of speeding up the flow of goods between organisations.
- Value chain substitution via sub-contract or alliance: such as connecting a supplier's designer to the host team of the organisation to allow the data exchanges to accomplish a joint design.
- Electronic markets- such as connecting a travel agent to different major carriers to reserve seats and the agent can look around for the best price to compete. This is the most highly developed form of electronic integration.

(3) IT is causing shifts in the competitive climate in many industries

At all levels of industry, IT has a unique impact on the competitive climate. Organisations can capture benefits by earlier use of IT and then invest actively in innovations that continue to increase these benefits. In other words, benefits do not flow from the mere use of IT but also from organisational, human and system innovations that add on the original business benefits. IT is the enabler that provides an organisation with the opportunity to apply innovation if it wishes to keep ahead of its competitors.

(4) IT presents new strategic opportunities for organisation that reassess their missions and operations

Scott Morton and his colleagues contend that new ways of doing work, electronic integration and the shifting competitive climate discussed previously can provide an organisation with the opportunity to step back and rethink its mission and operation methods. There are three distinct stages that organisations go through if they attempt to respond to their changing environment: automation, informate and transformation.

At the automation stage, savings in production are usually achieved by reducing the number of works. Manual operations are replaced by automatic-controlled machines. Some information may be generated as a by-product from the automatic IT tools. However, at this stage little or no use is made for this information beyond the direct control of the existing process.

Informate is a term describing what happens when automotive processes generate information as a by-product. There are three distinct characteristics at the informate stage. First, production work involves new tools that provide information that must be used to get the job done. For example, the operator must see the screen to do his job. Second, new IT tools often generate new sorts of information as a by-product of the basic task. This kind of information can be used to analyse the production process and improve the organisation's performance. Third, the new skills and information are developed to the point where new market opportunities can be identified. For example, super markets often use IT to analyse customers' purchasing patterns and habits and hence generate ideas for new service or business.

Transformation is the term that reflects the fundamental difference in character exhibited by organisations which have been through the two stages described above and which are ready to embark on the third. The concept of transformation includes the broad view of total quality but goes beyond this to address the unique opportunities provided and enabled by IT. Scott Morton (1991) contends that all successful organisations in the 1990s would have had to pass through this stage.

(5) Successful applications of IT will require changes in management and organisational structure

IT is a critical enabler of the re-creation of organisations. IT can be used to link up all the personnel to be an *ad hoc* team on the same network at any time and any location. As these *ad hoc* teams become an alternative and effective way of working, a "networking" organisation can be formed (Scott Morton 1991). In such organisations, vertical and horizontal working patterns can be created with increased flexibility to response more quickly and accurately to the market. Thus the rate of information moving and decision making is speeding up. In such a dynamic environment, new management systems and processes are required. Organisations are facing the challenging task of changing the organisational structures and operation methods to keep them competitive in a dynamic environment.

(6) A major challenge for management will be to lead their organisations through the transformation necessary to prosper in the globally competitive environment

Scott Morton (1991) and colleagues point out that organisations which want to successfully go through the transformation should have a clear business purpose and vision of what the organisations should become. Organisations are required to invest a large amount of time and effort in order to understand where they are going and why. Having a robust IT infrastructure and a good alignment between corporate strategy, information technology and organisation dimensions are the two preconditions for successful transformation (Scott Morton 1991).

"People issues" are also critical tasks for managers since people are an integral part of any organisation. Changing the way people work can be extremely difficult and requires a great deal of effort. However, the investments in IT should ideally be complemented with new skills, knowledge and training provided to employees for a successful change enabled by IT. These investments have to be made throughout the organisation since management itself is also a part of the required change. Understanding the organisational culture and what it means to have an innovative culture is a key first step towards an adaptive organisation. Having innovative human resource policies and understanding how to cope with a changing and more competitive world are two of the major challenges for organisations in the IT eras.

2.4 Benefits and constraints of IT

2.4.1 IT benefits

Remenyi et al (1993) define IT benefit as follows:

> *"An IT benefit is an advantage or good, something produced with the assistance of computer and communications for which a firm would be prepared to pay. In functional terms the benefit derived from IT relates to the fact that the technology allows more tasks to be completed with greater accuracy and quality in less time and for lower cost."* (p.57)

There are two generic categories of IT benefit: the tangible benefits and the intangible benefits. A tangible IT benefit can directly affect the organisation's profitability while an intangible IT benefit has a positive effect on the organisation's business but does not necessarily have a direct influence on the profitability. Furthermore, within the broad categories of tangible and intangible benefits, a further classification can be derived: the quantifiable benefit and the qualitative benefit.

A quantifiable benefit can be objectively measured, for example, cost reduction and sales increment. A qualitative benefit, on the other hand, cannot be precisely measured. Examples include improving the computer knowledge of staff and developing a better way of handling information. Consequently, both tangible and intangible benefits can be sub-classified as quantifiable and non-quantifiable ones. Figure 2.1 shows the examples of this classification.

Figure 2.1 IT Benefits Matrix (Remenyi et al 1993)

Tangible \ Measurable	High	Low
High	Staff Reduction Lower Assets More Sales	Improve Security Lower Risks
Low	Positive Staff Reaction	Market Reaction

Rementi et al (1993) also classify IT benefits by functions. They are (1) Financial; (2) Quality of Service; (3) Customer Perception; and (4) Internal Management Benefits. However, this method of classification is not exhaustive since new technologies and strategies are being developed and applied with increased frequency. Consequently, focusing on the reasons for investment in IT might be a more appropriate method.

Ward and Griffiths(1996) indicate that the main objective of using IT is to achieve internal productivity. Those internal objectives would normally have been derived from external/market-place objectives. Thus, there are three main objectives for the usage of IT:

(1) to improve the efficiency of operation;

(2) to increase the effectiveness of management; and

(3) to enhance the competitiveness of the business (directly).

The first two IT objectives indicated above can make important contribution to the internal business performance. In terms of competitiveness, improving internal business performance by using IT can reduce some direct and indirect business costs. However, these benefits are derived from task-by-task improvements by merely purchasing new technology - which is available to all. Hence, the relative competitive advantages are limited and short-term. Consequently, the third objective of using IT is to gain business competitiveness **directly**. For example, using IT to create new business opportunities or establish barriers to prevent new entrants can assist the organisation to achieve a long-term competitive advantage.

Remenyi et al (1993) also support these objectives. However, according to a recent research project mentioned in their book, other objectives for the usage of IT have been stated, such as, *essential for business operation* and *aim to match investment levels in the market.* In addition, his research identifies the major ways in which IT helps to obtain internal and external management benefits as shown in Table 2.1.

2.4.2 IT constraints

There are also constraints in the investment and implementation of IT. Davenport (1993) cites the main constraint as the need to design a new system. Firstly, existing

Table 2.1 Potential Management Benefits Derived from IT (Remenyi et al 1993)

Internal	External
• Removal of productive tasks	• Analysis of competitors
• Awareness of outstanding duties	• Tying customers to company
• Better work allocation for staff	• Lowering product price
• Communication with staff	• Provide better market information
• Communication with managers	• Attract quality staff
• Better supervision of work flow	• Improving after sale service
• Preparation for meetings	• Responding quicker to enquiries
• Analysis of past business performance	• Improve company image
• Being able to take on more work	• Improving product quality
• Speeding up business cycle	• Analysis alternative scenarios

systems and technology used in organisations are often expensive and complex. In this sense, it may be difficult for an organisation to just give them away and replace with new and innovative ones, especially when the organisation relies heavily on the existing system.

Secondly, when a process extends across organisational boundaries into organisations of the customers and suppliers, the newly designed system might not be compatible with those of the customers and suppliers. For example, Paul Davies, the IT manager of BDP (Building Design Partnership), indicated in a pilot interview conducted in February, 1997 for this research work that they managed to overcome the problems of system incompatibility with their clients by adopting both AutoCAD and Microstation systems. Unfortunately, the solution is not economical at all. In addition to the costs of these two systems, it raises internal costs for training and system support.

Third, the IT packages available for purchase off the shelf are usually too general in design and support only limited and specific functions. Thus, companies wishing to utilise these packages for process innovation may be disappointed with the results because not all of their objectives and demands can be met by their expensive purchase.

Moreover, there are constraints, inherent in the installation of IT, which are related to people. Firstly, the people in the organisation may misunderstand the management motive of IT installation and maybe reluctant to change the way they work. They may fear loss of job, potential discomfort and health problems (Remenyi 1993). Secondly, the current workforce may not possess the skills required to operate the new IT system. Thus, further training for the current workforce or recruitment of skilled staff may be required. However, this may prevent the full implementation or delay the time scale of the project.

Focusing only on the constraints mentioned above may also limit the prospects for IT investments. If an organisation decides not to change any of its current system to avoid possible inconveniences, the possibilities of IT innovation will be restricted. Consequently, an analysis of any possible constraints needs to be performed before any decisions can be made regarding a proposed IT investment.

2.5 Management of IT

2.5.1 IT strategy

The IT strategy is primarily concerned with technology policies and tackles architecture questions including risk attitudes, vendor policies and technical standards (Earl 1989). This strategy is mainly developed by IT professionals in organisations, but with top management's involvement in order to ensure that technology supply is in line with business needs. Currie (1995) asserts that IT strategy is not simply about the vision which organisations should adopt for their long-term IS planning, but instead a working IT application for core business needs. Frenzel (1996) also indicates that a well-developed IT strategy can help an organisation to set its direction for IT investments, ensure consistency of the direction among different units in the organisation, and reduce uncertainty in short range decision making process.

Moreover, Frenzel (1996) contends that IT strategy should address at least five issues. They are (1) business aspect; (2) technical issues; (3) organisational concerns; (4) financial matters; and (5) personnel considerations.

Business aspect is concerned with whether the development of IT supports the business goals and objectives of the organisation. IT managers must acknowledge their group's involvement in the core strategy statement and ensure that their actions conform to the long-term goals and objectives of the organisation (Frenzel 1996). Technical issues are concerned with the technical vitality of advanced technology applied in the organisation. IT managers should ensure that IT operates within the norms of the organisation and makes the most efficient use of the organisation's resources.

Organisational concerns are related to the organisational consequences beyond the IT development itself. Changes brought about by the introduction of IT may be resisted by many people for a variety of reasons. Training and education associated with the introduction of IT may be required. These actions must be reflected in the IT functional strategy.

Financial matters are concerned with the allocation of resources for IT development. In some cases, financial constraints limit the range of opportunities for IT development. IT managers should take actions to champion the important role of IT if required. Finally, personnel considerations are related to the management task of recruiting, training and retaining skilled employees. Frenzel (1996) indicates that personnel considerations are intimately related to technical issues since strong people develop solid technical strategies while advanced technical strategies attract strong people. The IT functional strategy should co-ordinate these thrusts.

Organisations must develop and maintain a functional strategy to guide the actions of the IT function. These actions must also support the goals and objectives of the organisation. Consequently, a sound strategic plan is required. The strategic plan for a firm combines the strategies for its business areas and for all of its functions. The combined details can be used to support the organisation's overall business strategic objectives. Some of the famous strategic planning approaches for IT/IS developments will be introduced in the subsequent section of this chapter.

2.5.2 IT sourcing policy

Managing information technology is a difficult task. The ability to develop IT strategic directions and plan effective implementation is a vital first step towards successful IT management (Frenzel 1996). Due to budget limitations, small and medium-sized firms usually do not have any in-house staff with sufficient IT development skills and can only rely on off-the-shelf software or systems, which may only partially suit the needs of the firms. As a result, the IT investment in these firms may not bear the expected benefits. Since the deficiency in IT resources has been identified as the nub of the problem in most firms, it is logical to assess the benefits of consigning the IT processes to a specialised firm so that they can be accomplished more efficiently and cost-effectively.

"Outsourcing" is the term for delegating essential, routine, albeit non-core business processes to an external third party under a contract (P.A Survey 1996). The IT outsourcing industry has continued to grow steadily in recently years (Lacity and Hirschheim 1993, P.A. Survey 1996, Currie 1998). Outsourcing has evolved extensively in recent years with potential changes in the management, evaluation, implementation and maintenance of corporate IT services.

According to Currie (1995), three reasons are paramount. Firstly, the recession of global economy has forced many firms to search for cost savings, particularly in overhead areas such as in-house IT experts, hardware and software. Secondly, some new strategies such as process innovation, compulsory competitive tendering and business process re-engineering have led many senior executives to reassess their

Table 2.2 Common Reasons for Initiating IT/IS Outsourcing Evaluation (Lacity and Hirschheim 1993)

Participant's reasons for initiating outsourcing evaluations
1. Reaction to the efficiency imperative. 2. The need to acquire resources. 3. Reaction to bandwagon. 4. Reduction of uncertainty. 5. Elimination of a troublesome function. 6. Enhancement of credibility

company-wide performance. Thirdly, the supplier hype about IT outsourcing, coupled with unacceptable IT failure rates, have encouraged both the private and public sectors to view outsourcing as the cost effective alternative to in-house system and applications development. Kodak, Merrill Lynch and General Motors are examples of firms that have turned over some of their IT operations to third-party operators like IBM, MCI and EDS (Frenzel 1996). Lacity and Hirschheim (1993) also identify six common reasons for firms initiating outsourcing evaluation as shown in Table 2.2.

Cost saving may be perceived as the most important benefit from IT outsourcing. Lacity and Hirschheim (1993) indicate that the theory of outsourcing overhead accounts is that through economics of scale, a vendor can produce a service cheaper. However, Currie (1995) contends that evidence has shown that this is not always true; thirty percent of respondents in a survey reported no saving from outsourcing, some even claimed that costs increased.

Other important benefits from outsourcing are improved quality, flexible resourcing, IT investment risk transfer, headcount reduction and the release of top management to concentrate on core activities. Outsourcing can also solve the concern that in-house IT development cannot keep pace with rapid development of new technology.

There are also problems for IT outsourcing. PA consulting survey (1996) shows that reported problems include over-dependence on their supplier, cost escalation, lack of flexibility of suppliers, loss of control on IT and lack of management skills to manage the supplier. The skills found to be lacking are: formulating outsourcing strategy, selecting services to outsource, carrying out market analysis, selecting supplier, preparing service level management, negotiating contracts and managing suppliers. Currie (1995) contends that 10 key problems were identified in her study on using large management consultancy firms for IT developments in both private and public sectors. They are:

- Too generalist in approach to business problems
- Provide 'off-the-shell' package solutions
- Costs are too high
- Do not understand client's business
- Are not accountable
- Do not "own the problem"
- May upset "equilibrium", e.g. create conflicts in clients
- Quality problem

- Fail to meet project deadline
- Lack knowledge/training for complex IT development

There are different types of outsourcing options. Lacity and Hirschheim (1993) conclude three types of outsourcing options: body shop, project management and total outsourcing. Body shop refers to the situation where management uses outsourcing to meet short-term requirements, such as, the use of contract IT programmers. Project management outsourcing is employed for all or part of an IT project. Outsourcing suppliers will develop a new system and support other relevant requirement such as staff training and network maintenance. Total outsourcing includes all hardware and software support. Outsourcing suppliers are given full responsibility in the selected areas.

However, Willcock et al's (1996) study found that organisations mainly follow three paths into outsourcing: incremental, hard learning and strategic. Incremental outsourcing involves starting small on an obvious area to achieve cost saving or because of lack of internal expertise for in-house IT development. Hard learning is induced when an organisation was forced to outsource on a large scale due to environmental pressure. The organisation will learn from its mistakes and experiences with time. The third path emphasises the development of a strategic approach to outsourcing, both on how to fit outsourcing with business strategy and on how to manage outsourcing.

Willcocks et al (1996) has identified the different circumstances for choosing whether to outsource or stay in-house with regards to IT implementation.

The following set of circumstances usually led to the decision for staying in-house:

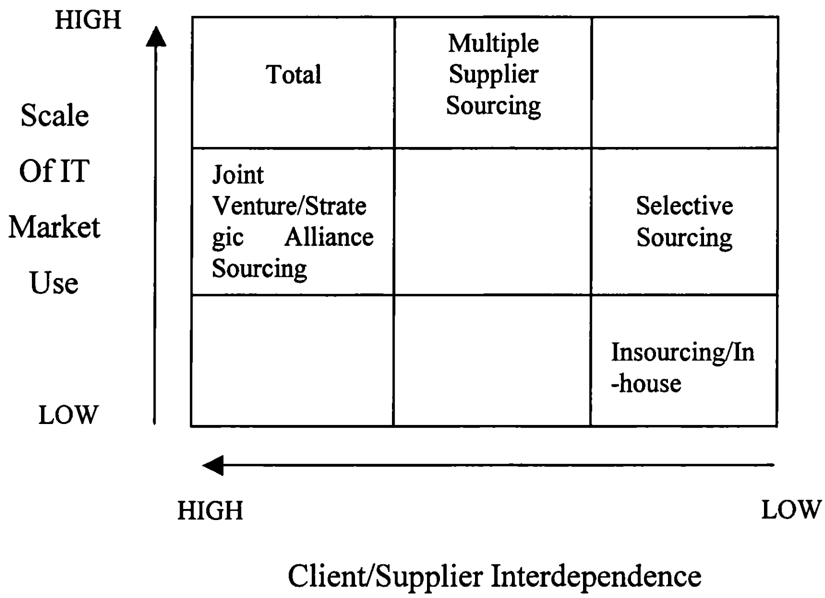
- business positioning impact- high
- link to business strategy- high
- further business uncertainty- high
- technology maturity- high
- level of IT integration- high
- in-house versus market expertise- high

The surest case for outsourcing is where the following circumstances apply:

- business positioning impact- low
- link to business strategy- low
- further business uncertainty- low
- technology maturity- high
- level of IT integration- low
- in-house versus market expertise- low

Willcocks et al (1996) also make some suggestions regarding the choice between IT outsourcing and retaining in-house IT capability. First, sourcing decision should follow a market logic, not management despair. Secondly, a sourcing decision should be based on in-house rationalisation and focus essentially on commodities. It is also suggested that the decision to outsource or retain an in-house development should be based on whether the IT/IS project was seen as a commodity or a part of a company's core competitive strength (Kass and Caldwell 1990, Currie 1995). Third, targeted outsourcing rather than total outsourcing could reduce risks.

Figure 2.2 Five Types of IT Sourcing Decision (Currie and Willcocks 1998)



There is an alternative approach to assist the outsourcing decision making process. Currie and Willcocks (1998) have developed a typology of outsourcing decisions from their empirical research of IT sourcing in the Europe and USA (as shown is figure 2.2). Five types of outsourcing decisions are included in the typology: total outsourcing, multiple supplier sourcing; selective sourcing; joint venture/strategic alliance sourcing and insourcing (remaining in-house development). According to Currie and Willcocks, total outsourcing usually deals with one single IT supplier. The success of the outsourcing therefore depends upon the relationship between the two parties.

Multiple supplier sourcing deals with various IT suppliers who compete with each other for business. The interdependency between the client and supplier is reduced, however, the problems of lack of co-ordination and logistical issues may occur in this type of sourcing. Selective sourcing, on the other hand, can remove some of the co-ordination problems associated with multiple supplier sourcing since the client organisation usually selects its IT sourcing supplier(s) carefully.

The common problem found in the case of joint venture/strategic alliance sourcing is that the development of IT project goes invariably over-time and over-budget (Currie and Willcocks 1998). The use of IT suppliers usually increases the interdependency of the client and suppliers and the risk of failure if the IT supplier cannot deliver a system with the required functions. Thus some organisations have opted to develop their IT systems in-house. However, Currie and Willcocks contend that in-house IT development by internal staff does not necessarily produce effective IT projects. Risks are associated with all the five types of IT sourcing discussed above. They also indicate that the trend toward outsourcing is increasing, thus it is essential that organisations understand the strategic positioning and priority of their IT suppliers in deciding on future outsourcing arrangements.

2.6 Strategic use of information technology

IT can have different effects and impacts on industries. The previous section has illustrated that current IT applications are mostly beneficial both economically and technically to the internal systems of individual companies. IT can also be used strategically to improve the companies externally. External improvements can impact on a firm's position in its business environment, especially among customers, suppliers and competitors (Bjornsson and Lundegard 1993). Porter's (1985) research on IT has identified five competitive forces that determine industry profitability: the entry of new competitors, the threat of substitutes, the bargaining power of customers, the bargaining power of the suppliers and the rivalry among the existing competitors. The implementation of IT strategically may boost the performance of a firm, for example, in the airline industry to:

- Establishing barriers to deter new entrants: e.g. increasing IT entry cost for reservation systems and tying in the distribution channel.
- Increasing the switching costs to the customers: e.g. linking purchasing and remittance systems to reduce the overheads of customers.
- Changing the basis for competition: e.g. by developing an expert system to optimise yield per aircraft to reduce cost.
- Realigning the balance of power in the supplier-customer relationship: e.g. agent is constantly aware of seat availability of the competing airlines from the on-line reservation system.
- Creating new business/service: e.g. offering integrated travel package to high mileage business customer directly (bypassing agent).

Ward (1986) also provides examples of how banks and building societies could use IT/IS strategically to improve competitiveness:

- Use IT to improve customer interface, sale data capture and processing efficiency.
- Use IT to extend service and compete in new market such as "Action-Line home banking service" offered by Natwest Bank and on-line banking service by Barclays Bank.
- Use IT to 'package' products to capture the whole business of the customer such as cash management service.

- Use IT to decentralise parts of the internal value chain to increase operation efficiency and effective use of current resource, 'back-office' branch systems are an example.

Ward and Griffiths (1996) define IT as an 'enabler', which provides short-term advantages and opportunities to develop new systems and obtain required information. From a competitive point of view, competitors are able to purchase the same technology, and the advantages could soon be negated. However, a new and exclusive Information System utilising new technology and which incorporates the strategy of the company can have more long-term advantages. In addition, its business values are less likely to be undermined by competitive imitation as the system is designed exclusively for the company. The new system is also less vulnerable to erosion by competitors if this system alters the value/cost effectiveness of the internally and externally connected value chains (Ward 1986).

Consequently, when considering the application of any new Information Technology tools, a company needs to plan and develop its information system in line with its business strategies in order to achieve maximum benefits. Strategic Information System Planning (SISP), as discussed in the next section of this chapter, is regarded as good means to facilitate the achievement of this goal (Ward and Griffiths 1996, Fidler and Rogerson 1996).

2.6.1 Strategic information system planning

Reponen (1993) defines a Strategic Information System (SIS) as a system designed to bring competitive advantages or one that has resulted in a competitive edge. A broader perspective on SIS is provided by Fidler and Rogerson (1996) who have proposed that a SIS must satisfy two essential criteria:

- The system is directly linked to the business strategy.
- The system significantly affects organisational performance.

When linked directly to the business strategy, SIS may either have a direct role in the business strategy or have the function of supporting the strategic decision-making process. SIS can also help to achieve the second objective of improving organisational performance by either increasing the competitiveness of the company or decreasing the competitor's competitiveness (Fidler and Rogerson 1996).

Strategic information system planning (SISP) refers to planning for the effective long-term management and optimal impact of information (Ward and Griffiths 1996). Remenyi (1991) defines SISP as the process of establishing a program for the implementation and use of IS to optimise the effectiveness of the firm's information resources and use them to support the objectives of the whole enterprise as much as possible. Fidler and Rogerson (1996) give a more general and all-embracing definition of SISP:

> *"SISP is the means of identifying application systems which support and enhance organisational strategy and provide the framework for effective implementation of these systems."*(p.219)

They also suggest that SISP is based on the following principles:

- SISP should be suitable for all types of organisations regardless of their mission, industry sector or financial status.

- SISP should encourage strategic alignment incorporating the suitable feedback from the information system.
- SISP should consider all types of systems.
- SISP should promote a strategically-oriented culture.

There are numerous techniques and methodologies that can be used in the SISP process. Earl (1992) found that five different SISP approaches are being adopted. All these approaches have their strengths and weaknesses. They are labelled as:

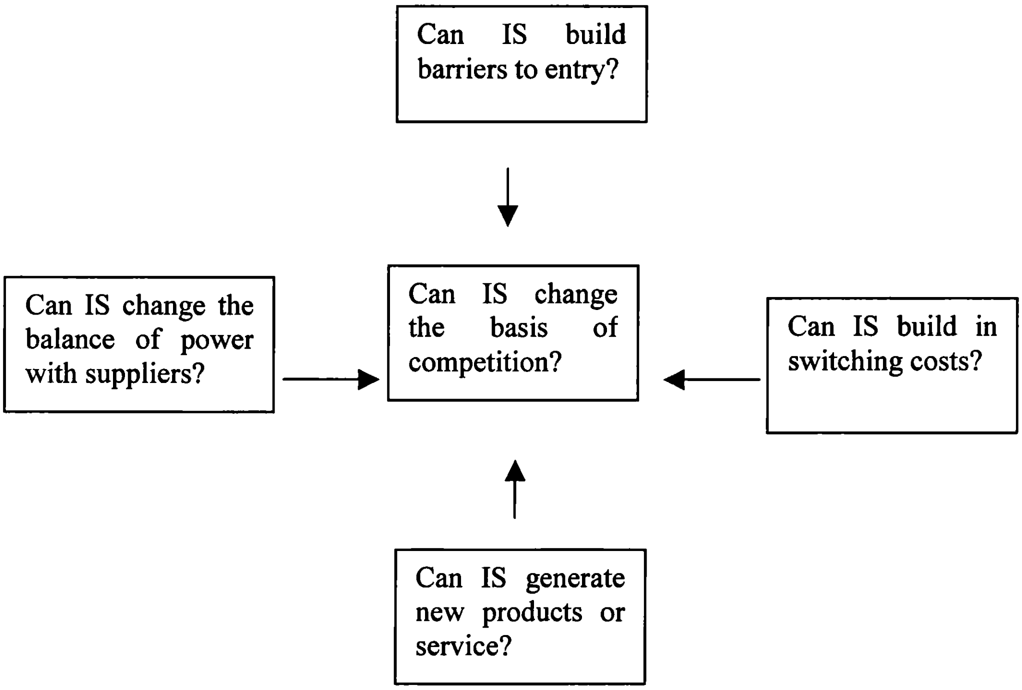
- Business planning led;
- Method –driven;
- Administrative;
- Technological, and;
- Organisational.

Some of the common methods and technologies for SISP are described below:

Five Forces Model - This widely accepted model by Porter (1985) identifies five basic forces determining an organisation's competitive structure. These forces are: the bargaining power of the organisation's suppliers, the bargaining power of the organisation's customers, the threats of new entrants into the market, the threat of new or substitute products and organisational rivals.

The five-forces model is valuable in deriving the IT/IS strategy since it is believed to be capable of analysing the effect of IT/IS within an industry and how IT/IS can be

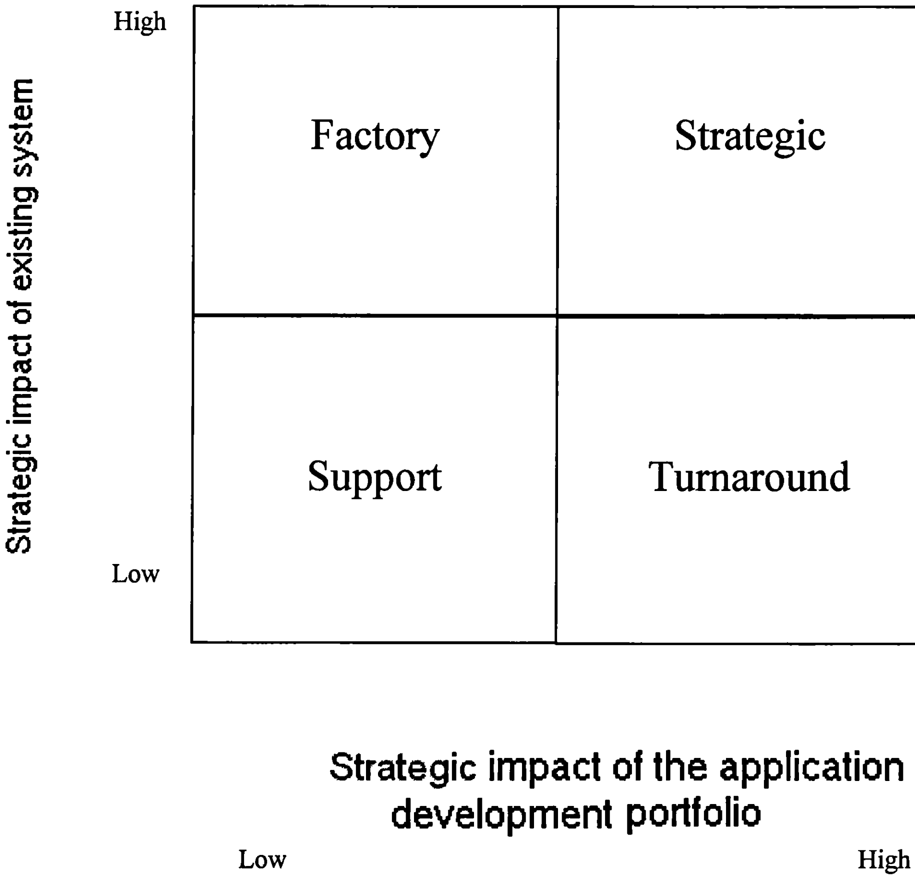
Figure 2.3 Porter's Five Forces model and IS Opportunities (Robson 1997)



applied to gain competitive advantage (Earl 1989, Peppard 1993). It can also be used to categorise each information need and assist the company in addressing the five forces and to rank the existing IT/IS system according to the relative importance of the five forces. An example of using five forces model for IS planning is shown in Figure 2.3.

Strategic Relevance and impact Grid - As the name suggests, this often-cited matrix focuses on the strategic importance of IS. This grid can be used to review the strategic positions of existing systems and identify the lack of IT/IS support areas that are vital to the organisation. With the dimensions of current systems and future or planned systems, four quadrants are formed with each having a different

Figure 2.4 Strategic Relevance and Impact Grid (McFarlan et al 1983)

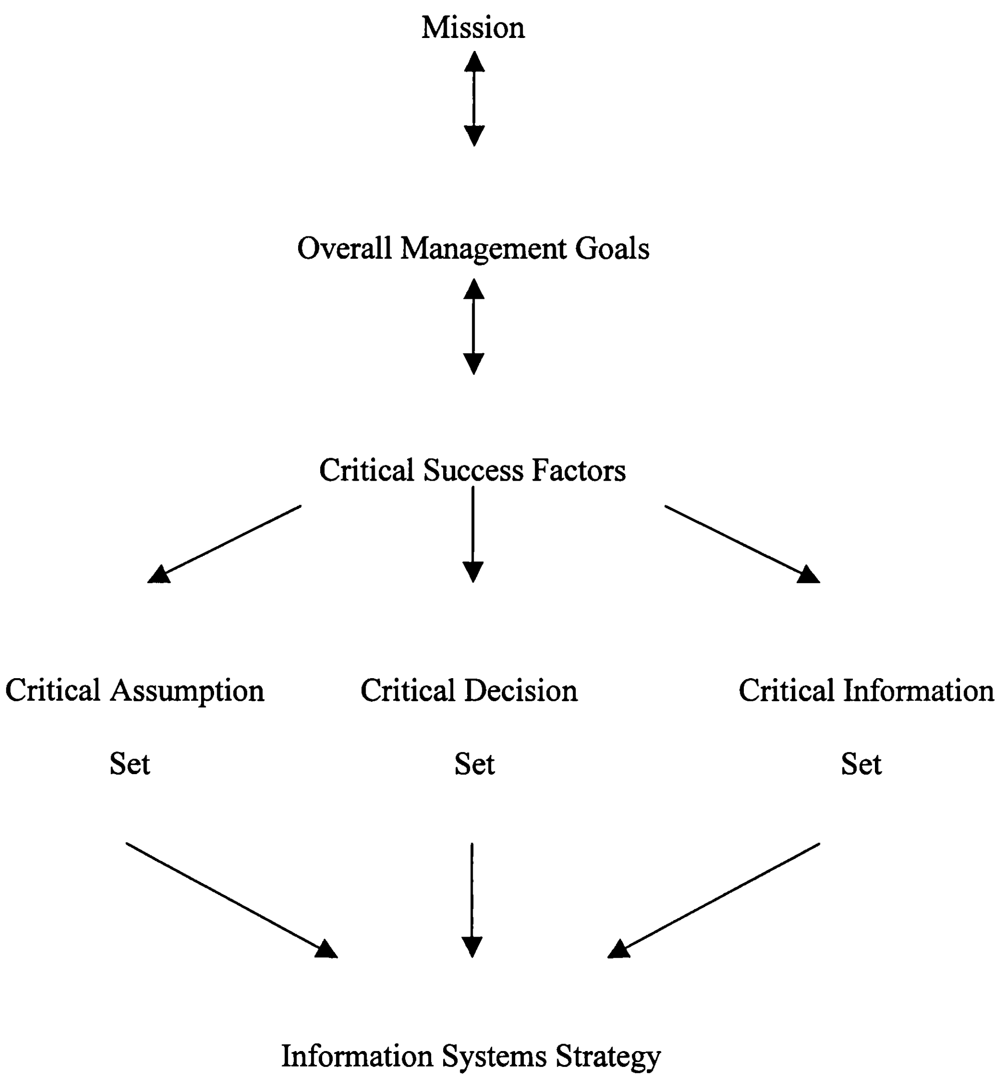


implication for IS planning decisions (as showed in Figure 2.4). Due to the rapid development of advanced technology, a system may move from one quadrant to another after a certain time. For example, the ATM (Automatic Teller Machine) was considered as a strategic system vital to the long-term growth of banks some years ago but today nearly all the banks and building societies operate ATMs. They have become an essential part of daily operations of banks and can now be placed in the Factory quadrant of the grid.

Critical Success Factors - CSF approach is a way of investigating the information requirements of operations within organisations. It was first developed by Rockart (1979) as a way of investigating the information required for top management to define the few key areas that dictate organisational success. It has evolved into a special-purpose information planning approach to identify opportunities in a top down manner. The main focus in the CSF approach is upon the executive's intuitions and experiences in determining the factors that are critical to the successful achievements of business goals. The CSF technique is believed to be the best tool used in strategic IS/IT planning due to its intrinsic simplicity and because it requires few resources to utilise (Remenyi 1991, Fidler and Rogerson 1996 and Ward and Griffiths 1996). An example of using CSF methodology for IS/IT strategy is shown in Figure 2.5.

SWOT analysis- The SWOT analysis identifies strengths, weaknesses, opportunities and threats of the current organisational situation. Strengths and weakness are mainly internal and are about present reality. Opportunities and threats are mainly external and are about future prospects. The SWOT analysis is a conventional and essential tool in any strategic planning activity. It provides the function of keeping both the internal and external factors in balance. The point of performing this analysis is for the organisation to develop an awareness of the risks created by the combinations of external factors (opportunities and threats) and internal factors

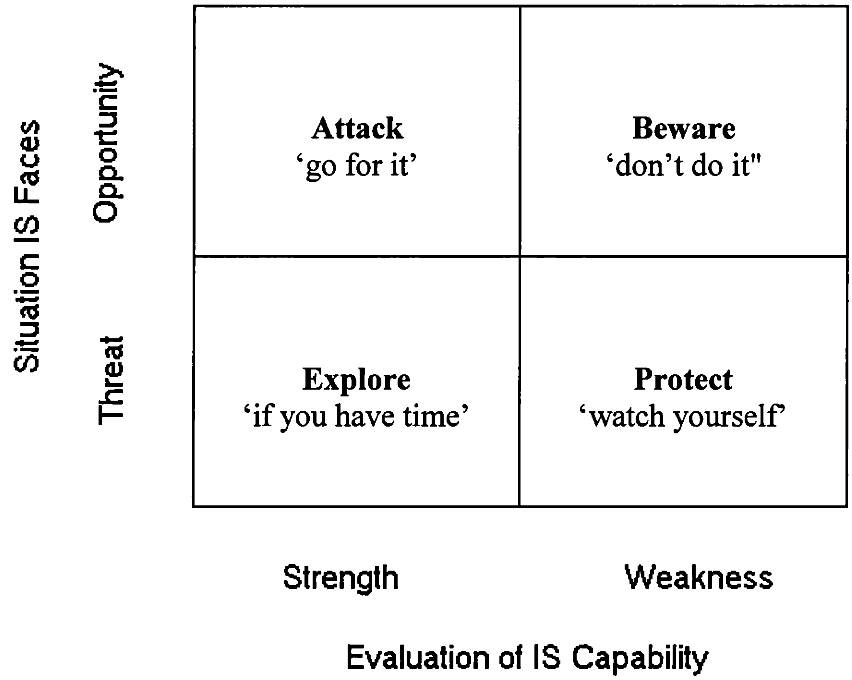
Figure2.5 Products of CSF Approach for IT/IS Strategy (Fidler and Rogerson 1996)



(strengths and weaknesses) and to decide on an appropriate response to deal with each risk.

For example, when both the opportunities and strengths are present then the organisation is in a position to "attack" its competitors through the use of IT/IS with

Figure 2.6 Possible Response on Basis of SWOT Analysis (Ronson 1997)



a good prospect of success. On the other hand, when the organisation faces threats and there are weak capabilities the organisation should consider taking actions to "protect" itself from the competitors' "attack". Figure 2.6 illustrated the four types of risks and the appropriate response that should be taken for each risk.

Strategic Option Generator - This model was developed by Rackoff et al (1985) to offer a more comprehensive model of industry competition based on Porter's works. It enables a manager to analyse the relationship between IS/IT and the three strategic targets of the organisation's operating environment: suppliers, clients and competitors. This model is shown in Figure 2.7. The main orientation that an organisation can adopt in the search for competitive advantage are differentiation, cost reduction, innovation, growth and alliance. This model permits the analysis of the three strategic targets of the organisation's industry and helps the managers to

Figure 2.7 Strategic Operation Generator (Rackoff et al 1985)

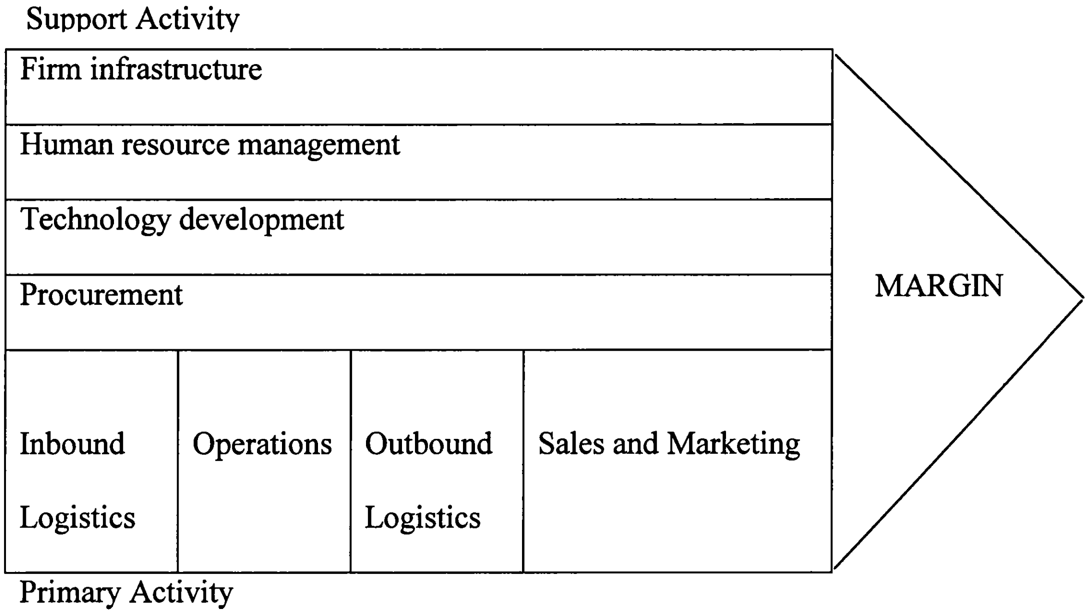
	Strategic Target		
Strategic Thrust	Supplier	Customer	Competitor
Differentiation			
Low Cost			
Innovation			
Growth			
Alliance			

become more aware of the actions that the organisation can take to achieve competitive advantages.

Robson (1997) suggests that this model can serve two purposes in the IS strategic arena. Firstly, the role that IS plays in supporting the chosen strategic thrusts (e.g. differentiation or cost reduction) can be identified. Secondly, the opportunity that IS offers to sharpen the organisation's strategy by enhancing the strategic thrusts can be identified. Areas of IS activities that play supporting roles or shaping roles can then be classed as of high competitive importance and treated accordingly.

Value Chain Analysis - This is a technique for analysing the sources of competitive advantage. Porter suggests that all organisations have an internal value chain which

Figure 2.8 Porter's Value Chain Model (Porter 1985)



is linked to the overall industry value system. In this sense, because profit margin is the difference between total value and the collective cost of performing the value activities, an organisation can usually assess whether the application of IS has led to an increasing of the value, as well as to an reduction of costs. An organisation's strategically important activities are defined and sub-divided into primary activities (comprising inbound logistics, operations, outbound logistics, sales and marketing, and service) and support activities (comprising corporate infrastructure, human resource management, technology management and procurement) by Porter (1985) and which is depicted in Figure 2.8. The total cost of the activities is, of course, the total cost of the production process- the value chain. With the value chain and value system, IS opportunities can be identified by the analysis of the activities and linkages in the value chain and applied to support the activities adding value or reducing costs.

These techniques and methodologies can be applied to assist the SISP process. However, with so many different techniques and methodologies available, it is vital that careful consideration be taken in the selection of the approach that is most appropriate to the needs of the organisation.

2.6.2 Business processes re-engineering (BPR)

Business Processes Re-engineering (BPR) is another popular approach taken by organisations to improve organisational efficiency and effectiveness. Innovative use of IT/IS has been considered essential and vital in BPR projects (Fidler and Rogerson 1996, Stroetmann et al 1994). Davenport (1993) indicates that the fundamental concept of BPR is built on the anticipation that a business process should be redesigned before applying information technology.

There have been many definitions of BPR:

- Peppard and Rowland (1995, p.20)- "*It aims to achieve step improvements in performance by redesigning the processes through which an organisation operates, maximising value-added context and minimising everything else.*"
- Hammer and Champy (1995, p32)- "*the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed.*"

- Miers (1994, p.142)- "*the constant search for, and implementation of, radical new approaches to business practice leading to step change improvements in productivity and customer service*".

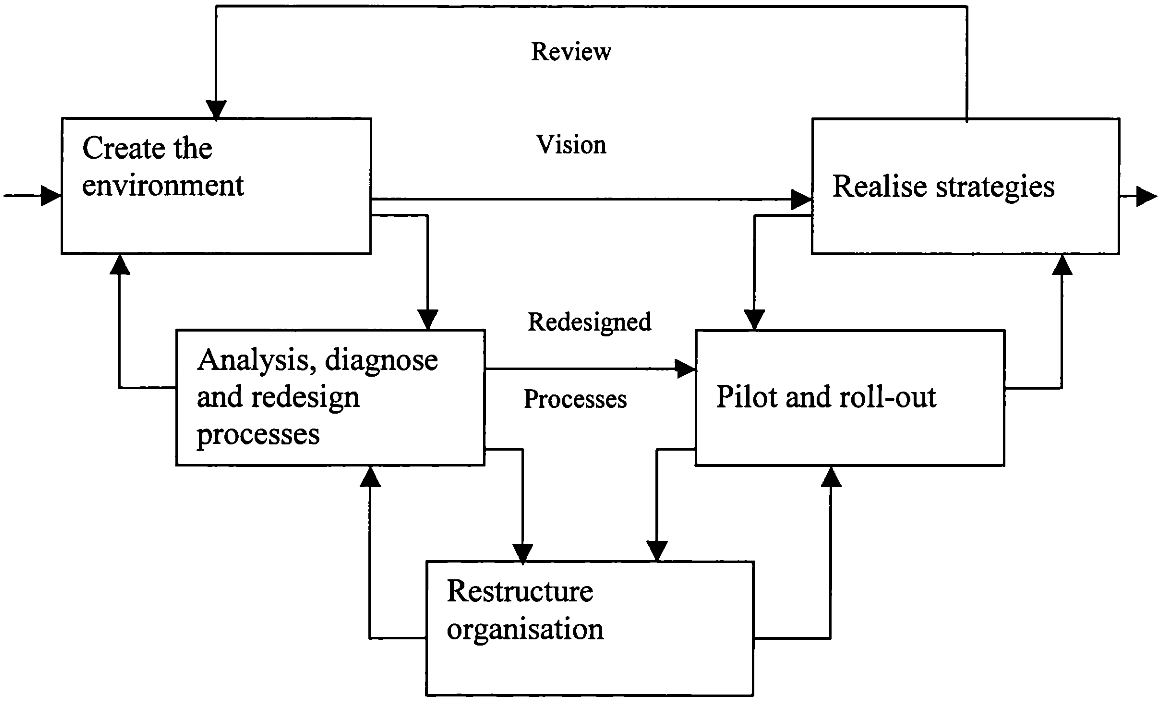
BPR is not an incremental change or improvement, rather it is a radical innovation and change process for organisation transformation. A number of BPR step models have been proposed by researchers over the years. For example, Peppard and Rowland (1995) have proposed a framework for approaching a BPR programme. This framework is shown in Figure 2.9. Activities such as identifying objectives, setting goals and targets, identifying critical and bottleneck processes and problems, innovative use of IT/IS and implementation are considered vital in these BPR models.

Earl (1994) argues that there are two schools of thought on the role of IT/IS in BPR. The first one proposed that BPR is enabled by IT/IS. It suggests that IT/IS investments could only be approved if they were conceived as part of a BPR programme. In this situation, BPR acted as a monitoring mechanism in the company's IT/IS project development.

The second school of thought is that BPR should be driven by IS/IT. In this situation, BPR is an approach to SISP forcing the IT/IS initiatives to be business oriented and aligned to other business strategies (Earl 1994).

Consequently, the interaction between SISP and BPR is dependent upon the different cases above. In the first case, SISP and BPR are more likely to be undertaken as

Figure 2.9 An Overall Approach to BPR Developed by Peppard and Rowland (1995)



separate, though related, activities. BPR provides the overriding focus for SISP to ensure that the IT/IS projects are associated with the company's reengineering programme developed by BPR itself. In the second case, there is likely to be an overlap between SISP and BPR activities. SISP is used as a pointer to help the company to identify where IT/IS can be applied. BPR can then be considered in the SISP process to help the implementation of the IT/IS projects more efficiently and effectively.

2.7 Discussion and conclusion

This chapter has provided a detailed insight into the conceptions of Information Technology and innovation by IT. Information technology comprises the computer-based technological and management systems and applications used in information handling and processing. There is a belief that the use of IT can help organisations to improve the efficiency of their operations, the effectiveness of management and to obtain competitive advantages. However, there are constraints in IT innovations. These main constraints are related to the new system itself and the users of the new system in the organisations.

IT provides the opportunity for the organisations to improve their business performance and achieve competitiveness. To keep these advantages in the long-term and prevent competitive imitation, the new IT system should be associated with the organisational business strategies and both internal and external value chains. Strategic information system planning (SISP) offers the framework for the organisation to identify the IT systems and applications effectively. There are many techniques and methodologies available for the SISP process. The organisations should consider carefully when selecting the approach for their IT/IS planning.

Managing IT is a difficult task. Outsourcing IT systems is considered a good way for companies that are not capable of building their own in-house systems. The benefits of outsourcing IT include improved quality, flexible resourcing, headcount reduction and the release of top management to concentrate on core business activities. There are also disadvantages of outsourcing IT such as over-dependence on supplier, cost escalation and loss of control on IT. Consequently, it is suggested that the IT systems which have high business positioning impact and high linkage to the business strategies should be developed in-house.

Chapter 3: IT Innovation and Organisational Change

3.1 Introduction

The review literature discussed in Chapter Two provided conclusive evidence that IT could be used as a potential enabler for organisations to achieve business success by improving internal business performance or obtaining externally competitive advantages. However, the use of IT can be regarded as a new and innovation process for organisations looking to adopt IT since it almost always results in changes in organisational operations and business processes. Consequently, an understanding of the fundamental theories of innovation and organisational change may provide an integral link in ensuring a smooth transition and minimise resistance to change in the adoption of IT at organisational level.

This chapter begins with a review of contemporary literature on innovation theory. The definition and diffusion of innovation are discussed. Secondly, the potential opportunities provided by IT innovation are identified. This is essential since process innovation by IT provides organisations with the means for radical process change so that business improvement can be achieved. Lastly, Pettigrew's conceptions in organisational change are reviewed. The three elements of organisational change described by Pettigrew provide a basis for the development of a conceptual framework for this research. This framework, which is described in greater detail in

Chapter 8, is used to analyse the relationship between IT implementation and organisational characteristics in construction organisations.

3.2 Innovation

3.2.1 Definition of innovation

Before we embark on a discussion of IT and its potential role as an enabler for innovation, it is necessary to define the term "innovation". West and Farr (1990) define innovation as:

> "*The intentional introduction and application within a role, group or organisation of an idea, process, product or procedure, new to the relevant unit of adoption, designed to significantly benefit the individual, group, organisation or wider society*" (p.9).

The UK Government White Paper on Competitiveness stated that:

> "Innovation- the successful exploitation of new ideas- is essential for sustained competitiveness and wealth creation. A country aiming to keep ahead of its competitors needs companies that innovate. Successful innovation requires good management, appropriate finance, skills and a supportive overall climate".

However, there is a distinction between creativity and innovation; "to create" is to bring something new into existence, whereas "to innovate" is to make changes by bringing in novelties. Thus innovation may involve creativity but not all innovations are creative. An innovation should bear benefits and public effects.

There is also a distinction between invention and innovation. Invention is the process by which a new idea is created or discovered, while innovation includes adoption- which is a decision and action to make full use of the new idea. However, an innovation is not necessarily a fixed entity as it diffuses. Re-invention, defined as the degree to which an innovation is modified or changed by the adopter, may occur in the process of its adoption and implementation (Rogers 1985).

Many types of innovation are described in the literature, for example, product innovation, process innovation and managerial innovation. However, a three-dimension typology of innovation proposed by Zaltman et al (1973) has gained support among a number of researchers such as West and Farr (1990) and King and Anderson (1995).

The first dimension is programmed-non-programmed. Programmed innovations are scheduled and planned in advance, such as the extension of a current service; while the non-programmed innovations are not planned in advance and may be either stimulated by the availability of resources or result from an urgent problem. The second dimension is instrumental-ultimate. The ultimate innovations can be considered as ends in themselves while instrumental innovations are introduced as means of facilitating the adoption of ultimate innovation. The last dimension is incremental-radicalness. A radical innovation represents a clear departure from existing practice and is entirely novel and highly risky (Dewar and Dutton 1986).

In contrast to radical innovations, incremental innovations are minor improvements or simple adjustments in current practice. The major difference between radical and incremental innovations is the degree of new knowledge and novel technological practice embodied in the innovation. The programmed innovation is likely to be routine or incremental (of low radicalness) while the non-programmed one will often be radical.

Contemporary innovation literature distinguishes between two basic types of processes in innovation, namely: diffusion and implementation (Winch 1998). The diffusion of innovation will be discussed in the next section, while the implementation of innovation will be discussed in Chapter 6.

3.2.2 Diffusion of innovation

The diffusion of an innovation refers to its spread between adopter organisations. Rogers (1995) found that six factors would influence innovation diffusion:

(1) Adopter characteristics;

(2) The social network to which the adopter belongs;

(3) Attributes of the innovation;

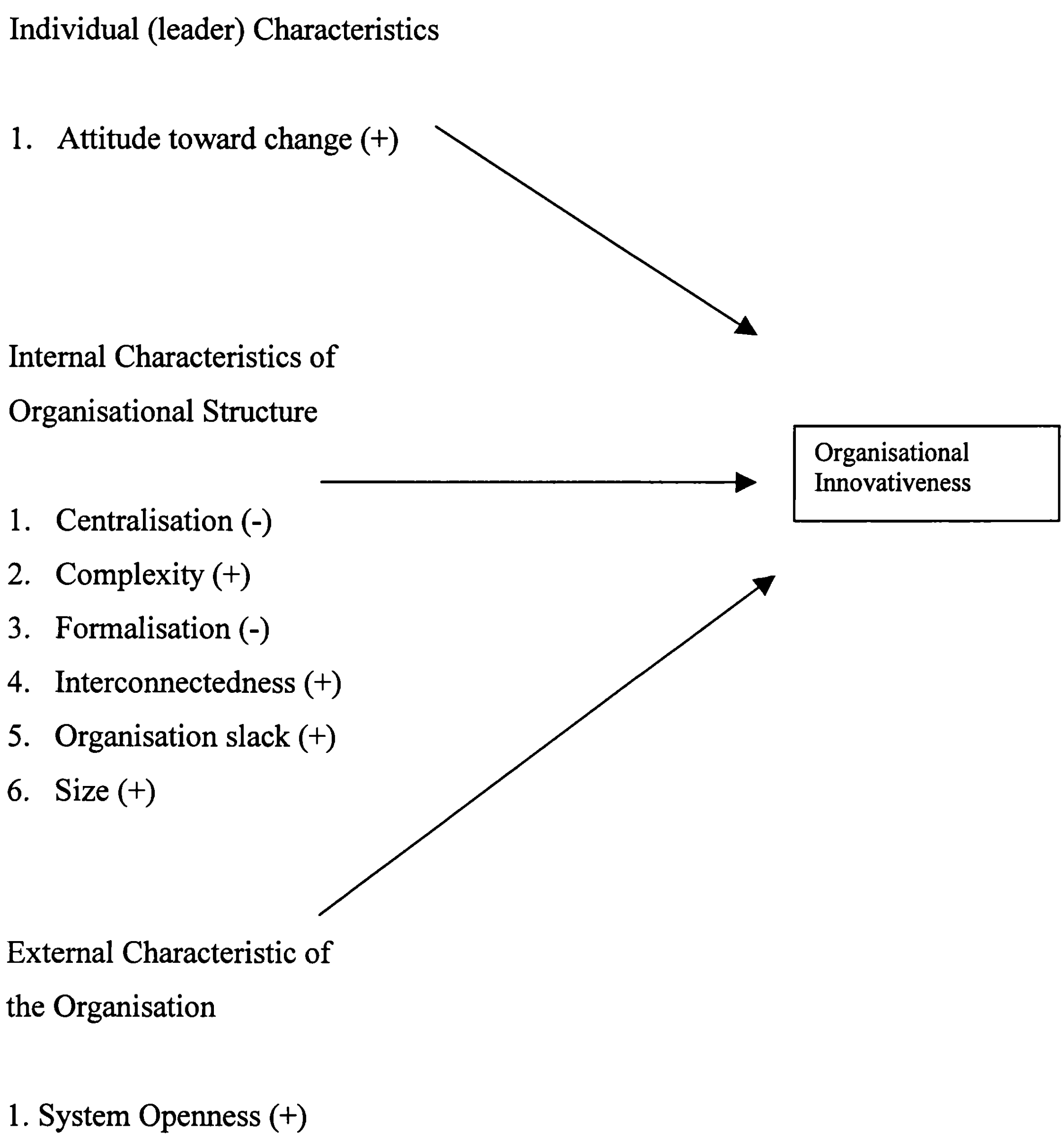
(4) Environment characteristics;

(5) The process by which an innovation is communicated, and;

(6) The characteristics of those who are promoting an innovation.

Furthermore, the degree of technology complexity is identified as a significant factor in the innovation diffusion (Tornatzky and Klein 1982).

Figure 3.1 Variables Related to Organisational Innovativeness (Rogers, 1985)



Rogers (1985) also summarises the variables influencing the organisational innovativeness from past research. These variables are classified into three groups: individual (leader) characteristics, internal organisation structural characteristics, and external characteristics (as shown in Figure 3.1). Rogers gives a detailed explanation of the organisational structure variables related to the innovativeness of the organisation:

- Centralisation: centralisation is the degree to which power and control in a system are concentrated in the hands of relatively few peoples. Centralisation has been found to be negatively associated with organisational innovativeness.
- Complexity: complexity is the degree to which the members in an organisation possess a relatively high level of knowledge and expertise. It is usually measured by the range of occupational specialities and professionalism in an organisation. Complexity has been found to be positively associated with organisational innovativeness since it may encourage organisational members to conceive and propose innovation.
- Formalisation: formalisation is the degree to which an organisation emphasises the following of rules and procedures in its member's performance. Such formalisation may inhibit the generation of innovation ideas, however it can help the implementation of innovations if the organisation has decided to adopt them.
- Interconnectedness: interconnectedness is the degree to which the units in an organisation are linked by interpersonal networks. It is believed to be positively related to organisation innovativeness since new ideas can flow more easily among the members in an organisation if the organisation is highly interconnected.

- Organisation slack: it is the degree to which uncommitted resources are available to an organisation. It is obvious that an organisation with more slack is more likely to be innovative.

However, Rogers argues that the correlations of each of the variables with the innovativeness of organisations are rather low. The main reason for this is that the organisational structure variables may relate to innovation in one direction during the initiation phase of the innovation process, but in an opposite direction during the implementation. For example, low centralisation, high complexity and low formalisation facilitate the initiation of innovation, but these organisational characteristics may make it difficult for the organisation to implement the innovation.

3.2.3 Opportunities in process innovation by IT

Process innovation, developed by Davenport (1993), is a management change that is designed to improve business performance by IT. According to Davenport:

> "*Process innovation combines the adoption of a process view of the business with the application of innovation to key processes. What is new and distinct about this combination is its enormous potential for helping any organisation achieve major reductions in process cost or time, or major improvement in quality, flexibility, service levels, or other business objectives*" (p.1).

In particular, Davenport distinguishes between the concepts of process innovation and business process re-engineering (BPR). He argues that the latter one specifically

Table 3.1: The impact and opportunities of IT on process innovation (Davenport (1993)

Impact	Explanation
• Automational	Elimination of human labour from a process
• Informational	Capturing process information for purpose of understanding
• Sequential	Changing process sequence, or enabling parallelism
• Tracking	Closely monitoring process status and objects
• Analytical	Improving analysis of information and decision making
• Geographical	Co-ordinating process across distances
• Integrative	Co-ordination between tasks and processes
• Intellectual	Capturing and distributing intellectual assets
• Disintermediating	Eliminating intermediaries from a process

refers to the re-design of a business process and is only part of a radical change process. On the other hand, process innovation encompasses the envisioning design activity, and the implementation of the change in all its complex technological, human, and organisational dimensions (Davenport 1993).

He also suggests that there are at least nine different opportunities supporting process innovation by IT (as shown in Table 3.1). The details of these opportunities for process innovation by IT are described below.

(1) Automational

The most obvious of the IT opportunities is to reduce human labour by computer-based tools and applications. Robotics, automatic document flow and transformation, image recognition and CAD are some examples of IT opportunities for automation.

(2) Informational

Information Technology can be incorporated within a process to capture information about the process performance. The information can then be analysed either manually or with IT tools (see analytical). Management information system (MIS) and executive information systems (EIS) are examples of the supportive informational function of IT.

(3) Sequential

IT can enable changes in the sequence of processes or transfer of a process from its sequential cycle to a parallel one in order to achieve cycle-time reduction. A well-known example is Kodak's approach to reducing the design cycle time for the single-use camera radically.

(4) Tracking

Other than the function of gathering information, IT can also monitor and trace a process. In some industries such as package delivery and logistics businesses, this function has already become an essential part of their business operations.

(5) Analytical

IT can also provide the capacity to analyse information for decision making. This analytical function can be built into the process or employed separately from the process. Expert systems and decision support systems are examples of IT applications for information analysis.

(6) Geographical

An important contribution of IT dating back to the invention of telegraph is the ability to overcome geographic problems. The ability to transfer information all over the world is essential to global companies. Networking (LAN and WAN), electronic mail and electronic conference are common tools used to transfer information and thereby overcome all geographical barriers.

(7) Integrative

In some processes, tasks are segmented and split across many departments in an organisation. For example, the process for ordering may need to be completed by many departments- sale department receiving order, inventory department checking current stock level and accounting department sending invoice. However, IT can provide the capacity to integrate the whole process by networking all information needed and complete all the required procedures at the same time. The integrated data base system (DBS) is a common example of this application.

(8) Intellectual

In businesses requiring knowledge-intensive activities, the knowledge and experiences of the employees are as important as the organisation's assets. However, it is difficult to manage the knowledge and experience of individuals. Consequently, IT is used by many industries to provide quality information to their customers concerning issues such as tax, law, medicine prescription, and accounting.

(9) Disintermediating

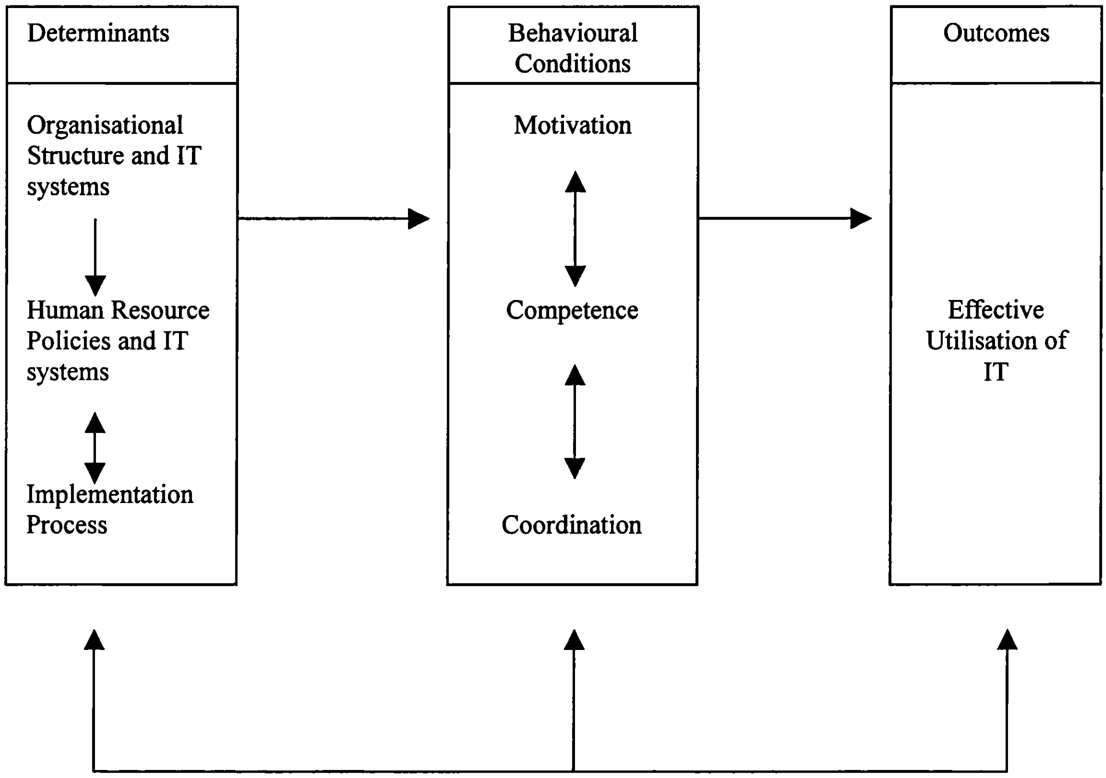
It is becoming clear that the human intermediaries are relatively inefficient and unreliable in relaying information compared with computers, especially for the stock and financial markets. Thus, an automatic exchange system has been developed to reduce human intermediaries in data and information transactions.

Collectively, the 9 impacts and opportunities presented above clearly illustrate how process innovation can help to attain business objectives such as cost and time reduction. Davenport has also developed a five-step model for implementing process innovation by IT. This model will be discussed in Chapter 6 and compared with alternative innovation process models.

3.3 IT and organisational change

Mckersie and Walton (1991) indicate that the full potential of IT innovation in organisations could only be realised if it is associated with appropriate changes in the organisation and human resource practices. In other words, the adoption and implementation of IT innovation should involve both social and technology

Figure 3.2 Framework for Effective Utilisation of IT (Mckersie and Walton 1991)



development processes. They have developed a framework for effective utilisation of IT, as shown in Figure 3.2.

In their framework, IT implementation comprised three tasks: designing the IT system and the organisation that will operate it, developing enabled human resource policies, and managing the implementation process. The design, development and implementation of IT influence three key conditions: motivation, competence and coordination.

The motivation condition in those who play a critical role in successful IT implementation can range from reluctant compliance to a high level of spontaneous commitment. The competence of those managing and operating the technology can also range from limited operation skill to comprehensive master in the technology. Coordination can range from strictly individual work taking to tight teamwork. These three key conditions will strongly influence the integration of the technology into the organisation.

According to their research, the fundamental key to effective IT innovation is the "alignment" of the technology and the organisation factors (e.g. organisational structure and human resource policies) that operate it. Such alignment is defined by Mckersie and Walton (1991) as the idea that:

> "*The requirements of a particular IT system- for certain levels of motivation, types and amounts of knowledge and skill, and communication and coordination- are matched by the capabilities of the organisation. Conversely, alignment also means that the requirements of the organisation- for example, decentralised decision making, continuous learning, challenging jobs, or attractive career paths- are accommodated by the design of the IT system.*" (p.248).

Mckersie and Walton also demonstrate three common routes that can lead to alignment. First, some of the enabling organisational conditions may already exist or can be developed in anticipation of the introduction of IT. Second, an organisation effectively puts the technology in place so that the operations of the organisation and the technology can be improved simultaneously, each adapting to the other. Third, management can focus exclusively on the implementation of technology and let the technology drive subsequent organisational adaptation. The technology then can be effectively integrated into the organisation.

From Mckersie and Walton's conclusion, organisational change and the alignment between organisation and technology are necessary pre-conditions for the effective utilisation of IT. However, similar to most of the SISP techniques described in Chapter 2, Mckersie and Walton's framework for effective utilisation of IT focuses mainly upon the relationships between organisational internal environment such as structure, human resource policies and technology. In other words, their considerations are limited by the organisation boundary. Factors such as those inherent from external business environment (e.g. the industry, clients and suppliers) and the process of IT implementation are not included in their framework.

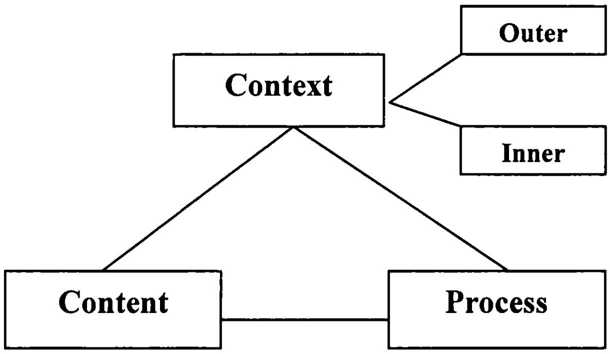
Winch (1994) contends that the analysis of the implementation of technological change (e.g. the use of IT) in organisations should focus on organisational change. Indeed, Buchanan (1983) also argues that technological change is usually organisational change. However, Pettigrew and his colleagues (1985) argue that traditional research in this area continue to focus on change episodes and little of the work has taken into account the organisational context of the change process. In studies of a variety of organisations, he develops a "contextualist approach" to the analysis of the processes of organisational changes. Willcocks and Margetts (1994) contend that this approach *"rightly strove to avoid the ahistorical, aprocessual and acontextual character of much research on organisational change"*(p213). Pettigrew and his colleagues identify three critical elements in the analysis of organisational change- the context, the content and the process. Pettigrew et al also distinguish between "inner context" and "outer context" as the two distinct levels in the analysis of the context of organisational change. This approach is shown in Fig 3.3. The relationship and interplay among these three elements can influence the outcome of the change.

The outer "context" refers to the industry, economy, politics, markets, and competitive environment in which an organisation operates. The inner "context" refers to the organisational characteristics including strategy, culture, management, human resources and policy. The "content" element refers to the particular areas of organisational change under examination. For instance, if a firm seeks to improve business performance by introducing new technology then the content of change is the technology itself. The "process" element refers to the action and implementation of the change as well as the interaction and reaction from the participants in this change. Consequently process covers "how" things are done and issues perceived, while content indicates "what" the change is, and inner and outer context can be utilised to explain much of "why" the change takes place.

After completing a study of change in the NHS, Pettigrew et al (1992) contend that having "correct" policies for change is not sufficient; an organisational capacity for change is also required. They suggest that:

> *"Theoretically sound and practically useful research on change should involve the interplay between ideas about the context of change, the process of change and the content of change together with skill in regulating the relations between the three"* (p.6).

Figure 3.3 Pettigrew's Three Elements of Change (Pettigrew 1985, 1990)



Pettigrew's three element of change has rightly solved the major problem discussed previously (e.g. Mckersie and Walton's framework) in analysing the utilisation of IT innovation in organisations as it emphasises the interactions between the various possible levels of organisational context both within the organisation under study and also the environment within which the organisation is located. However, Pettigrew's work does not provide any coherent methodology to analyse the implementation process of organisational change. Winch (1994) also argues that his approach "reveals few clues as to how to specify the relevant levels of analysis for any particular change"(p.36). Consequently in order to investigate the diffusion and implementation of IT innovation in construction organisations, an analytical research framework based on Pettigrew's three element of change was developed (see Chapter 8). Also further discussions and reviews regarding the context, contents and process of change in IT innovation are required.

3.4 Discussion and conclusion

This chapter has laid out the issues derived from contemporary literature on innovation and organisational change. Innovation is the whole process that starts from exploring new ideas, adopting the new ideas to making full use of the new ideas. Information technology can be used as the enabler for process innovation. Opportunities provided by IT innovation can help to attain business objectives such as cost and time reduction.

Rogers has identified three groups of variables that could influence the diffusion of innovation in organisations: individual (leadership) characteristics, internal organisation structural characteristics, and external characteristics. However, Rogers argued that the correlations between each of the variables with the innovativeness of organisations are rather low. Some organisational structure variables may help innovation during the initiation phase of the innovation process, but obstruct innovation in the implementation phase.

Mckersie and Walton conclude that organisational change and the alignment between organisational factors and technology are necessary conditions for effective utilisation of IT innovation. However, their framework mainly focuses on internal organisational context and pays no attention on the implementation process. Alternatively, Pettigrew et al provide a broader view and indicated that the interplay between the context (both outer and inner), content and process of change should be analysed since it affects to the outcomes of the change. Thus these three elements can be brought into analysing the diffusion and implementation of IT innovation in construction organisations. The following chapters will explore the issues in the context, content and process of change in IT innovation based on Pettigrew's organisational change framework.

Chapter 4: The Context of Change

4.1 Introduction

The construction industry is information intensive. It requires accurate and reliable information ranging from specifications, codes and standards for design drawings to building process data for project sites. The glowing complexities of project and client requirements present construction organisations with the challenge of managing their organisations in an increasingly competitive business environment. In order to adapt to the new business environment, many of the organisations are considering innovation.

This chapter focuses mainly upon the outer context and inner context of organisational change by innovation in construction firms. Firstly, the problems of innovation in the construction industry due to the "complex system" environment are discussed. Secondly, a model explaining the dynamics of innovation in construction firms is introduced. The orientation of innovation in construction firms can be explained by this model. Thirdly, organisational characteristics as antecedents of organisational innovation such as organisational structure and culture are identified. Finally, the importance of individual characteristics of organisation members in innovation is emphasised.

4.2 Innovation in the construction industry

4.2.1 Innovation in construction

The construction industry is a mature and traditional sector. It has a low adaptability to change and is generally not receptive towards innovation (Aouad and Price 1992). However, innovation is not new to the construction industry. According to Pries and Janszen, a total of 290 innovations were recorded in the Dutch construction industry between the years 1945-1992. Two conclusions can be drawn from their survey: first, the major motivation of innovation is to increase productivity and price reduction; and second, most of the innovations for contractors are process innovations. They found that half of innovations in the Dutch construction industry originated from other sectors. Furthermore, most of the innovations in construction were process innovations in the domain of price-cutting.

Pries and Janszen (1995) also contend that there are four major obstacles to innovations for the contractors. The first obstacle is that every project is unique and there is little reason for contractors to invest in innovation, other than the optimisation of their familiar procedures and operations. The second one is that the high costs and long life span of buildings and structures compel customers to stick to proven methods to avoid failures.

The third one is that management in construction is dominated by engineers. Top management in many contractors consists mainly of civil engineers whose management skills originate from project practice and their engineering backgrounds. They tend to have a strict technical rather than managerial and market focus on product and process. This has a major effect on the policy of enterprises for innovation (Pries and Janszen 1995).

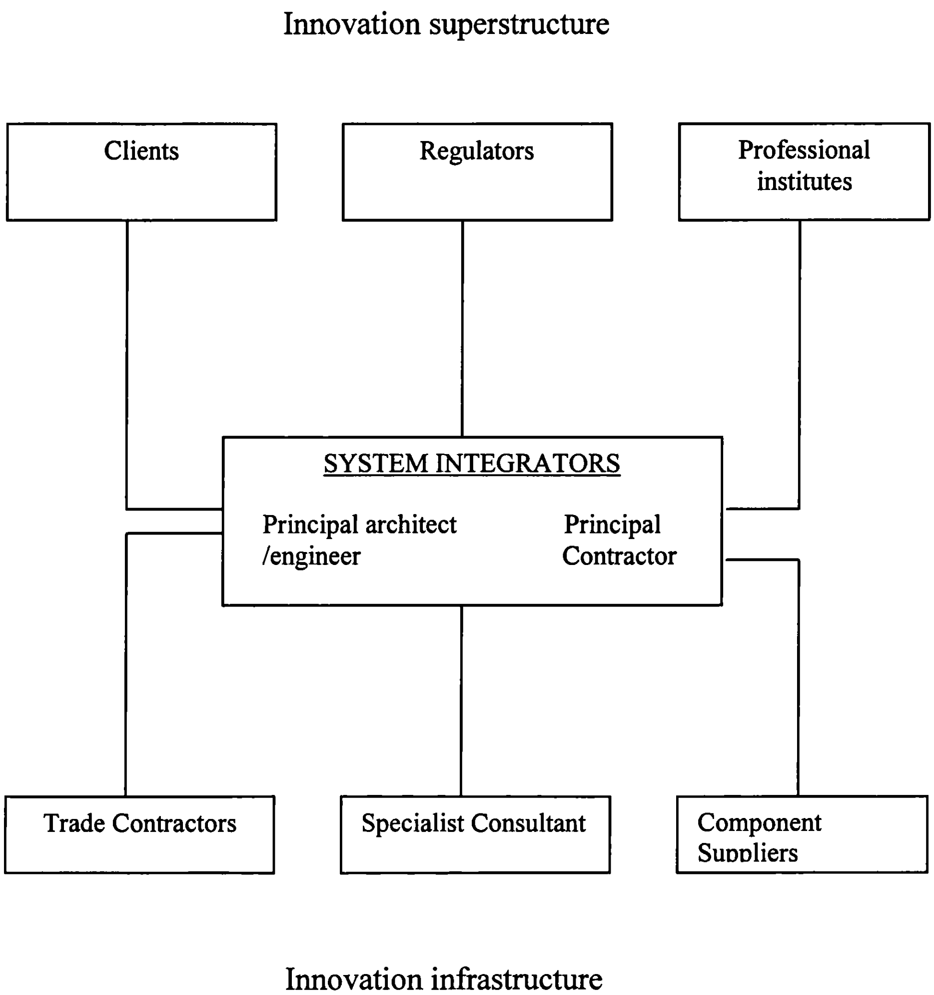
The last obstacle to innovation in construction is governmental influences. The government is not only responsible for various financial and technical regulations; it is also a very dominant client in the construction industry, thus leading to a situation where there is very little variation in the quality of production (Pries and Janszen 1995). As a result, very uniform demand arises and contractors are forced to seek competitive advantage through cost leadership and tend to overlook other market and management strategies.

However, Winch (1998) contends that the problem is not that there has been no innovation, but is that the rate of innovation in the construction industry lags behind that of most other sectors. Winch also argues that this problem may be explained by the nature of "complex systems" in the construction industry. According to Miller et al (1995), complex product system could be distinguished by the following characteristics:

(1) Many interconnections and customised elements are organised in an hierarchical way;
(2) Small changes to one element of the system can lead to large changes elsewhere in the whole system;
(3) Users are highly involved in the process of innovation. The industries that create such complex product systems can be characterised as complex systems industries.

Similarly, Winch regards construction as a complex systems industry and illustrates the complex systems conceptions applied to the construction industry, as shown in Figure 4.1.

Figure 4.1 Construction as a Complex Systems Industry (Winch 1998)



According to Winch, although construction is a complex systems industry, there are a number of distinct features that set it apart from the model developed by Miller and his colleagues. Firstly, both the principal contractor and the principal architect/engineer share the role of system integrator. Consequently, construction can typically be divided into two processes: one is the design stage and the other is the construction stage. The design and construction teams of a construction project usually have distinct responsibilities.

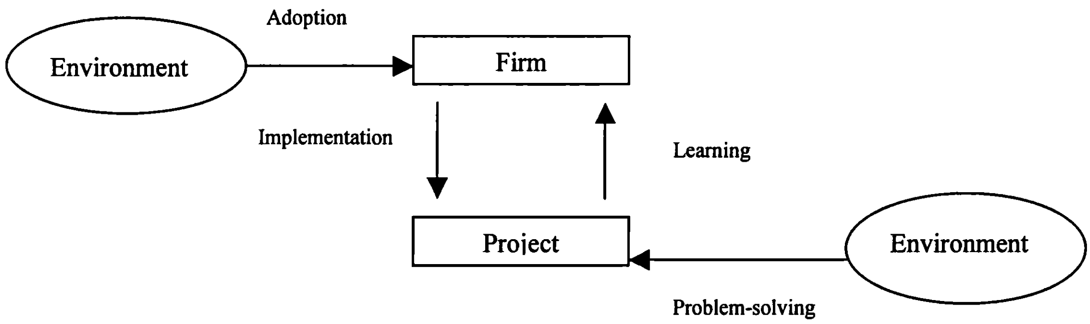
Secondly, the fragmentation of the principal corporations in construction may reduce the opportunities for innovation in construction as changes usually threaten the interests of one or other parties amongst them. Thus, government has played a critical role in brokering innovation through the regulatory system.

Thirdly, trade contractors (specialised suppliers) in construction are rarely given full technical authority and subject to separate specialist consultants. Thus trade contractors; specialist consultants and component suppliers are three distinct roles in the innovation infrastructure.

From the perspective above, three major factors inhibiting the rate of innovation in construction can be suggested. The first one is the intricate diversity of roles and parties involved in the complex systems. Incentive for innovation in construction cannot be improved without the support and co-operation from project client and project coalition. The development of gain-sharing methods, where rewards are shared by clients and project coalition, are also critical for the diffusion of innovation in construction.

The second one is the influences from the regulator, the professional institutes and research establishments in the construction industry. These bodies play important roles as brokers in innovation. However, this brokering role that provides the basis for the new regulation may also sometimes slow the process of innovation. Winch

Figure 4.2 A Model of Construction Innovation Process (developed by Winch 1998)



gives an example of Royal Institute of British Architect's (RIBA) case. He points out that:

> *"The RIBA resisted the use of patented reinforced concrete systems because it meant that they lost control over the technology. It was the recommendations of the RIBA which formed the basis of the new regulations from 1909 onward. Thus the dynamics of the British institutional structure in construction resulted in the shifts from load-bearing masonry to structuring framing lagging that in other industrial countries by 20 years or more"* (p.272).

The third one is the role of system integrator in the construction complex systems. As shown in Figure 4.1, the system integrator is at the interface between the innovation superstructure and the innovation substructure. New ideas are proposed within the substructure, accepted within the superstructure and mediated by the system integrator. Thus, the system integrator needs to have the skills to integrate interdependent components into a coherent whole. However, the systems integrator role in construction is split between two distinct actors: the principal contractor and the principal architect/engineer. This means, the championing and mediating roles essential to successful innovation are less likely to be carried out effectively by the systems integrator in the construction complex systems (Winch 1998).

4.2.2 The dynamics of innovation in construction firms

Winch (1998) has also developed a model to provide a context of innovation at the firm level to show how decisions to adopt new ideas are made and moved into good currency. This model is shown in Figure 4.2. There are two distinct moments in this model of construction innovation- a top-down moment of adoption/implementation, and a bottom-up moment of solving/learning. New ideas are either adopted by firms and implemented in projects, or result from problem-solving process on projects and are learned by firms.

New ideas for the top-down moment of adoption/implementation can come from three sources:

(1) They may come from the result of formal R&D processes.

(2) They may be transferred from abroad or other sectors.

(3) They may be copied from the leading innovators in this sector.

All of these sources are, by definition, external to the innovating firm. The projects in which firms are engaged offer the main internal sources of new ideas for the bottom-up moment of problem solving/learning or meet the client's specific requirements. New technologies can be applied to solve particular problems found on construction sites. The solutions reached for the particular problems can then be learned and applied by the firm in future projects.

Organisational characteristics may influence the ways in which construction firms adopt innovation. For example, if the culture in one organisation does not favour change, then innovation is unlikely to take place unless forced to by project clients or required to solve project problems. Such organisations are *reactive* to innovation and only adopt the bottom-up problem solving/learning innovation process. On the other hand, some construction organisations may be *proactive* to innovation. They will not only adopt innovation to satisfy their client's requirement or solve project problems, but are also keen to seek any opportunity for innovation from the external sources discussed previously (e.g. copy from other sectors). Both bottom-up problem solving/learning and top-down adoption/implementation innovation processes can be found in such organisations.

Other organisational characteristics such as business strategy may also influence a construction organisation's adoption on innovation. As Ramsay (1989) argues, there are only two basic strategies to secure a substantial advantage for competition in construction: one based on cost leadership, the other on product differentiation. Thus, organisations with cost leadership competition strategy may avoid any unnecessary investments and are reluctant to adopt any innovation in order to keep capital costs low.

4.3 Organisational characteristics and innovation

4.3.1 Organisational structure

The importance of an organisation's structure for its ability to innovate has long been a major theme in the literature (King and Anderson 1995). John Child (1977) defines organisational structure as:

> *"a means for allocating responsibilities, providing a framework for operations and performance assessment, and furnishing mechanisms to process information and assist decision-making."* (p.23)

Burns and Stalker (1961) conducted a study of British firms from a variety of industries and located their organisational structure on a continuum of "**mechanistic**" to "**organic**". They found that bureaucratic-type (mechanistic) structure worked well for organisations operating in stable circumstances, but an organic structure is required for organisations seeking to innovate or adopt change. The characteristics of mechanistic and organic organisations are summarised in table 4.1.

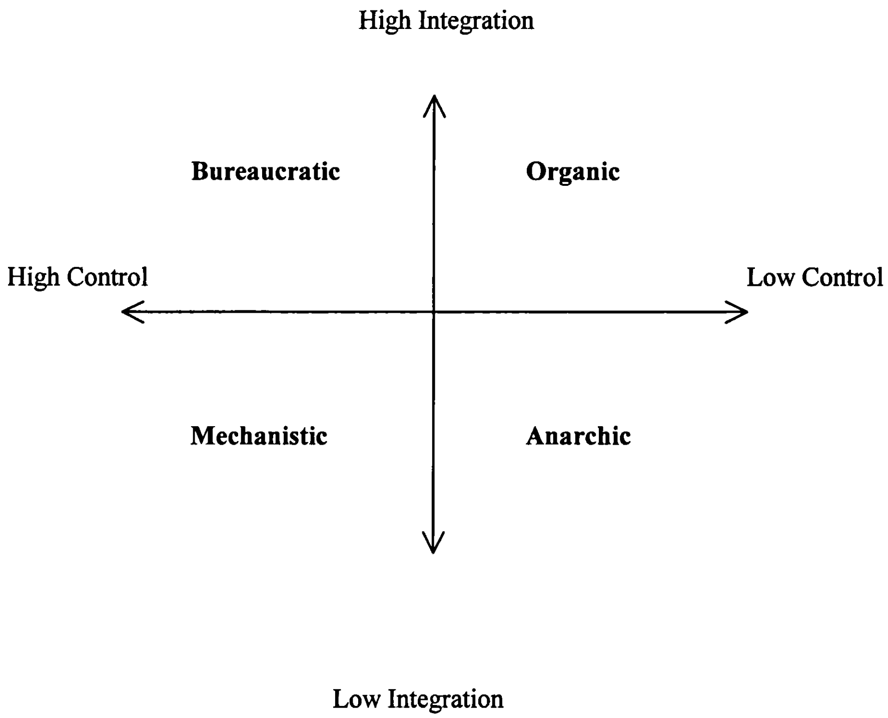
However, Lansley et al (1974) argue that they encountered difficulties in using the Burns and Stalker's model in a study of organisational structure in the building industry. These difficulties were both theoretical and practical. At the practical level, firms appeared to combine certain mechanistic and organic characteristics simultaneously.

Table 4.1 Characteristics of Mechanistic and Organic Organisations (adopted from Burns and Stalker 1961)

Mechanistic organisations	Organic organisations
• Hierarchical structure, with stable divisions/departments based around function; • Vertical communication dominates; • Rigid job definition, set by senior management; • Power and authority based on seniority in hierarchy.	• Flat structure, with temporary work group/teams based around specific projects; • Lateral communication dominates; • Flexible job definitions, defined by individuals through interaction with colleagues; • Power and authority, based on skill and abilities, change with changing circumstances.

At the theoretical level, they argued that the enormous complexity and variability of real-life management structures could not be reduced to the single dimension suggested by Burns and Stalker. Consequently, they have developed a rather more complex model based on the nature of the **control** system and the degree of co-ordination or **integration** achieved in a firm, which is consistent with Child's definition for organisational structure stated previously.

Figure 4.3 The Organisational structure Model (developed by Lansley et al 1974)



The control factor is concerned with the methods employed by the organisation to ensure that people perform their tasks in desirable ways as determined by top management in the organisation, while the integration factor is concerned with the way relationships between tasks and the employees performing them are closely regulated and co-ordinated in relation to the firm's objectives. Taking both factors into account, a four-fold typology for organisational structure classification can then be made, as shown in Figure 4.3.

From this approach, the burns and Stalker's mechanistic type represents the situation where control is high but integration is low. The organic type involves high integration and low control. The remaining two types: high control, high integration and low control, low integration, have been labelled by Lansley et al as bureaucratic and anarchic respectively.

Lansley and Quince (1982) also provide a number of indicators to measure the degree of control and integration in organisations, as shown in Table 4.2. Their methodology illustrates a way to measure and classify different types of organisational structure in construction firms. Although their research objective was to measure the relationship between organisational structure and business performance, their structure typology might be applied to the study of organisational structure and innovation in the construction industry.

A different perspective on organisational structure and innovation structure from the Burns and Stalker's organic-mechanistic division is provided by Zaltman et al (1973). Their work was concerned with how structure contributed to the overall ability for innovation in organisations and how it influenced the progress of innovation at different innovation stages (e.g. initiation stage). Three variables were examined: centralisation, formalisation and complexity.

Centralisation refers to the extent to which authority and decision-making is concentrated at the top of organisation hierarchy. Formalisation is the degree of emphasis placed upon rules and procedures determined by the organisation.

Table 4.2 Indicators of Organisation Structure by Lansley and Quince (1982)

Variable	Indicator	High	Low
Integration	Grouping of staff	Team structures based on task	Vertical structures based on function
	Communication	External reliance on formal methods of communications, e.g. meeting, circulars, etc.	External reliance on informal channel
	Job information	Reliable, rarely conflicting	Unreliable, often conflicting
Control	Specification	High degree of differentiation between functional tasks;	Low degree of differentiation between functional tasks;
	Reporting Relationships	Narrow chain of command	Broad chain of command
	Use of system and procedures	Extensive and obligatory use of well defined financial and non-financial systems	Informal and *ad hoc* systems
	Performance Standard	Strict and well defined short term performance objectives set at department and project level	No clear performance objectives below operating unit level

Complexity refers to the amount of occupational specialisation and task differentiation in the organisation.

Zaltman et al (1973) argue that these variables have contrasting effects at different stages of the innovation process: initiation is facilitated by low levels of centralisation and formalisation and high level of complexity, while implementation is facilitated by high levels of centralisation and formalisation and low levels of complexity. However, King (1990) argues that although there is empirical evidence to support this so-called "innovation dilemma", it is incomplete and ambiguous. For this proposition to be adequately tested, longitudinal studies which can monitor the influences of centralisation, formalisation and complexity on the different stages of innovation process are required.

4.3.2 Organisational climate and culture

As indicated by King and Anderson (1995), recent research into antecedents for successful innovation has been shifted away from people and structure characteristics towards less tangible features of organisations such as culture and climate. Indeed, organisational climate and culture have been identified as important antecedences of innovation by many authors such as Fisher and Farr (1985), Kanter (1883) and Morgan (1986). However, there is a considerable overlap and a lack of consistency in the usage of the terms for culture and climate. Morgan (1986) contends that it is generally the case that climate is a more limited concept than culture and is concerned with "atmosphere" or "mood", whereas culture comprises those symbols and structure which enable shared meaning, understanding and sense-making to be generated and maintained. Nystrom (1990) defines organisational culture as "the values, norms, beliefs and assumption embraced by participants" and climate as "the feelings, attitudes and behavioural tendencies, which characterise organisational life and may be operationally measured through the perception of its members".

Duncan (1972) identifies three important dimensions of climate for change: need for change, openness for change and potential for change. He found significant positive correlation between openness to and potential for change, but also significant negative correlation between the need for change and the other two variables. This finding suggests that the greater the perceived need for change, the less the perceived openness to and potential for change. Zaltman and Duncan (1977) explain that high perceived need for change might create anxiety and a feeling among organisational personnel that the change is an unachievable reality

The shift of interest from climate to culture in the study of organisations may be discerned in recent research work (King 1990). Handy (1985) identifies four types of organisation culture and their relationships with organisation innovation by focusing on the links between culture and organisational structure. This structured approach to culture is described below:

Role cultures are typical of class-bureaucratic type of organisation, where the structure is one of multiple layers of hierarchy and each reporting to the one above it. Ambiguity of any kind is highly threatened, and formal rules, regulations and procedures abound. In this sense, role cultures are generally not conducive as effective innovators. Role cultures function well in stable and predictable environments. King and Anderson (1995) suggest that role cultures might be successful at managing non-radical innovations which do not threaten the fundamental organisational structure.

Power cultures are usually found in organisations which have grown up with one strong, authoritative individual. Handy (1985) compares this structure to that of a web, with its maker- the spider, in the centre. In this structure, status, obedience and control are highly valued. Decision making in particular circumstances are made on an *ad hoc* basis rather than aided by fixed rules and regulation. This enables such culture to initiate or respond to innovation more rapidly than role culture. However, King and Anderson (1995) argue that such cultures can be very effective innovators only if the organisation is small enough for the power figure to exert his control and where most of the staff members share his vision. Also, a lack of autonomy among those staff members distanced from the centre may lead to dissatisfaction and a reluctance to exert effort in the innovation process.

Person cultures emphasise individual autonomy and interpersonal relationships. They are associated with highly decentralised and informal structures, and control is exercised through mutual accountability. Organisations such as co-operatives or professional partnerships (e.g. architects) are examples of person cultures. This culture may facilitate high level of individual creativity. However, this may not always transfer into organisational innovation due to the need to achieve consensus among all key individuals.

Task cultures are associated with a matrix structure. They emphasise flexibility, adaptability and performance within project teams and sensitivity to the organisation's environment. In this structure, communications are more lateral than vertical and individual and team achievements are highly valued. Handy (1985) suggests that task culture is the most favourable to innovation. However, he also argues that such a culture is not appropriate for all circumstances. For example, a small organisation with a power culture may be able to respond faster to an unexpected new market opportunity. Consequently, Handy argues for intra-organisational diversity of cultures.

It would appear that an understanding of organisational culture and climate can aid us in making sense of innovation than focusing only on tangible aspects such as organisational structure. Indeed, the idea of managing culture as a means of managing change and about the type of culture that is desirable, have been accepted by practitioners as key aspects of organisational change (King and Anderson 1995). However, King and Anderson (1995) stress the danger of overemphasising the extent to which climate and culture can be "managed" since organisational culture and climate are deeply rooted in history and personal experiences within an organisation. Also, King (1990) indicates that organisational culture and climate are areas of speculation rather than empirical investigation in the innovation literature. Further research is therefore required to not only examine which types of culture facilitate or inhibit innovation, but also to measure the extent to which innovation requires changes in organisation culture.

4.4 Characteristics and behaviour of individual in organisation

The preceding sections have discussed innovation both at whole industry level and at the individual firm level. However, the roles of individuals in a firm also play a critical part in successful innovation. The influence of the individual characteristics of organisational members has been emphasised by many research works.

(1) Leader and decision maker

Effective leadership is essential for technological innovation in construction (Nam and Tatum 1997). West (1990) indicates that top management's values for innovation play a crucial role in an organisation's level of innovation. Indeed, the innovations are more likely to be implemented if they are consistent with the top management's goals and values. The technological competence of the leaders is another important factor in initiating construction innovation. This is because a risk of failure is always associated with any innovation activities. In this sense, top management's comprehension of the technology employed in the innovation could help to reduce risks in the innovation process. Indeed, responsibilities for the technological decision making in innovation often rest with top executives in firms.

However, King and Anderson (1995) argue that a short-coming of past studies focusing on individual characteristics such as value or belief for innovation is that they are unable to identify characteristics which predict innovation in all types of leaders. For example, Kimberly and Evanisko's (1981) study explored leader characteristics in American health organisations and found leader's characteristics to be poorer predictors for innovation than organisational factors.

Faced with these difficulties, studies on innovation and leadership changed to examine the leadership style or management style for innovation (King and Anderson 1995). Manz et al (1989) examined the influence of leadership style on the development of seven major innovations and concluded that different leadership styles are required for different types of innovations, and at different stages of the innovation process. However, there is a general consensus among a number of authors like Kanter (1983) and Peters and Waterman (1982) that a participative and democratic style of leadership is preferable since it encourages subordinates to suggest novel ideals and be involved in the innovation process.

(2) Change agents and Idea champions

The influence of individuals other than leaders or decision makers on organisational innovativeness may be the change agents and idea champions. A change agent may be defined as a person given explicit responsibility for the task of overseeing the process of a specific change in the organisation. Rogers (1985) stresses the importance of change agents in the diffusion of organisational innovations and proposed eight factors and characteristics which are positively related to the successful innovations. They are (1) the extent of change agent effort in contacting clients, (2) a client orientation, rather than a change-agency orientation, (3) the degree to which the diffusion programme is compatible with clients' needs, (4) the change agent's empathy with clients, (5) the degree to which the change agent and his clients share the same outlook and background, (6) the change agent's credibility to clients, (7) the extent to which the change agent is able to work through opinion leaders in the organisation, and (8) increasing client's ability to evaluate innovations.

Similarly, the champions for innovation who hold positions of authority as well as power beyond authority can play an important role as well. The introduction of innovations is often not considered by formally appointed change agents, but rather by "idea" champions who feel a strong commitment to a new idea and are keen to "sell" it the other members of the organisation. The individuals with the technical expertise and are keen to be the "drive force" in innovation are especially vital. Also, the success of an idea champion will depend on his ability to persuade powerful and influential people of the value of the innovation.

Nam and Tatum (1997) have stressed the importance of champions for innovation in the construction industry. They found that the champion in a position of authority or with power is essential for the success of construction innovation. Consequently, they suggest that management in construction organisations should allocate sufficient power to employees and create slack resources if they want to make their organisations innovative.

(3) Project owner's involvement

The importance of the owner's involvement for innovation is a unique feature of innovation in the construction industry. In the construction industry, the role of the project owner (buyer) is more active than that of his counterpart in the manufacturing industry. Indeed, besides the mere purchasing of the finished products, the owners (buyers) of buildings or other heavy sectors of the construction industry are often the main participants on the project. Nam and Tatum's (1997) survey findings revealed that a high level of owner involvement in construction innovation appears to be critical for better results. In addition, Nam and Tatum (1997) indicate that owner's technological competence and knowledge would help to induce his involvement with the innovation project, which can lead to a better outcome.

(3) Other organisational members

However, Tatum's research neglected a crucial factor: member's commitment for innovation in organisations. As indicated by King (1990), innovation researchers tend to concentrate on leaders and/or decision makers as change agents, and the role of other members of the organisation that has been concerned in innovation research is usually in the context of *resistance.* A number of individual psychological factors have been studied in relation to resistance to organisational innovation. Waston (1973) and Zaltman and Duncan (1977) both used the term "selective perception" when arguing that people tend to respond to subsequent suggestions for change within their established attitude and outlook. Personal factors such as conformity to norms, habit, low tolerance for change, and low risk-taking propensity have also been associated with resistance to innovation.

According to King and Anderson (1995), there are three psychological processes underlying resistance in organisational innovation. First, change is unknown and therefore presents a threat to those affected by it. Change may be resisted just because it is "change". Second, change challenges the status quo and may be resisted because of powerful vested interests in maintaining the current equilibrium position. In particular, those who stand to lose the most, whether in terms of positional power, resources or rewards are most likely to resist change. Third, change may bring extra work for those affected by it. In this circumstance, resistance to change here can be argued to be "rational" rather than "emotional". This is especially evident where the new and old systems are continued in parallel for a period of time following the change implementation.

From the discussion above, it would seem that the commitment for innovation from those who are affected by the change is also a critical factor for successful innovation. Consequently, this factor should be considered jointly with Tatum's three key factors while studying innovation in construction.

4.5 Discussion and conclusion

Innovative IT project investments usually triggers changes to organisational structures and working method, which may make many top managers reluctant to adopt IT. The barriers to the adoption of innovation in construction organisations vary with different business environments and policies. The complex system in the construction industry discussed has provided a framework to explain why the rate of innovation in construction lagged behind that of other sectors. The separate systems integrators- one at the design stage and one at the construction stage, and the fragmentation of the professional bodies are identified as the main causes for preventing the implementation of innovation in this sector.

There are two dynamics of innovation in construction organisations. One is the top-down adoption/implementation dynamic and the other is bottom-up problem solving/learning dynamic. The former usually come from the awareness of a performance gap in relation to competitors, the outcome of formal R&D, or copied and transferred from other sectors or leading innovators in this sector. Whatever the source, it is, by definition external to the innovating firm. The latter usually comes from the needs to solve a specific problem on a construction project or to meet a project client's specific requirement. For problem-solving to become innovation, the solution reached must be learned by the firm and applied to further projects. These two dynamics of innovation can be applied to study the orientations of innovation in construction firms.

Both organisational characteristics and individual characteristics of organisational members are regarded as antecedents of organisation innovation by many authors. As to organisational characteristics, this chapter concentrated on the influence of structure, culture and climate and management style on innovation. Some methodologies to determine the types of structure in organisations were provided. These methodologies will be applied to the measurement of organisational internal context in this research.

Some characteristics or behaviour of organisational members were also discussed. Leader's value and competence and leadership style are important factors for innovativeness in an organisation. Idea champions and change agents also play important roles in the introduction and implementation of innovations; especially the champion plays a critical role in a successful innovation process. Thus, it is essential for a champion to be of an authoritative position in an innovation process. Other members of the organisation have been considered in the context of resistance. Many factors such as habit, belief and rewards in individuals may also affect their attitudes toward the innovation. Thus, the commitment of those organisational members who are affected by the changes is also vital for successful innovation.

Chapter 5:The Content of Change

5.1 Introduction

Strategic use of IT for maximising competitive advantage and operational efficiency is currently a popular topic in the construction industry. Although the progress of development and implementation of IT projects in the construction industry is still lagging behind those in many other sectors, top management in construction firms are becoming increasingly aware of the benefits that IT can offer and have started to consider using IT. Many leading construction firms have already developed their own IT strategy to gain competitive advantage as discussed in the previous section.

This chapter mainly discusses the uses of IT applications in the construction industry. The first part of this chapter discusses the barriers of IT applications in the construction industry. Most of the barriers result from the unique characteristics of this industry as discussed in the previous chapter. Second, the IT management and some current IT applications in the construction industry are introduced. These IT applications are separated into four categories according to their nature.

Third, some strategies for effective IT investment and management in the construction industry are highlighted for discussion. These strategies include innovation, investment, people, and procurement issues. Finally, a technology-impact-grid model and IT application portfolio for strategic IT planning are introduced. These approaches can be used for placing IT investment priority and conducting benchmark studies for competitive advantage.

5.2 IT and the construction industry

5.2.1 Barriers of IT application in construction

Previously Chapter 4 has discussed the major obstacles to innovations for the construction industry, this section mainly focus on the potential barriers to IT application in the industry. As discussed in Chapter two, although the application of information technology can reap many benefits, not all IT projects are successful. Many authors such as Alty (1993) and Brandon et al (1998) have reported that the applications of information technology have not been outstandingly successful in the construction industry and that it has not fully produced the benefits that were found in other industries. The barriers that prevent full IT opportunities in construction are also related to the unique characteristics of the construction industry.

Brandon et al (1998, p3) argue that "*the fact that each construction project is different from the one before, is not a good basis for a fundamental approach to subjects like production control and the effective use of IT*". Indeed, the nature of construction activities, its environment and structure are dynamic and fluid (Betts et al 1999). However, such dynamism can become a significant barrier for IT opportunities. Some of the reasons why IT has not been taken up readily by the construction industry from literature are discussed below:

(1) The construction industry is fragmented.

As discussed in Chapter four, the construction industry is very heterogeneous in nature. Construction projects usually have substantially distinct and fragmented activities of design and production. Thus, the planning, designing, and execution of a construction project require a large number and diverse groups of people to combine and exchange information at any level. These groups include clients, architects, contractors, suppliers, consultants and so on. Brandon et al (1998) contend that because the various phases of construction processes are dealt with in a fragmented way for organisational, legal and economic reasons, the use of IT in construction has failed to achieve levels of integration that are found in other sectors.

Moreover, it is difficult to introduce a standard for communication and data transmission between dissimilar parties (Alty 1993). The CICA's survey (1993) shows that only one third of the organisations have a formal IT strategy and few of these include Open Systems standards to reduce the problems of system incompatibility. There is a need for clearer information on the role of formal and de facto standards because data transactions by IT are only possible between compatible systems.

(2) SMEs predominate in the construction industry.

The construction industry comprises a large number of different enterprises, some are large but most are small and medium-sized enterprises (SMEs). Due to their budget limitations, the small firms can only rely on off-the-shelf software, which may only partially suit the needs of the firms but may also be incompatible with the standard format for data transfer (Young 1990, Betts et al 1991). In such circumstance, the benefits of using IT in these small and medium-sized construction firms are usually limited.

(3) IT is treated as a technological tool.

IT has been used successfully in the construction industry as a technological tool; however, its strategic application in the industry is less successful (Betts et al 1991, Bjornsson and Lundegard 1993). Betts found that most construction enterprises could not see beyond the function of IT as a piecemeal tool to improve the efficiency of discrete operations. Progress in the usage of IT strategically in construction appears to lag behind that in most other sectors of the economy. This may be due to the technical background and culture of the construction industry.

(4) Top management in the construction industry shows a lack of support.

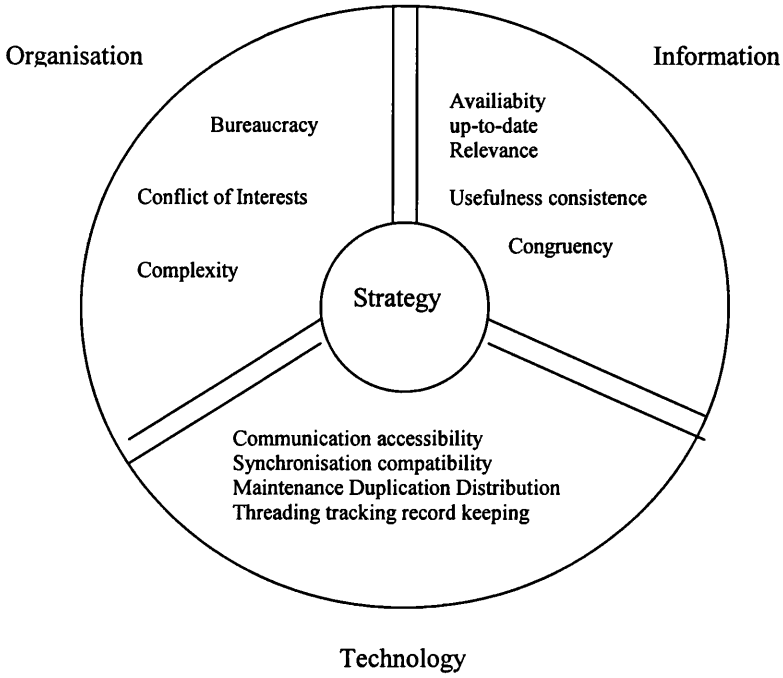
Atly (1993) indicates that the most important reason why IT has not been taken up readily in the construction industry is probably due to the low degree of support exhibited by top management. Young (1990) in her investigation also found that "computer skill and knowledge" was ranked by the construction managers to be of the least importance among the thirteen skills and knowledge required in their jobs. Consequently, it is not surprising to find that the diffusion of IT implementation in construction organisations is slow. According to CICA's survey (1993), the median spending for IT facilities (hardware and software) for contractors in 1992 was between 0.25% to 0.5 % of their turnover and while that for consultants was between 1% to 1.5 %, which is much lower when compared to other industries.

(5) The expected benefits are difficult to quantify.

CICA's survey shows that quantifying the expected benefits of IT continued to be the major problem expressed by 66 % of both consultants and contractors in the questionnaire. It can be argued that IT can offer new opportunities to achieve competitive advantage, improve productivity and performance, reduce costs and save time. However, there is no standard yardstick for success. Wateridge (1995)'s research found that project managers often place too much emphasis on meeting budgets and time-scales for judging project success, as a result a number of projects were deemed to be failures. Consequently, he suggests that the criteria for success and other factors that can influence success need to be clearly defined and identified by all parties at the beginning stage of the project.

Brandon et al (1998) summarise some problems that make it very difficult to introduce the possibilities of IT within the construction organisation into three main groups, as shown in Figure 5.1. Barriers in Organisation group are mainly caused by the fact that different organisations are involved in a temporary project. Different culture, expertise and norms of working make bureaucracy exist in the form of excessive paper work, duplicated information and approval procedures. On the other hand, barriers in Information group such as information-bound problems frequently occur due to the structure of a typical construction project. There is usually an overflow of information and much effort is to ensure that information is available to the parties who need it. However, not all the information is relevant and required for every party. Finally, barriers in the Technology group are caused due to the problems of communication and accessibility for every participant in the construction project. Information cannot be available and reachable in real time because the participants

Figure 5.1 Barriers of IT Application in Construction (Brandon et al 1998)



are not being able to share the same space and moment in time in a construction project.

Brandon et al (1998) also assert that the use of groupware or standard software packages (such as Lotus notes) may improve the coordination of all different participants in the construction processes. However, this solution is only short-term since each construction team is temporary in nature. In other words, a new team has to be set up for every new construction project and the procedures within the groupware system have to be created once again. Consequently, Brandon et al suggest that a kernel strategy of integration (as shown in figure 5.1) could be the key to overcoming the barriers discussed above.

5.2.2 Types of IT in construction

Many authors have classified IT applications in construction. Young (1990) describes IT as a general label given to three strands of computer technology: Information Transmission (communication), Information Transformation (computation) and Modelling (symbolic). Brandon et al (1998) classify generic IT in construction into three fields: communication, intelligence and visualisation. Each of these technologies merged to formulate IT. Some examples of IT applications in construction are described as follows:

(1) Communication systems

Communication or exchange of data is one of the most important activities in the construction process. IT communication tools such as electronic mail (E-mail), fax, and electronic conferencing are believed to have the function of facilitating the free flow of information among the different stakeholders in the construction industry (Young 1990, CICA 1993, Ahmad et al 1995). E-mail is used by many construction firms and its usage is expected to grow prodigiously in the coming years (CICA 1993). However, electronic conferencing has not been fully introduced to this industry yet (Tan 1996).

In recent years, IT tools for data storage (DBS), data accessing and transmission such as electronic data interchange (EDI), local area network (LAN) and electronic CAD data exchange have become popular topics of discussion in the construction industry. Examples can be found at Lend Lease's Bluewater shopping centre project near Dartford and BAA's Heathrow Terminal 5 as they have established a system for different project teams to exchange and access CAD data at separate offices (Building 1996).

EDI has already been used widely in the automobile industry and achieved a high degree of success in supplier management (Atkin et al 1995), but has yet to make any real impact in the construction industry (Bjornsson and Lundegard 1993, Atkin et al 1995, Tan 1996). EDICON (Electronic Data Interchange Construction Limited) has contributed greatly to the progress of establishing message structures, which enables the transfer of documents, such as bills of quantities, orders and invoices between contractors and suppliers in the UK's construction industry (Atkin et al 1995).

Other alternative data accessing tools are CD-ROM and Integrated Digital Network (ISDN). Many computer software specialists provide a range of CD-ROMs that contain useful information such as Building Regulations and British Standards. BT Construction Online is an example of a data source via the ISDN line.

(2) Artificial Intelligence/ Knowledge Base Expert System

Artificial Intelligence (AI), knowledge-based expert systems (KBEs) and advanced information systems are used for data computation, integration and analysis. In the last ten years, research into KBEs has grown to assist the construction process (Young 1990, Li 1996). Some examples are provided below:

Yamazaki (1995) has developed an integrated construction planning system using object-oriented product and process modelling (ICPS). Alkass et al (1995) have developed a system: CDCA for performing construction delay analysis and claim preparation. In addition, a fuzzy expert system for contract decision making has been developed by Wong and So (1995), and a similar system, CTS, to be used for training young engineers to select contract type is under development at the University of Birmingham (Wang et al 1996). From the point of view of supplier, Dawood (1995) provides an integrated knowledge-based approach for pre-cast production planning and bidding. Other projects such as ICON (modelling of integrated process and data), OSCON (integrated object-oriented database), SPACE (integrated system for design, management and estimating), COMMIT (integrated system for management of construction information) are examples of knowledge-based integrated systems developed for the construction industry (Brandon et al 1998).

(3) Visualisation systems

Visualisation technologies are based around CAD, VR and multimedia applications (Brandon et al 1998). CAD (computer-aided design) systems such as 2D or 3D CAD and Virtual Reality (VR) offer the potential to improve construction design activities and are now becoming widely used on construction projects. However, the diffusion of CAD in the construction industry has not been as rapid as those in the other manufacturing sectors (Winch 1991, 1994). Winch indicates that the main reason for this relatively poor diffusion is that most of the construction firms are SMEs and are reluctant to raise relatively large amounts of capital in purchasing CAD systems.

Mahoney and Tatum (1994) give some examples of using CAD to assist existing construction processes including planning survey layout, planning construction sequences and methods, analysing concrete placement, designing formwork for concrete, and co-ordinating subcontractors. They also suggested some potential examples of innovative use of CAD for construction site including analysing design requirements and visualise complex configurations, planning site development, and analysing requirements for construction equipment and planning concrete pre-case operation.

The current trend of CAD development is moving toward integration of design and knowledge-based system (Mahoney and Tatum 1994, Construct IT Centre of Excellence 1996). An example can be found in the project conducted by Wiezel and Becker (1996). They have developed a CAD assistant, PREVET, to help evaluate building performance during various design stages.

VR-DIS (Virtual Reality-Design Information System) is a project initiated by the group Building Information Technology of Eindhoven University of Technology (Brandon et al 1998). It uses virtual reality technology to simulate various processes related to buildings and their design processes, and as an enhanced interface for design support systems.

Multimedia is a mixture of picture, sound, video, music, diagrams, animation and other renderings to give information with computers. Multimedia applications can provide the function of performing several tasks at the same time or the same tasks at different times for education, learning and communication purposes. The use of multimedia applications in construction project presentations and briefings are now becoming common (Alty 1993). Moreover, the developments of integrating KBE databases and Virtual Reality (VR) technology for briefings are coming to the fore (Construct IT Centre of Excellence 1996).

Sadd and Hancher (1998) have developed a multimedia system called the Project Navigator. This system is used for tracking progress on a construction project as well as recording the lessons learned form the project for further reference. Other examples of using multimedia systems in construction included architectural and structural animated rendering, comprehensive design, bid documentation and engineering education and training (Vangas and Baker 1994, Hotchkiss 1994).

5.2.3 The current use of IT applications in construction

Information Technology is widely used in the UK's construction industry. According to a survey conducted jointly by CICA and KPMG (1993) at the end of 1992, the usage of computer hardware and software in construction organisations increased significantly between 1990 and 1992. The ratio of computers to staff members was 1:3 for consultants and 1:5 for contractors. Most of the software applications such as word processing, spreadsheets and CAD have also been widely used by UK contractors.

CICA survey also shows that only 35 percent of respondents had a formally documented IT strategy. In the survey, those with IT strategies felt that the establishment of open systems should be included in the strategy to reduce system incompatibility problems. The construction industry needed to focus more efforts on the establishment of open system since effective communication among different groups is vital to project success.

From CICA's survey, the median of expenditure on IT by contractors was just below 0.25 percentage of turnover. However, the IT expenditure by consultant companies is higher. The median level of IT expenditure by consultant companies was between 1 and 1.5 percent of turnover, which is less than the 1.5 percent found in 1990 CICA and KPMG (1993). Similarly, Building (1999) has done an IT survey amongst their readers. The respondents represented a wide cross-section of the UK's construction industry. The results show that 31% of the respondents spent less then 0.5% of their turnover on IT in 1998. The second large group was the 17% who spent around 0.5%-1% of turnover on IT. The results of Building's 1999 survey shows not much difference when compared with the CICA's 1992 survey results.

The Barbour Index report (1997) also reveals some findings regarding IT usage in the UK construction industry. They carried out in-depth interviews with some 550 industry professionals, some of the key findings are as follows:

- More then 80% of professionals across the industry have access to PCs and around two-thirds to a pc workstation.
- About 25% of the respondents have access to the Internet.
- In large and medium size organisations, 60% already are already using electronic media to access product information.
- Around 50% of product decision-makers use CD-ROMs.
- Around 47% of product decision-makers use CAD.

Moreover, the construct IT Centre of Excellence (1997) and Fisher et al (1997) provide some examples of current IT projects in the UK construction industry in their case studies. They are:

(1) Cash-flow management

The Cash Flow Management System (CFMS) is developed to support the construction company's financial policy and manage financial resources. CFMS is set in a spreadsheet format and designed to handle all incoming and outgoing transactions in any number of projects. Data inputted manually can provide the user with accurate and up-to-date information about the cash flow at any stage of the project and the information concerning the release of payments to the suppliers and sub-contractors and the payments received from the client. An interface is also designed in this system to integrate the cash flow and the profit and loss account for each contract.

(2) New business system

The lead tracking system (LTS) is a group wide database application for decision-making support. The decision making tool in this system can follow all the progress of leads from initial lead to tendering, through contract execution and finally historic data. Some of the categories include people, contracts, contacts, prospects, geographical areas, volume, dates, size and description.

The strategic benefit of this system is that it can provide data related to the organisation's business competitive and corporate strategies in the decision making process. Another benefit of this system is that the sales teams in all divisions are kept abreast of the current projects undertaken by their company. As a result, they enjoy considerable advantages over their competitors when tendering for new work with existing clients.

(3) Refurbishment modelling

This system is an integration of visualisation, CAD and project management applications. The original application of this system was to enable and enhance client visualisation of a hospital refurbishment project. This system used 4D CAD with time modelling as the fourth dimension to illustrate the refurbishment project. The client's main concern was to maintain the operation of the hospital during the refurbishment process. The visualisation technique in this system satisfied the need of the client and assisted the company in obtaining a competitive advantage and differentiating their business.

(4) Marketing

The Computerised Marketing Database (CMDs) is developed for customer targeting, service enhancement and market segmentation. The raw data in this database is usually collected from different sources such as published and historical data about their competitors' bidding behaviour. This system is designed to assist the company to retrieve information for decision making in bidding and analyse the strengths and weaknesses of the bidding companies. The company can then apply this system to identify its position among its competitors to determine its chances of winning the contract.

(5) Industrial Relation

This system is a database application dealing with human resource management. It is designed to manually capture information regarding every employee's length of service, geographical location, attendance record, skill level, development prospects and mobility. It can be used to select candidates for redundancy or promotion.

(6) Contract control

The contract control system is a fully integrated MIS for estimation, purchasing, accounting, surveying and project management. MIS (management information systems) is a general term for the computer systems in an enterprise that provide information about its business operations. This system is designed as a continuous process control that commences with the beginning of a successful tender and ends with the settlement of the final accounts. It enables the company to manage the control process more efficiently and effectively and provides useful data to assist with the operating decisions making process on projects.

(7) Global positioning of piling rigs

SAPPAR is an automated pile setting-out system using the real-time GPS (Global Positioning System) technology. It is designed specially for hydraulically operated piling rigs, which allows a driver to accurately position a rig over a pile. It improves piling productivity by reducing delay and increasing reliability. This innovative system has given the company a significant competitive advantage over its competitors.

(8) 3D modelling

The 3D Computer Modelling System (3DCMS) is designed to integrate project database and networked CAD. It allows engineers, architects and other professionals to work collaboratively and simultaneously. The shareing of CAD and project information can reduce the time needed for file transfer. This saving is substantial both in financial terms and in the elimination of bottlenecks in the construction activities. The system is capable of handling the entire volume of information produced in the project life cycle and can provide data related to planning and cost modelling to all stakeholders in the project. Object oriented modelling is currently a popular technique used for 3D CAD. It offers users the ability to view their particular world as various objects that are related to each other according to defined rules. This technique stores information about objects in an external database and allows them to be re-used.

(9) Civil engineering CAD

This CAD system is designed for earth moving work in a motorway project. It is used to improve the creation of geographical information and the flow of information from the design team to the construction team of the project. By using a Ground Modelling Programme (GMP), the system is able to directly transfer data from drawings to produce accurate data for digging operations. This system provides the company with competitive advantage by improving the quality of the operation data, reducing the time for data assembly and offering competitive pricing for the construction project.

(10) Health and safety

This system is a labour monitoring application. It is capable of capturing, storing and retrieving information about labourers' operations and their work locations on site. Bar code technology and scanners are used to speed up the ID recording process and prevent input errors. However, this system still relies on manual input. This case is indicative of the influence of government regulation. The strategic benefits of the system may not be apparent at first; however, the system can play an important role in establishing the work safety reputation of the company.

5.3 Strategic management of IT in construction

5.3.1 General strategies for IT development in construction

Nowadays, the construction industry in UK is increasingly aware of the use of IT strategically to support its core competence (Construct IT Centre of Excellence 1997). However, some construction professionals perceive IT innovations as incurring excessive costs, inappropriate technology investments and work process changes because of certain failures in delivering the expected benefits in the past. Consequently, the development of appropriate strategies for IT projects in organisations is vital. Some general strategies for IT development in construction have been suggested in the literature:

(1) Technology Innovation

It is difficult to forecast IT innovation in the industry and risky to be at the leading edge of technology. However, companies also cannot afford to fall behind in adopting IT innovations because of the threat to the company's industrial position. Hence, the most suitable strategy for IT innovation may be to focus on utilisation of the proven IT which can lead to efficiency or competitiveness in other sectors. The benchmark approach can be used to identify the best IT practice to achieve continuous improvement in other sectors.

(2) Software Procurement

Construct IT Centre of Excellence (1997) suggests that the best strategy for software procurement is to establish strategic alliance with the IT software houses. However, many construction companies predominantly rely on off-the-shelf software due to budget limitations (Young 1990, Betts et al 1991). Establishing an in-house IT development department may be a solution to reduce IT expenditure. It is suggested that the IT managers should be at a more senior level within the management of business in order to integrate IT effectively in their business (Construct IT Centre of Excellence 1997).

(3) IT users

Managing IT through a centralised structure of management is good for management culture, business vision and decision making, while the decentralised approach is good for departmental and user support. However, more and more construction organisations are decentralising their IT management (Construct IT Centre of Excellence 1997). In decentralised environments, IT users are required to be well trained and educated to deal with IT issues. Also, IT users should be involved in decision making for design and choice of IT project. IT users are believed to be a critical success factor in the achievement of successful IT innovations (Construct IT Centre of Excellence 1997).

(4) IT investment

As discussed previously, many IT projects are considered to be failures because the expected benefits are not reaped. Construct IT Centre of Excellence (1997) found that most failures are due to the absence of a proven economic model for assessment together with a lack of financial resources. Long payback periods on IT projects are often regarded as lack of progress in many organisations. It is suggested that top managers in construction organisations should understand the strategic values derived from long-term IT investments rather than focus on the cost reduction and short-term return of their projects.

5.3.2 Models for strategic IT applications in construction

Betts (1999) has developed a five-level framework for strategic applications of IT in construction. These five levels are:

Level 1: National construction industry;

Level 2: Professional institution;

Level 3: Construction enterprise;

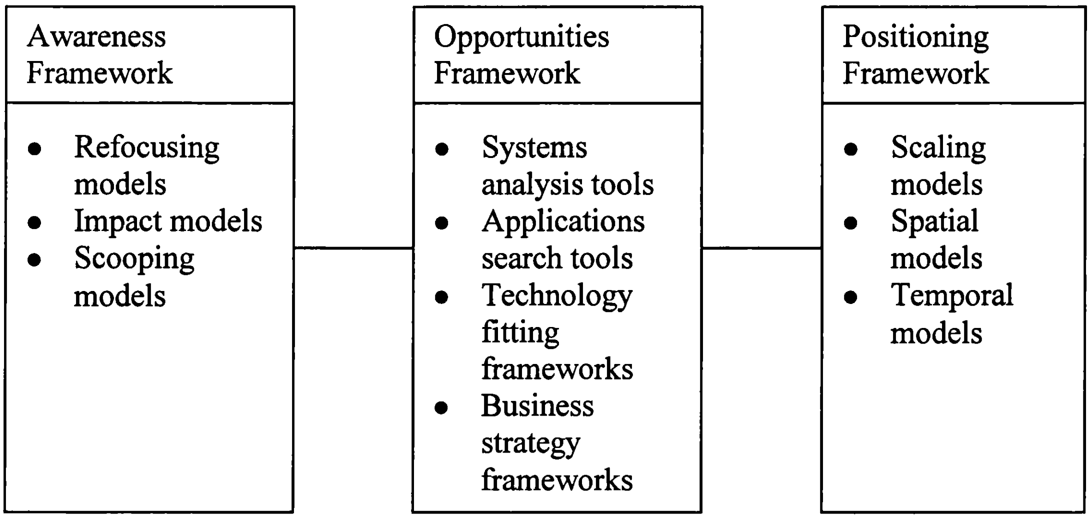
Level 4: Construction project;

Level 5: Construction product.

Among these five levels, the construction enterprise or company is the one that draws much attention for IT implementation. Indeed, the most significant and common examples of strategic IT planning and management occur at this level (Betts et al 1991, Betts 1999). Much of new thinking and new ideas about strategic use of IT for business also mostly addresses the enterprise or corporate level.

Over the years, many models and frameworks have been developed for strategic management of IT in organisations. Betts (1999) suggests that Earl's framework of classifying different types of models and frameworks for strategic IT management

Figure 5.2 Frameworks and Models for strategic IT planning in construction (source: Betts 1999)



issues can be used in the construction industry. He also outlines some models in the framework, as shown in Figure 5.2.

The first set of models within Earl's frameworks is the Awareness Frameworks. They are used to explore the potential impact of IT and identify the areas of impact. These frameworks can be used, for example, to identify whether IT should be significantly used to change current business operations as opposed to continuing with traditional processes. The second set is the Opportunities Frameworks. These frameworks are intended to be more practical such as help organisations to analyse their business activities as a prelude to implementing IT. The last set within the framework is the Positioning Frameworks. These frameworks are mainly concerned with the implementation and capability of IT within an organisation. They can be used, for example, to identify the positions of current IT applications in terms of their strategic importance to an organisation.

This research aims to identify the relationship between IT performance and organisational characteristics in construction organisations, consequently some models belong to Positing Frameworks set within Earl's framework are reviewed and discussed below.

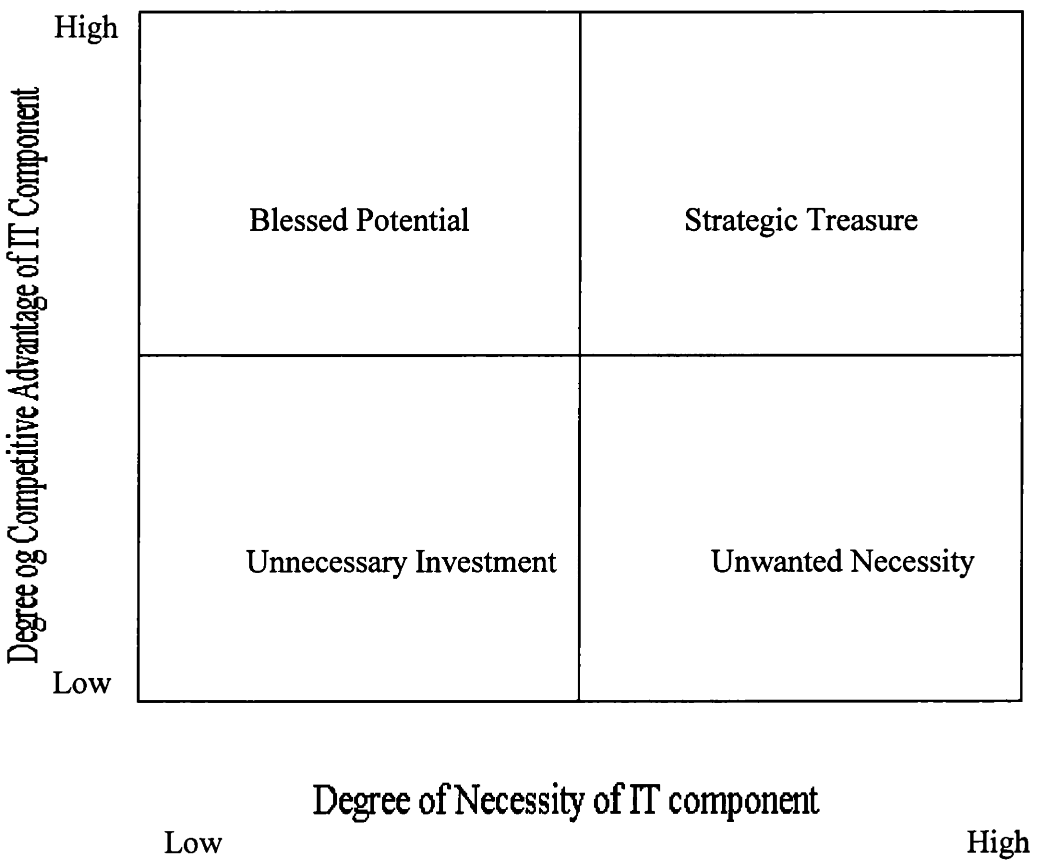
(1) Technology Impact Grid

Gonzales et al (1993) have developed a TIG (Technology Impact Grid) model for strategic IT planning for competitive advantage in construction. The grid can be used to assess the firm's current IT position and plan new IT investments to achieve competitive advantage. The grid uses variables like degree of necessity and degree of competitive advantage to divide IT investment into four groups: unnecessary investment, unwanted necessity, blessed potential and strategic treasure (as shown in figure 5.3).

IT tools which give both low competitive advantage and degree of necessity fall into the 'unnecessary investment' group. IT Components belonging to this group refer to those which are obsolescent due to new technology or better substitution. Examples are the systems that are developed mainly for user convenience.

'Unwanted necessity' group includes the systems that are so commonplace that they have become basic components to the business operation. They yield low competitive advantage but the company's dependence on the systems for business

Figure 5.3 Strategic Impact of IT Grid (Gonzales et al 1993)



operation remains. The company cannot survive without these systems. The automatic cash machine in the bank industry is a good example of these systems.

IT components which provide high competitive advantage but have not been recognised by the organisation belong to 'blessed potential' group. These components are usually new in the market and have not been proven by the industry. This IT investment presents high potential for the company, but since it is not critical in the business operation, users often choose to ignore it and continue with the traditional way of doing work.

The 'strategic treasure' group includes systems that provide high competitive advantage and are involved in the core business activities. They have the most strategic significance because if the company fail to operate them successfully, the company may lose its competitiveness. The global positioning of piling rigs system discussed previously is a good example. The company needs this system to operate its core business as the system offers a high competitive advantage to the company.

(2) Application Portfolio Approach

Ward (1994) introduces an application portfolio approach which could help organisations classify their IT investments and set priorities strategically. The classification is based on the judgment of the "value" of the systems from management's point of view, in terms of one of the four-folders matrix as shown in Figure 5.4. The objective of this classification is to determine the criticality of the relationship between the IT investment and business success and hence determine how the applications should be managed.

Applications in the **high-potential** segment of the matrix are those which may be important in achieving future business success. They may be the outcomes of R&D, technological opportunity or new ideas of individual initiative (e.g. idea champion) in organisations. The **strategic** applications are those which are critical to sustain future business strategy. The driving forces for such investments may come from

Figure 5.4 IT application portfolio approach (Ward 1994)

STRATEGIC	HIGH POTENTIAL
Applications which are critical to sustain future business strategy	Applications which may be important in achieving future success
Applications on which the organisation currently depends for success	Applications which are valuable but not critical to success
KEY POTENTIAL	**SUPPORT**

market requirements, competitive pressures or other external forces. **Key operational** applications are those which the organisation currently is dependent upon for success. Poor key operational applications can rapidly lead to business disadvantages. Consequently, The improvements of effectiveness and efficiency of the systems and their integration with other systems are the main challenges. **Support** systems are those which are valuable but not critical to business success. They need to be managed carefully to ensure that resources are not wasted since their impact on business are less critical.

Atkin et al (1996) have also developed a similar grid. They use the degree of importance and effectiveness of IT projects as the two variables in the grid. The classification in this grid can be used for placing innovation priority and conducting benchmark studies.

Although these grids are believed to be helpful in evaluating a strategic IT project, it must be understood that this method is only as good as the knowledge of the evaluator. This is because the decision of where an IT project is placed on the grid for its strategic position depends on the perception of the evaluator. An inaccurate or out-of-date perception of the decision maker for a specific system may cause it to be placed in the wrong group. Also, an IT project which is regarded as a strategically competitive weapon today may lose its advantageous edge as soon as a newer and better system emerges on the market. Consequently, the decision makers who are considering the use of this kind of grid should be up-to-date with the current IT development and implementation in the industry.

5.4 Discussion and conclusion

Innovation in the construction industry is a difficult issue. A mature industry tends to have a stable business environment, thus the companies involved are reluctant to change the way they work. Consequently, there are many barriers to the implementation of IT in the construction industry. To overcome these barriers, all the users, managers and top management need to fully understand the impact of the implementation of the chosen IT project and be committed to their IT projects.

Most of the SME construction organisations purchase off-the-shelf software for their IT systems due to budget limitations. However, this may result in their systems being incompatible with those of their clients or other stakeholders in construction projects. In order to resolve this problem, construction firms can establish strategic alliances with certain software houses so that they can obtain a more economical and effective service through the software houses' larger bargaining power.

Some strategic approaches of IT investments and management were also discussed in this chapter. However, the success of using these approaches to identify a potential IT project is dependent on the participant's IT knowledge. Ideally, this should be complemented with a good understanding of current IT practices and developments in the industry. Also, the users should be involved in the investment process, choice and design of new IT project, be allowed to participate in the decision making process and to be encouraged to seek innovative IT solution in their specific areas.

Investments in innovative IT projects are risky decisions. Organisations may obtain strong competitive advantage due to the uniqueness of the services provided by the innovative implementation. However, IT may fail to deliver the expected benefits. Consequently, organisations should evaluate their new systems carefully and thoroughly before making the final decisions. Much of the literature suggests that the choice between formal economic evaluation and informal evaluation approaches should be made according to the project's characteristics and the role of the project in their business operation. Some assessment approaches to IT investments will be introduced in Chapter 7.

Chapter 6: The Process of Change

6.1 Introduction

Influenced by the development of Pettigrew's methodology toward organisational change presented in section 3.3, previous chapters have discussed the context and content of change in IT innovation in the construction industry. This chapter focus mainly on the last element of organisation change proposed by Pettigrew: the process of change.

The introduction of various innovation process models is the main topic in this chapter. First of all, the conventional stage-based model of the innovation process is introduced. Some criticisms regarding the stage-based model are also reviewed. Second, some alternative models of innovation process are introduced. They include a general model for the innovation process in construction, IT implementation models, and a robust and recursive model of implementation developed by Winch (1994).

6.2 Models of the innovation process

Although there was a lack of empirical studies on innovation process, the process of innovation described in stage-based models for its sequence of events emerged in the 1960s (Zaltman et al 1973, Rogers 1985). According to Wolfe (1994) and King and Anderson (1995), this kind of models normally share three general features: firstly, they are based on conceptual and theoretical speculation. Secondly, they are presented in a series of stages that unfold over time. Thirdly, they regard the innovation process normatively.

Although Wolfe's (1994) composite model has as many as ten steps which include idea conception, awareness, matching, appraisal, persuasion, adoption decision, implementation, confirmation, routinisation and infusion, a typical stage-based model has fewer steps but consists of at least two main stages: initiation and implementation (e.g. Zaltman et al 1973). In Zaltman's model (as shown in Table 6.1), the division between the two main stages is at the point of adoption of the innovation. This distinction between pre- and post-adoption stages is also seen in most of the stage-based models of the innovation process (King and Anderson 1995).

King and Anderson (1995) contend that the initiation of the innovation process is conventionally described as the detection of a "performance gap"- the difference between actual and potential performance. Zaltman et al (1973) suggests that this may occur in two ways. Firstly, the firm realises its poor performance (or finds a problem) and therefore searches for an innovation to close the gaps (or solve the problem). Secondly, the firm becomes aware of a potential opportunity for innovation in the business environment and realises that it can improve its performance.

This awareness may be stimulated by the company's competitors (e.g. the innovation is used by a competitor) or clients (e.g. the innovation is requested by a client). However, King and Anderson (1995) argue that the pressure to innovation is not

Table 6.1 Zaltman et al.'s (1973) Model of the Innovation Process

INITIATION
Knowledge awareness- the organisation becomes aware of the existence of an innovation which it has the opportunity to utilise.
Formation of attitudes- members of the organisation form and exhibit their attitudes to the proposed innovation.
Decision- the potential innovation is evaluated and the decision to proceed with it or abandon the idea is made.
IMPLEMENTATION
Initial implementation- first attempts to utilise the innovation are made, often on some sort of trial basis.
Continued- sustained implementation- the innovation becomes routinised as part of organisation life.

necessarily only triggered by the environment and may originate from beyond that. For example, innovation may also be forced on the organisation by government legislation.

Moreover, Dewar and Dutton (1986) contend that the degree of new knowledge, the organisational complexity (e.g. the number of different occupational specialities) and the depth of an organisation's knowledge resources (e.g. the number of technical personnel) could also influence the decision for innovation adoption. The adoption of radical innovations incorporates a large degree of new knowledge, organisational complexity and the depth of the organisation's knowledge resource. In contrast, complexity and knowledge depth should be less important for incremental innovations since incremental innovations require less knowledge resource to support their development in the organisation (Dewar and Dutton 1986).

Implementation stage includes initial implementation and routinisation. Initial implementation is the first attempt to utilise the innovation. Routinisation is the term used for the stage when the innovation becomes absorbed into the everyday life of the organisation. Rogers (1985) indicates that modification and redefinition are often required before routinisation occurs. After adoption, the innovation will often be redefined as initial problems are identified and its meaning will gradually become clear to the organisation members. Rogers in his model described this as the 'clarifying stage'.

The conventional stage models for innovation process have been criticised by many authors. Although evidence does exist to indicate that identifiable innovation stages do occur (Wolve 1994), Kings and Anderson (1995) have raised doubt as to whether the limited evidence available supports the existence of stages in the innovation process. Winch (1994) argues that many stage models attempt to describe the content but do not clearly specify the inflection points of each stage. Schroeder et al (1989) also argue that the simple, sequential stage model could not accurately represent the complex innovation process. Others authors such as King (1992) and Witte (1972) also argue that a clear progression through stages in innovation process only can be distinguished in a minority of cases from their studies. Consequently, alternative models of innovation process based on inductive, longitudinal study have been suggested and developed by many authors. Examples can be found in Schroeder et al's (1989) research. They propose six common features of the innovation process but do not attempt to place them in discrete stages. They are:

1. Innovation is simulated by shocks, either internal or external to the organisation;
2. An initial idea tends to proliferate into several ideas during the innovation idea;
3. Unpredictable setbacks and surprises are inevitable; learning occurs whenever the innovation continues to develop;
4. As an innovation develops, the old and new exist concurrently, and over time they are linked together;
5. Restructuring of the organisation often occurs during the innovation process;
6. Hands-on top management involvement occurs throughout the innovation period.

However, despite these shortcomings, the stage model approach is still popular and applied by many authors to study organisational innovation process (Wolf 1994). Winch (1994) explains that the stage model is a sound analytical device to segment a flow of activity through time in the innovation process. Wolf (1994) contends that stage model research has contributed to an understanding of innovation process by confirming that identifiable stages in an innovation process do exist. The limitations of the stage model have also contributed to calls for more in-depth, longitudinal research in an effort to better explain the innovation process.

Some stage models for innovation process and implementation will be reviewed and discussed in the next section. These models include a general model for the innovation process in construction in the construction industry, two IT implementation models and a recursive model of implementation developed by Winch and Twigg (1993).

6.3 Some stage models of change

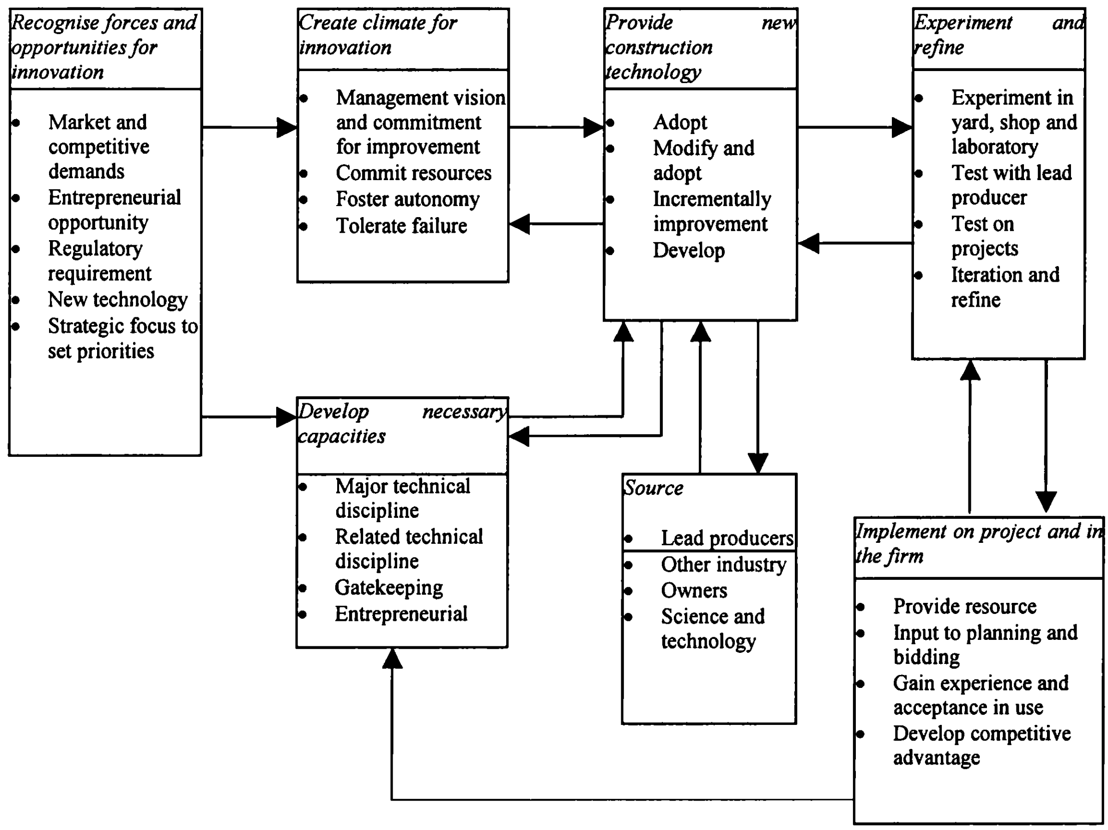
6.3.1 A general model for the innovation process in construction

Tatum (1987) has developed a general model for the process of innovation in construction (as shown in Figure 6.1). This model includes 6 major steps: (1) recognising forces and opportunities for innovation; (2) creating a climate for innovation; (3) developing necessary capacity for innovation; (4) providing new construction technology; (5) experimenting and refining; and (6) implementing innovation in project and the firm.

(1) Recognising forces and opportunities for innovation

The first step of this model is to recognise forces and opportunities for innovation in construction. The major forces and opportunities in this model include market and competitive demand, entrepreneurial opportunity, regulatory requirements, new technology and strategic focus to set priorities. However, other forces may also provide the opportunity for innovation in construction. For example, the owner's demands and the problems in the construction process are two driving forces for innovation.

Figure 6.1: A general Model for Innovation in Construction (Tatum 1987)



(2) Creating a climate for innovation

Many authors have emphasised the importance of creating the right climate for innovation (West and Farr 1990; King and Anderson 1995). A climate of excellence is seen to be of great importance to innovation (West and Farr 1990). In Tatum's model, the managers in innovative firms bring a vision and commitment for improvement, commit the necessary resources, foster autonomy and tolerate failure.

The necessity of creating a climate for innovation is just as important as the individuals who are involved in the process of innovation as discussed previously. Support from the owners and top management help to create a climate for innovation.

(3) Developing necessary capacities

In construction, every project is different. Thus, technical and entrepreneurial capacities are required in the creation of innovation (Tatum 1987). Major and related technical disciplines are key capacities for innovation. "Gatekeeping", the role of keeping the firm aware of new technical development is also an important element in innovation. Moreover, the process of innovation may include many parties other than contractors. Thus, different sets of entrepreneurial steps are required to convince other parties to share the risk of using new technology (Tatum 1987).

(4) Providing new construction technology

The major means of providing new construction technologies are by: (a) adopting new technology from external sources; (b) modifying and adapting available technology; (c) incrementally improving existing technologies; and (d) developing new technology. The development of past and existing technology by informal R&D, based on a leadership strategy and long-term perspective, is a practical first step to increase innovation in construction firms. (Nam and Tatum 1992)

(5) Experimenting and refining

The complexity and variation of construction projects make it necessary to experiment and refine new technology. Experimenting on site, testing new technology with suppliers, iterating and refining are methods that construction firms can adopt to integrate the new technology on to projects so that it can satisfy field conditions and achieve its full potential.

(6) Implementing innovation in projects

After the successful implementation of an innovation, managers would be more experienced in recognising new opportunities, creating an excellent climate for innovation, providing a better source for technology development and pursuing competitive advantages from the innovation. (Tatum 1987)

However, the steps in this model are not sufficient to achieve innovation by information technology due to the following reasons. First, the methods of identifying the potential areas for process innovation are not found in this model. Secondly, the advanced technology required in IT applications may be too complex for current staff in construction. Thus, recruiting IT specialists to set up in-house systems or outsourcing of the whole new system may be necessary. Lastly, as IT investment is expensive, post-implementation evaluation is very important and cannot be excluded in the model of innovation.

6.3.2 IT implementation models

Much research has been undertaken on the IT implementation problems and their solutions. Kwon and Zmud (1987) categorise this work into factor research, process research and political research. Factor research focused on individual, organisational and technological criteria which could help improve IT effectiveness. Factors such as top management support, good IT design and appropriate user-designer interaction were found to have important impacts on this issue (Alty 1993; Davenport 1993).

Process researchers have examined social change activities and found that commitment to change and extensive project planning leads to implementation success (Desanctis and Courtney 1983). In addition, the management of IT stakeholders may influence the degree of implementation success (Markus 1983). However, Kwon and Zmud (1987) argue that the IT implementation research is still limited in perspectives and progress due to the lack of a directing and organising framework. Consequently, they developed an IT implementation model based on organisational change, innovation and technological diffusion. This IT implementation model includes three main phases with six sub-stages:

Phase one: Unfreezing

(1) Initiation

The search for organisational problems or opportunities and their IT solution is prompted by organisational needs and/or technological innovation.

(2) Adoption

The decision to invest in IT implementation is reached by rational and political negotiation and consideration.

Phase two: Change

(3) Adaptation

After the IT application is developed, installed and maintained, organisational procedure is to be revised and staff is to be trained for the new procedure.

(4) Acceptance

When an IT application is employed in an organisation, its members are to be induced to commit to IT usage.

Phase three: Refreezing

(5) Routinisation

The usage of IT applications is encouraged as a normal activity and the organisational governance system is adjusted to account for IT.

(6) Infusion

Increased organisational effectiveness is obtained by using the IT application in a more comprehensive and integrated manner.

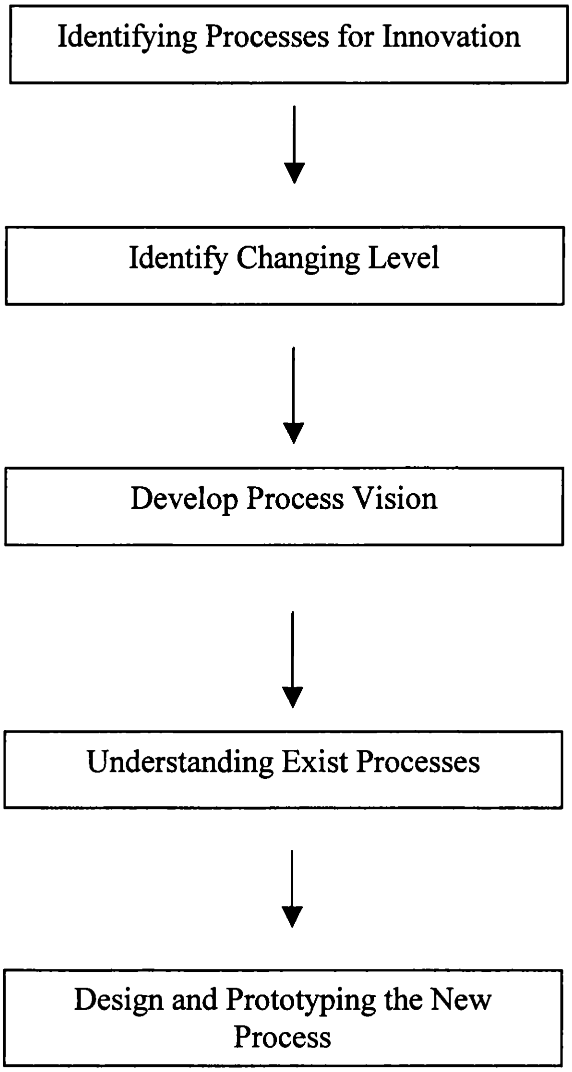
Kwon and Zmud (1987) also have identified five major contextual factors that may influence the progress of each stage. These factors relate the characteristics of the user community (job tenure education, resistance to change), the organisation (specification, centralisation, formalisation), the technology (complexity), the task to which IT is being applied (task variety, uncertainty, autonomy and responsibility of user) and the organisational environment (uncertainty, inter-organisational dependence).

Moreover, Cooper and Zmud (1990) contend that the interaction among the organisation, task and technology characteristics have a great impact on the success of implementation. Prior research conducted by Tornatzky and Klein (1982) also shows that successful innovation and technology diffusion occurred when the task and the technology were compatible. Therefore, the interactions among these five factors also have great impact on the success of IT implementation.

Another example of the IT implementation model can be found in Davenport's (1993) work. Davenport developed a five-step model for process innovation by IT as shown in Figure 6.2. This model includes 10 key activities where IT can play an important facilitative role:

1. Identifying and selecting processes for redesign;
2. Identifying enablers for new process design;
3. Defining business strategy and process vision;
4. Understanding the structure and flow of the current process;
5. Measuring the performance of the current process;
6. Designing the new process;
7. Prototyping the new process;
8. Implementing and operationalising the process and associated systems;
9. Communicating ongoing results of the effort; and
10. Fostering commitment toward the solution at each step.

Figure 6.2 The Process Innovation Model Developed by Davenport (1993)



This model demonstrated the steps for process innovation with IT. However, the final goal of this model is to help the organisation develop a new process which will achieve one or more revolutionary performance objectives effectively. The adoption, implementation and diffusion of process innovation are not merely designing, coding and testing the new business operation approach. The proposed process innovation and IT implementation need to match the organisation's business strategies and processes. Also, the initiation of implementation of IT innovation is critical to the success of the whole project. Davenport suggests that advanced information system-oriented analysis and project management techniques may enhance the quality of the project.

Currie (1999) argues that Davenport's process innovation framework shows many similarities with BPR, as well as the works of other authors such as Porter, Millar and Earl. However, Davenport's work perceives business activities as "*a series of interrelated processes*" (Currie 1999, p.655) and suggests that organisations should examine their current processes and consider eliminating or developing a new one. Currie also contends that with the applications of current information and communication technology, process innovation is becoming attractive to organisations since it provides an opportunity for functional integration between and within organisations, suppliers and clients.

6.3.3 A recursive model

Leonard-Barton (1988) argues that most of the literature on process innovation "focuses on either what can be done to the technology to adjust it to its environment or what is done to the organisation by the technology". He further argues that this is insufficient and has developed a model of implementation that emphasised "mutual adoption" where the process is conceived as one of mutual adoption between the technology and the organisation. In other words, the adoption and re-invention of the technology simultaneously occurrs in the process of implementation. The process of mutual adoption proceeds through a series of long and short cycles of adoption- long cycles are major evaluations and redirections of the implementation process, while small cycles are minor adjustments to the adoption flow.

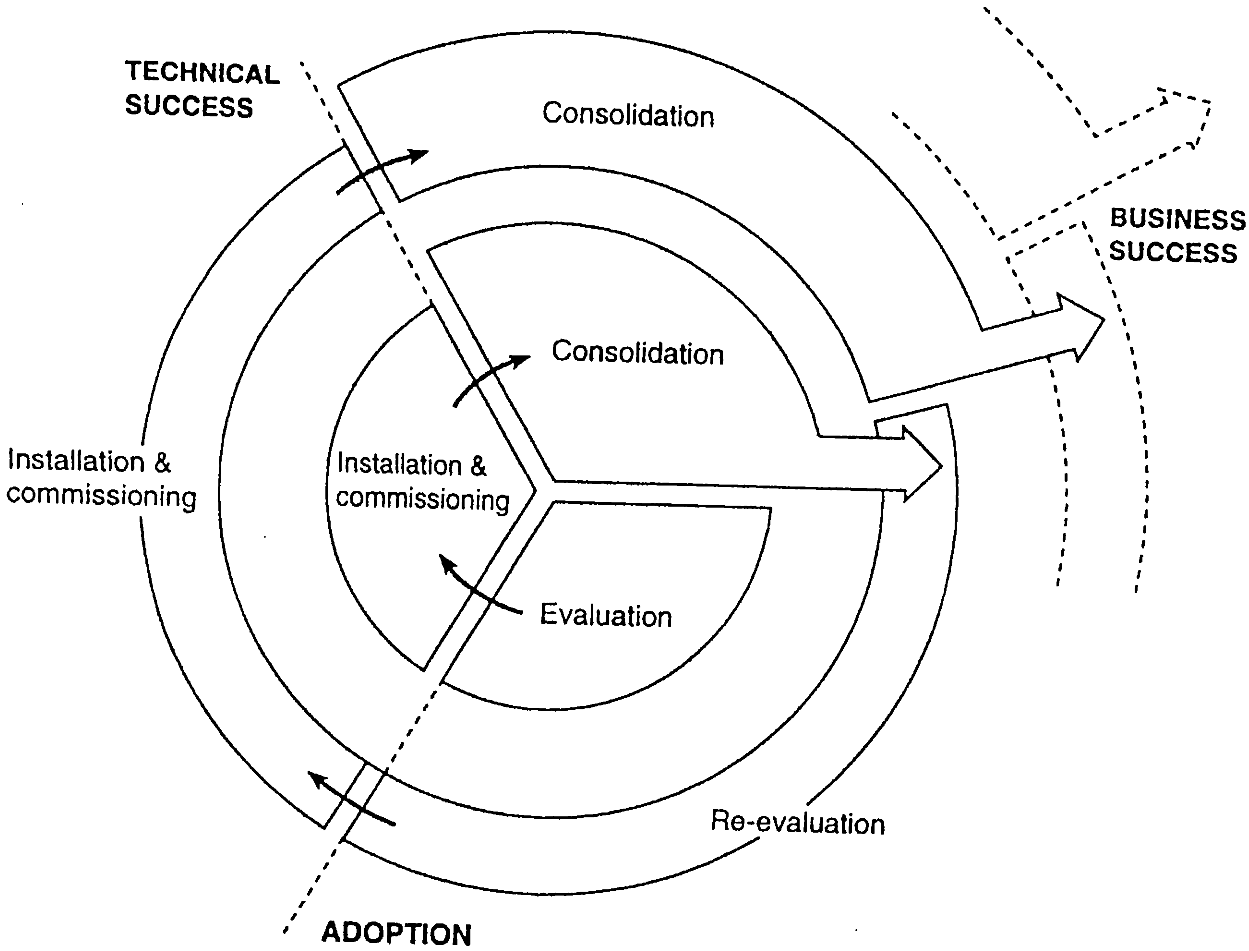
Based on Leonard-Barton's conception, Winch and Twigg (1993) have developed a recursive model for the implementation of innovation, as shown in Figure 6.3. The main feature of this model is that it emphasises the avoidance of a position of equilibrium and continuous change for continuous improvement. There are three stages in this model: evaluation stage, installation and commissioning stage, and consolidation stage. The successful outcomes of these stages are adoption, technical success and business success. These stages are interactive and recursive with each other.

After the successful completion of one phase of implementation, pressures may arise to force the organisation to consider re-evaluating the change and a new phase can then begin. In this model, implementation of innovation is regarded as the process of continuous change and learning. Business success in the implementation process is most likely to be achieved through double loop learning facilitated by a participative implementation project organisation (Winch 1994).

6.4 Discussion and conclusion

Despite the shortage of empirical studies of the innovation process, stage-based models of innovation process have emerged since the 1960s. Zaltman et al's model is typical of this kind of perspective. The general features of stage models of the innovation process are that they are based on theoretical speculation and normative

Figure 6.3 A recursive Model for the Implementation of Innovation Developed by Winch and Twigg (1993)



occurrence as a sequence of development stages, each of which must be passed through in turn.

There are criticisms of stage-based models. Many research works have also found only limited support for the existence of discrete development stages in the innovation process. However, the stage-model is still popular and considerable support for its adoption is evident in recent years by many researchers since the provision of a general stage-model enables a broad understanding of flow of activity in innovation process through time.

This chapter reviewed four different models of the innovation process. There are advantages and disadvantages in these models. However, the dynamic and recursive model for innovation process developed by Winch (1994) changed the inherent conceptions of implementation by rejecting the equilibrium analysis and emphasising on continuous change and learning. This model could avoid most of the negative criticisms previously expressed about stage-based model. Consequently, an analytical framework based on Winch's recursive model together with Pettigrew's three elements of change was developed for this research work. The details of this analytical framework will be discussed in Chapter Eight.

Chapter 7: Assessment Approaches to IT Investment

7.1 Introduction

The use of information technology and its integration with business strategy is of utmost importance to organisations. Indeed, the effective management and integration of IT are considered critical for the success of IT implementation by many authors (Bacon 1992, Elliot and Melhuish 1995). However, many IT projects continue to achieve less than desirable outcomes for organisations. Wateridge (1995) argues that a recent survey showed that twice as many IT projects are considered to be 'less successful' than they are considered 'successful'. In other words, many IT projects are not achieving what have been expected of them.

Elliot and Melhuish (1995) argue that the Strategic Information System Planning (SISP) frameworks merely identify the potential strategic investments in IT, but do not provide assistance or direction to management for IT assessments. Consequently, identifying the suitable IT project assessment technology would be the first priority for firms when initiating any IT investment.

Farbey et al (1993) also contend four reasons for appraising IT projects. First, investment in IT is high. Senior management must be convinced that the investment is economically viable. Secondly, it is important to prioritise IT projects in order to achieve optimal return for the investment. Thirdly, assessment can provide the benchmark of the IT investment in economic, operation and organisation terms. A measurement can be made from the benchmark of the proposed and actual implementation of IT project. Fourthly, a formal assessment can provide invaluable information to the top management so that they can assess the IT investment fairly and formulate future strategies accordingly.

Assessment of the costs and benefits of IT investment is currently a major issue. The amount of literature on this topic is substantial and increasing (King and Mcaulay 1997). This chapter reviews the literature regarding the role of IT project assessment, decision making for IT investment selections, problems in IT project assessment and current IT investment and risk assessment technologies used in the construction industry and other sectors.

7.2 The role of IT project assessment

7.2.1 Objectives of IT assessment

Assessment serves a variety of different objectives from different viewpoints (Hawgood and Land 1988). Farbel et al (1992), and Hawgood and Land (1998) provide the following possible objectives of assessment. Other authors such as King and Mcaulay (1997), Ginzberg (1988) and Etzerodt and Madsen (1988) also provide similar reasons to why IT investment should be assessed.

Firstly, it may be used to justify an installed system or a proposed new system. Assessment can provide answers to potential questions relating to installation or maintenance of a system and assessing the outcomes in terms of organisational interests such as costs, benefits, or competitiveness.

Secondly, assessment can assist the organisation in comparing the merits of various projects in the organisation, which are competing for resources. The assessment results enable the organisation to allocate its resources to the "best" projects.

Thirdly, assessment can reduce uncertainty. A reduction of uncertainty can stimulate action. The purpose of this kind of assessment is often to give reassurance and confidence that the proposed project is likely to have predictable and positive outcomes.

Fourthly, assessment enables the organisation to exercise control over the project. The organisation can learn from the experience to estimate the resources required and predict the benefits of the new system.

Finally, assessment and subsequent measurement and comparison with actual achievement provide the organisation with the ability to improve its assessment and system building capacity. The organisation can learn from the experience and establish a standard for further assessment.

7.2.2 The stages of IT project assessment

There are various stages into which an IT project can be divided for assessment in its development and implementation process. Ginzberg (1988) uses a general three-stage model for his IT assessment frameworks. In his framework, there are three distinct points in the system life cycle: the feasibility study, the post-implementation audit and a quality assurance check accompanying system maintenance. The feasibility study is usually undertaken to decide whether or not a proposed system should be chosen or which system is the best choice. The post-implementation audit tends to occur after the system installation to ensure that performance standards and objectives have been achieved. Quality assurance checks involve periodic reviews of the system's operation to ensure that it meets the expected requirement consistently.

Other authors such as Willcocks and Lester (1996) and Farbey et al (1992) provide more detailed models for IT project assessment:

Willcock and Lester use a five-stage proposal in their research:

(1) Proposal/feasibility- evaluating the acceptability of an IT project against organisational requirements.

(2) Development- monitoring the development of the system in terms of time, cost and performance. System testing and acceptance may be included at this stage.

(3) Implementation- assessing the operating system with the organisational time, budget and performance requirements by comparing the actual and proposed results.

(4) Post-implementation- this audit includes assessing the completion of the project and comparing it with the expected outcomes such as anticipated benefits.

(5) Routine operation- assessment of the system on a regular basis to assess its operation.

Farbey et al develop a seven-stage model for IT assessment. This model showed that IT assessment should be applied when:

(1) A strategy is being developed: an IT strategy should be developed alongside the organisation's business strategy, and the role of IT should be assessed before the strategy can be finalised.

(2) A specific project has been defined: at this stage, the cost of the project has to be justified and an appropriate design has to be developed to meet the organisation's requirements.

(3) A project is at the developmental stage: checks must be made to ensure and monitor the progress of the project and that it stays within the budget allocated.

(4) A project has reached the point of "sign off": after the system is transferred to the user department, the users have the responsibility of ensuring that the system does what is designed to do.

(5) A project has just been implemented: the system must be checked to ensure that it is working as planned and generating the expected benefits.

(6) A project has been in operation for some time: assessment at this stage involves monitoring the impact of the new system, comparing actual cost and benefits with proposed ones and identifying any intangible benefits.

(7) A project is near the end of its life cycle: feasible replacement options are being investigated and proposed.

Collectively, the models discussed above have highlighted the three main stages for an IT project assessment: feasibility evaluation, post-implementation audit and assessment in the project consolidation stage. The evaluation starts with the recognition of a "performance gap", which prompts an evaluation to justify the adoption of IT by the organisation (Winch 1994). The outcome of this stage is the decision whether to proceed with the implementation of the project.

In addition, three types of assessment criteria are suggested by Ginzberg (1988) for the viability of the proposed system: technical, operational and economic. Technical assessment concerns the organisation's ability to build and maintain the proposed system. Operational assessment relates to whether the proposed system, if installed, will be accepted and operated by the organisation's personnel. On the other hand, economical feasibility concerns the advisability of investing the organisational resources in the proposed system.

The intended outcome of the post-implementation stage audit is to assess if the expected performance of the new system is met after installation. Willcock and Lester (1996) have identified the criteria for post-implementation audit: direct comparison with the original proposal or feasibility study, checks to determine if the business objectives are met, cost/effectiveness, quality of project, system availability, productivity, and job satisfaction.

In the project consolidation stage, Ginzberg (1988) argues that the assessment tended to ignore the economic issues and focus on a very narrow range of technical and operational issues. Farbey et al (1992) suggest that the audit at this stage should focus on the project's impact and the recording lessons for future reference. When the system is nearing the end of its use, a feasibility evaluation of the replacement options should take place.

Willcock and Lester (1996) conclude from their study that the IT project assessment conducted by the majority of organisations consists of five distinct stages: All of the organisations in their survey completed an evaluation at the "feasibility" stage. However, only 66 % of the organisations investigated completed the assessment at all stages. It would seem that these organisations placed considerable emphasis upon the feasibility stage while ignoring the rest. Ballantine et al (1996) also conclude the same point of view in their study.

However, evidence shows that most organisations are not clear about the different purposes of assessment and might be confused about the stages (Farbey et al 1992). They found that most organisations conducted the feasibility evaluation in an *ad hoc* way to suit a particular situation. A significant finding that also emerged from the study was that some organisations do not conduct a feasibility evaluation for their new IT projects (Farbey et al 1992, Ballantine et al 1996). Farbey et al (1992) contend that this situation usually happens for several reasons:

(1) The use of IT is an essential part of the corporate strategy;

(2) The division follows the headquarter's instruction to install the IT project;

(3) The project does not fit into the organisational formal justification procedure;

(4) The organisation must use IT to survive (got to do).

Ballantine et al (1996) argue that organisational problems such as a lack of time, management support, and the organisational structure which hinders the evaluation process (e.g. no defined responsibilities) also explain why organisations do not conduct a feasibility evaluation. Moreover, Ballantine et al found that evaluation was associated with companies who had higher levels of turnover, and for larger projects, when measured relative to the total IS/IT budget allocation. However, the absolute cost of the IT/IS project did not affect whether evaluation was carried out or not.

7.2.3 Characteristics of IT assessment

Ginzberg (1988) found that the three most important characteristics in the assessment of IT investment are, namely, (1) the domain of the assessment; (2) the time frame of the assessment; and (3) the nature of the assessment.

The domain of the assessment refers to the assessment areas of an information system. Ginzberg (1988) indicates that assessments made at different stages in the system life cycle tend to focus on different domains. For example, in the feasibility stage evaluation, most of the approaches focus on the economic domain. The post-implementation justification then tends to change the domain of assessment to the system's performance.

Time frame concerns the time horizon of the assessment. The feasibility assessment of a new project incorporates the past, as well as current experience to predict the system's future performance. On the other hand, post-implementation assessment invariably focuses on the recent past and the current system performance.

The nature of the assessment refers to whether it is summative or formative. Ginzberg (1998) explains that a summative assessment provides evaluation information only. It answers questions such as how well or how poorly a system did in meeting the organisation's objectives. On the other hand, formative assessment provides diagnostic information which helps to explain why the system performed as it did. Feasibility assessment tends to involve summative assessment, while assessments at other stages of the system life cycle tend to include both.

7.2.4 Problems in IT assessment

There are major problems in IT project assessment. Many authors such as Iivari (1988), Ginzberg (1988), Willcocks (1992), Farbey et al (1993) and Whiting et al (1996) discuss the nature of problems faced in the assessment of IT investments.

First, the value of an IT investment is difficult to quantify in financial terms because benefits attributed to an IT system may be indirect and several steps away from the actual achievement of profits. Ballantine et al (1996) conducted a survey of the top 1000 UK organisations and found that both the identification and quantification of relevant benefits were the greatest areas of concern for the respondents. Different types of IT contribute more or less directly to an organisation's core business. Consequently, the techniques for IT investment assessment need to vary according to the degree of directness.

Secondly, the cost of investment is difficult to predict accurately in the assessment. Willcocks (1992) has identified four major assessment problems relating to cost estimation. The champion may understate the cost in order to get support and acceptance from top management. On the other hand, the project manager may overstate the cost at the feasibility stage for the purpose of making sure that the system can be delivered within time and budget (Willcocks 1992).

Thirdly, many benefits derived from IT investment are intangible and unexpected. The systems to increase internal efficiency in an organisation are likely to have the highest proportion of tangible benefits (Whiting et al 1996). On the other hand, IT infrastructure systems and strategic systems are likely to have the highest proportion of intangible benefits. Organisations may be ignorant of the intangible benefits and conclude wrongly that they have failed to achieve the targeted benefits. In addition, providing meaningful financial estimates for intangible benefits is complex and full of uncertainties (Whiting et al 1996).

Fourthly, there is a consensus that the traditional assessment approaches are only adequate when they are applied to certain types of IT investments (Whiting et al 1996). Traditional approaches based on financial value would exclude the costs and benefits that are difficult to quantify but critical to the assessment. IT infrastructure systems or systems in which value is strategic are considered as inappropriate subjects for traditional assessment approaches. Applying these traditional approaches to these types of IT investments may result in a conservative IT portfolio. Although, this may minimise risks, it may potentially affect the competitiveness of the organisation. Hirschheim (1988, p.28) also supports this argument. He points out that *"Fundamentally, it is the uncritical adoption of the so-called 'scientific method' which is at the root of the problems with IS evaluation".*

To solve these problems, some techniques have been developed specially for IT project assessment in recent years. These new techniques, which are termed 'modern approaches', will be compared with some traditional assessment approaches in the next section.

7.3 Techniques for IT project assessment

Control of IT investment to ensure value for money is currently a major issue of contention for most businesses. New IT products, both software and hardware, are constantly being developed and released. There are also many types of computers and systems available in the market. However, not all the applications are clearly beneficial to the organisations. In this sense, the need to achieve a good match between the capabilities of the system and the needs of the organisation is a critical, but complex issue.

Various assessment techniques can be found in the literature. According to Whiting et al (1996), a survey conducted by Unicom in 1992 showed that traditional investment assessment techniques were widely used in IT investment assessment, with the traditional cost-benefit analysis being the most common assessment technique used. However, modern methods such as SESAME or Return on Management were not mentioned in the survey. Coleman and Jamieson (1994) conclude that the absence of these modern methods may result from lack of practical application. Some techniques including traditional and modern approaches are reviewed in this chapter. A summary of these approaches is shown in Table 7.1.

Table 7.1. A Summary of The Approaches

Approaches	Methodology Characteristics	Data Characteristics	Features of Method
Cost/Revenue analysis	Comparing the cost of the whole system cycle with the financial benefits it generates	Tangible, accounting data	Ex ante or ex post
Return of investment	Calculating the tangible costs and benefits and aggregating these as cash flow	Tangible, direct, objective financial value	Ex ante or ex post
Cost-benefit Analysis	Provide money value to the decision makers for each element of the outcomes	Cost and benefit elements are expressed in money value	Ex ante or ex post
SEASME	Provide a subjective evaluation by comparing the proposed IT system with non-IT ones.	Assign subjective perception and requirements as weight points and scores	Ex post
Information Economics	Based on CBA and ROI but designed to cope with intangible benefits and assign values in economic term	Ranking and rating both tangible and intangible elements	Ex ante or ex post
Multi-objective, Multi-criteria	Explore perceptions from various stakeholders and seek consensus to identify the best choice	Subjective Perception from various stakeholders	Ex ante
Kobler Unit Framework	Use Critical Success Factors to identify the organisation requirement as the selection metrics and compare the sum of weighted score in the checklists to find the most suitable project	Subjective perception of the project and use checklist to assign the perceptions to points for further comparison	Ex ante
Return on management	Produce a residue value added by management and emphasis that management value is more important than cost saving	Management resource e.g. time, labour, etc. Values added for Management	Ex post
Value analysis	Involve all participants in the decision making to seek the likely outcome by using a Delphi method	Indirect, subjective evaluation of intangibles	Ex ante
Experimental Method	Develop model or using game playing to simulate the proposed project before the final decision is made	Exploratory data For the purpose of reducing uncertainty	Ex ante

7.3.1 Traditional assessment approaches

(1) Cost/revenue analysis

This method is derived from classical cost accounting and is regarded as the most basic and popular method of assessment. The cost of system planning, implementation and operation is compared with the value of benefits generated by this system. However, these benefits must be realised in the form of cost saving, cost replacement or other revenue generated and the analysis can only be made where the benefit can be directly attributed to the change of system.

This approach generally includes four steps:

(i) Estimate the cost of developing and implementing the system.

(ii) Estimate the expected life of the system.

(iii) Estimate the value of the benefit the system can generate.

(iv) Collect and sort the cost and saving per time period and compare them.

The data collected and sorted can then be analysed by using ROI type technique described in the next section.

(2) Return-on-investment (ROI) approaches.

Traditional ROI approaches include a number of formal investment assessment techniques such as Discounted Cash Flow (DCF) and Net Present Value (NPV). They are widely used in evaluating investments in financial terms (Frenzel 1996).

The propositions of ROI are that an investment must yield a positive return over a period of time and the notion that the money held now has more value than the same amount received in the future. Hence, the longer a return is deferred the lower is its current value. ROI approach permits management to compare the return of various potential investments and select the one providing the best return. This approach tends to be used by organisations with tight financial disciplines.

The ROI approach is most suitable when the investment can be supported by reliable calculations and is expected to deliver direct savings or direct revenue benefits. However, the ROI calculation may fail to reflect the collective effect of IT systems since ROI is based on a static environment but IT investments are designed to change the environment by increasing the availability and accuracy of information (Frenzel 1996). Farbey et al (1992) also contend that ROI is unable to capture many of the qualitative benefits derived from IT applications.

(3) Cost benefit analysis (CBA)

This approach attempts to find a money value of each element contributing to the cost and benefit of a new system. This approach is originated as an attempt to identify the value of expected benefits and to calculate the money value of elements without market value or price (Farbey et al 1993).

A traditional CBA analysis normally consists of five steps:

(a) Defining the scope of the project;

(b) Evaluating costs and benefits;

(c) Defining the life of the project;

(d) Discounting the values; and

(e) Performing sensitivity analysis.

According to Amos (1990), this approach is most suitable when there is an agreement on the measures used to assign a value to the intangibles. However, the main weakness of this approach is that the decision-maker may be unable or reluctant to accept the "value" recommended by the cost-benefit experts. Moreover, CBA approach may be unreliable since the potential benefits (e.g. intangible benefits) and hidden costs (e.g. maintenance) are sometimes ignored or under-estimated in the assessment (Whiting et al 1996).

7.3.2 Modern assessment approaches

(1) System effectiveness study and management endorsement (SESAME)

SESAME (Lincoln 1988) was proposed and designed by IBM. It applies primarily cost replacement techniques to evaluate the benefits of the information systems that have been installed and used for a certain period of time. The SESAME approach focuses on the system that has been implemented for at least 12 months and identifies the full costs and benefits of the system in considerable detail to date. This method is not intended to provide an accurate measurement of the new system in financial terms, but to provide an objective assessment of the new system's overall performance. In this method, the costs and benefits of a project are derived by calculating what cost will be if the same functionality of the system is delivered by a reasonable non-IT alternative. Then, the net benefit can be obtained by computing the difference between these two values.

Whiting et al (1996) argue that the intangible IT benefits are not considered in the SESAME approach because it is based on the comparison of two systems for their end results. Consequently, many side effects such as improving the computer literacy of staff and gaining experience for further IT projects are ignored in the assessment.

Willcocks and Lester (1996) also point out that SESAME seeks to compare the cost-benefit of an IT system with those derived by a manual system. This may be cumbersome and less meaningful for the companies computerised already. Moreover, this approach is more suitable for *post* implementation audit rather than an IT investment feasibility study for evaluating alternative potential IT investment proposals.

(2) Information Economics

Information Economics (Park and Benson 1988) is a variant of CBA developed specially for the assessment of IT projects. Park and Benson (1988) felt that the traditional assessment methods, such as, CBA and ROI have certain shortcomings. For example, (1) traditional cost-benefit and ROI approaches evaluate IT investments from a microeconomic perspective and encourage low risk investments with small returns; (2) they are the result of a manufacturing economy where labour is treated as an expense; and (3) the analysis is static and short term.

Information economics attempts to cope with the intangibility and uncertainty found in IT projects. It retains the ROI calculation for those costs and benefits which can be ascertained but provides a score to rank the intangibles and risks. It is designed to identify, rank and measure the economic impact of all changes in the performance of the organisation through the introduction of the new IT system.

This approach classifies IT into three types: substitute, complementary and innovative applications. It is intended to measure and identify the economic impact of the change created by the installation of the new IT system. On the cost side, it recognises organisational risk, strategic uncertainty and technological uncertainty as cost elements to be evaluated.

Information economics emphasises the view that the benefits of an IT system should be regarded as valuable to the organisation in all aspects rather than just in financial terms. It provides capabilities for dealing with identified problems, however, it may require considerable expertise to conduct the in-depth analysis and tracing process. Moreover, Whiting et al (1996) contend the main thesis of information economics which regards the benefits of IT as value to the organisation is certainly valid, however no coherent methodology is offered in Information economics for an IT investment assessment strategy.

(3) Multi-objective, multi-criteria methods (MOMC)

This method is based on the assumption that the value of a project can be measured in terms other than money. The decision-makers can assess the systems on the basis of their own preferences by applying a weight scale to rank goals for different outcomes of the systems. Where there are many stakeholders the best system is the one that provides the highest overall score in the assessment.

MOMC is best used when there are various objectives to serve a number of units or persons with different views and judgements on the value of outcomes from the proposed systems in the organisation. The users may find it easier to express their preference in other terms rather than money value. It is particularly useful at the stage when a strategy is being decided (Farbey et al 1992).

The advantages of this approach are that it permits an exploration of the different points of view of various stakeholders and explore the values of the proposed systems in terms of relative preference for different system features. However, this approach would not provide any data to show the return on the investment and would involve a great deal of discussion among stakeholders (Farbey et al 1992).

(4) Kobler Unit Framework

The Kobler Unit has developed an approach for evaluating and prioritising IT investments. This framework consists of four models, each of which corresponds to a stage in the process of assessment. The first model evaluates the proposed project against a checklist of critical success factors (CSFs) identified previously. The

Kobler Unit has found that the check and affirmation of CSFs in the first stage is particularly important for the whole process of assessment (Whiting et al 1996).

The activity in the second model is mainly to ensure that the costs of the IT investment are truly understood by the appraisers. This is because research has shown that most companies tend to underestimate the total cost of their IT investment (Whiting et al 1996). The third model is concerned with the identification and specification of business performance metrics that can be used in the assessment of IT investment. The specification of metrics can help the decision-makers to identify the requirements for the new IT system for their business practices and objectives (Whiting et al 1996).

The fourth model is to compare the merits of the adopted IT system with those of alternative IT systems. The appraisers rate each system across a number of predetermined dimensions. A weight is also attached to the perceived importance of each dimension. Then, the overall value of each project is the summation of the weight scored for each dimension. However, as Whiting et al (1996) point out, a potential problem in this framework is its neglect to take into account the other stages in the system development cycle, such as, the feasibility study stage and post-design, pre-installation stage. According to them, the framework was over-complex as it classified the IT system into nine areas.

(5) Return on management (ROM)

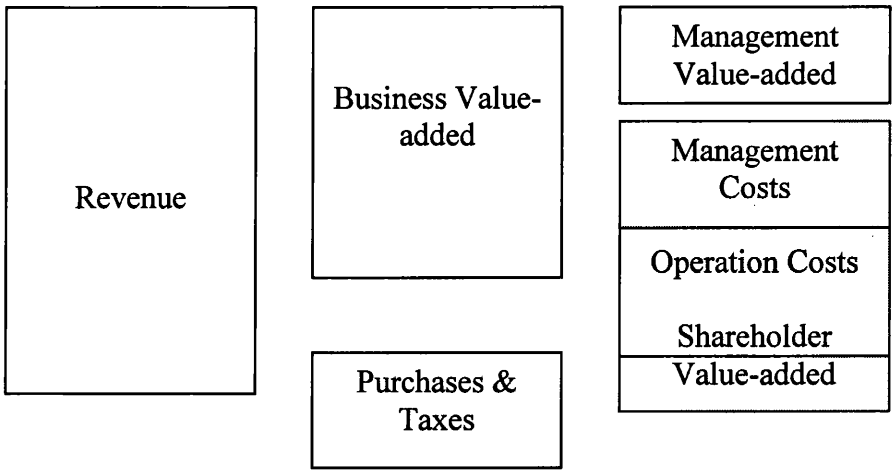
ROM (Strassmann 1985, 1990, 1997) expresses the outcome of a new information system as the change to the value added by management stemming from the introduction of a new system. It is based on the notion that the real value of the IT system is that it enhances management productivity. Strassmann identified the quality of management as the critical factor in superior IT performance regardless of the size of the investment capital. This approach is intended to supplant the traditional ROI as a technique for IT investment assessment (Farbey et al 1993).

ROM is a measure of the value-added which comes from the managerial activity in the organisation as compared to the costs incurred by these activity. The calculation is based on an estimate of revenue after the new system is installed and estimates of changes to resource costs and contributions. The management value-added is defined as “Revenue minus Purchases minus Shareholder Value-added minus the Costs of Operation minus the Cost of Management” (Strassmann 1990), as shown in Figure 7.1. The ROM of an IT system can then be calculated by using the following formula:

$$\text{Return-on-Management} = \frac{\text{Management Value-added}}{\text{Management Costs}}$$

Significant difficulties encountered in such estimates prior to system implementation suggest that this approach is better suited to the assessment of existing systems (Whiting et al 1996). The advantage of this approach is that it concentrates attention on the value added to management process. However, the disadvantage is that the value assigned as added by the management may not be directly attributed to the management process (Farbey et al 1993).

Figure 7.1 The Definition of Management Value-added (Strassmann 1990)



(6) Value analysis

This approach also evaluates a wide range of benefits, including intangible benefits, by establishing a value for the outputs. It is based on the philosophy that value generated from the system is more important than the cost saved. The Delphi method, for example, is used in this approach to assess the value of the intangibles.

The Delphi approach confronts all the participants in the decision making process with the speculations of the others. After a number of consultations with all the participants, a consensus tends to emerge which can be regarded as the most likely outcome. A prototype of the system or game playing simulation can then be applied to gain more experience.

The main advantages of this method are that all the participants can be involved in determining the values of intangible benefits together and that uncertainty can be reduced by means of prototype demonstration (Farbey et al 1993). However, establishing the values can be a lengthy and costly exercise. In addition, prototyping may face difficulty of predicting the indirect consequences of the real system (Iivari 1988).

(7) Experimental methods

With advanced software and simulation methods, it is possible to develop an experimental prototype or model before making a decision on whether to introduce a new system on site. This enables the designer to modify and test the system and its impacts experimentally before the installation of the new system. Project champions can demonstrate the experimental model to sceptical users and use it to persuade top management to support the project. There are three main categories of experimental method:

(a) Prototype - a prototype is usually developed by a 4^{th} generation language and is best used when the impact of a new system is highly uncertain and when the system is innovative and likely to have a great impact on the business operation, e.g. decision support system.

(b) Simulation- these approaches involve formulating the project in the form of a model and using this model as a basis for further experiments. Simulation can be very important for IT projects since it allows sensitivity analysis that can resolve the robustness problems of the system resulting from uncertain assumptions.

(c) Gameplaying- gameplaying can be used to assess the outcome of doing certain tasks in a revised way without building a costly prototype model. The roles in gameplaying can help participants understand each other's jobs and obtain more knowledge about the operation of the proposed new system.

7.3.3 *ad hoc* approaches

An alternative approach is the use of assessment criteria in evaluating IT investment. This approach is based on the perception that not all investments in information technology is of a capital nature, but that the need to meet the organisation's requirements is the first priority in the investment.

Elliot and Melhuish (1995) developed a methodology for project feasibility assessment to examine whether a specific technology is potentially suitable for resolving a business problem or need. This methodology includes three processes:

(1) Analysing the business situation: determining the business problems and requirements and then weighting each requirement.

(2) Determining the IT contribution: evaluating technologies against each requirement, considering risk factors and reaching a conclusion about whether there is a suitable IT solution and the sequence of the implementation. If more than one IT solution is available, a preferred order of implementation should be determined by applying the weight score method.

(3) Recommendation: making formal recommendations for further actions.

This method is regarded as *ad hoc* in nature since it uses some parts of the formal assessment method and adapts them to suit the requirement. In practice, many organisations combine selective parts of a number of methods or make variations to a particular method to suit their requirements. They contend that the *ad hoc* methods are the most frequently used IS/IT assessment methods.

Elliot and Melhuish also indicate that frequently the decision to choose a standard assessment approach or an *ad hoc* one is based on political rather than business factors. The advocates or those who have an interest in getting approval for an IT project may use an *ad hoc* approach to collect information which is useful in gaining approval for the project.

7.4 Assessment practice

7.4.1 The role of stakeholder in assessment

Identification of the stakeholders and their tasks are critical to the assessment and implementation of the IT system. Farbey et al (1993) provide a generic external stakeholder map of a large organisation involving 12 parties. They assume that only the system vendor (supplier) is directly involved in the preparation of the assessment, and that the other parties are not directly involved in the process. However, other parties, such as, the customers can often play a decisive role in determining whether to adopt a particular system. For example, customers may demand that the system be compatible with theirs. In addition, although the government is only an external stakeholder and is indirectly involved in the process, the outputs of the systems are required to conform to legal regulations.

There are also internal stakeholders involved in the decision process. Farbey et al (1993) also categorise these internal stakeholders into six groups. They are (1) Management, (2) Systems, (3) Supporting Department, (4) Finance, (5) Users, and (6) Champion. A map of the internal stakeholders and their examples are shown in Figure 7.2.

The person, who takes up the idea and persuades the organisation that the new system is worthwhile, is called the "champion". In most cases, the champion plays a pivotal role in the final decision-making process of a new IT investment. In this sense, the development of the new system cannot go ahead without their participation.

Alternatively, Ginzberg (1988) classifies stakeholders into four dimensions:

(1) internal-external to the adopting organisation;

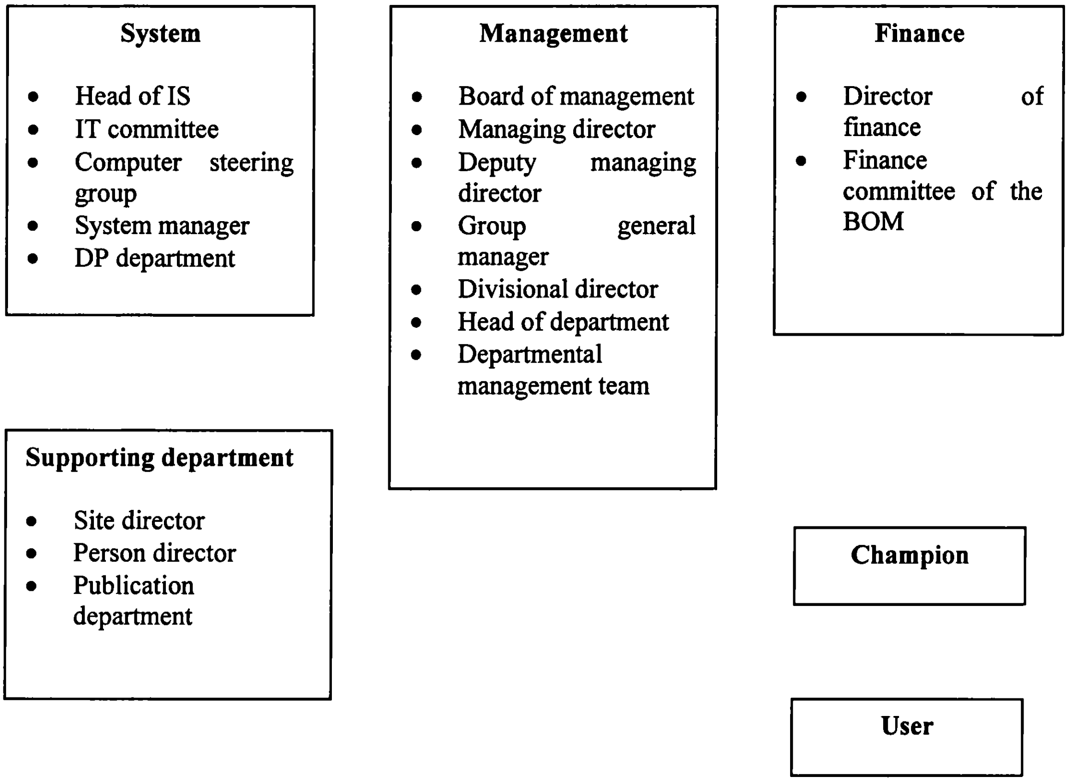
(2) relationship to the IT project, such as users or sponsors;

(3) directly-indirectly related to the system, and;

(4) level of aggregation, such as, individual, group, organisation and society segment.

The stakeholders, normally considered in the feasibility stage and post-implementation stage assessments, tend to be internal users, usually individuals or groups, but not both, who interact directly with the system (Ginzberg 1988).

Figure 7.2 An Internal Stakeholders Map (Farbey et al 1993)



However, this is not always true. As discussed previously, a customer's request or the government's legal policy may have more influence on the assessment than the internal stakeholders. Therefore, a comprehensive stakeholder analysis is critical in the assessment process.

7.4.2 Criteria in the IT assessment

Five criteria for successful assessment of IT investment have been identified by Farbey et al (1993). First, a comprehensive search for benefits is required.

Organisations must understand the expected benefits and search for possible unexpected benefits in order to set standards in their assessment process.

Secondly, a champion is needed to drive the investment. Top management may not have enough knowledge of the IT system and the benefits it can gain through its use. Consequently, a champion is required to be involved in the decision process.

Thirdly, the understanding of relevant management processes is a crucial aspect of the assessment process. This is because without a full understanding of the organisational business strategy and direction, the decision-makers may lead a ineffective assessment in the wrong direction.

Fourthly, good communication among stakeholders is essential. Both the external and internal stakeholders may have different perspectives of the new project, thus the publicity of the assessment and decision process will help to fulfil the needs of different groups.

Finally, a post-implementation review should be included in the assessment agenda. The review will help the organisation to assess the proposed return on the investment and the technical performance of the system.

Bacon (1992) in his study identifies 15 criteria for the IT investment selection and assessment. He found that the most important criterion in the survey is whether the investment would support the organisation's explicit business objectives. While it is not always feasible to quantify the benefits of the IT investment, such benefits can usually be represented as explicit organisational goals and objectives. Consequently, if the IT investment can satisfy the organisational needs and support the business strategy, the costs/benefits justification no longer dominates.

7.4.3 Selection of assessment approach

Farbey et al (1992, 1994) in their research provided a model to match a project with an assessment method. First, they categorised the circumstances of the project into five dimensions and then located the results of their samples as points on various 2x2 matrices. The five dimensions used by them are listed below.

(1) The role of assessment

This dimension is defined by two factors: the time (from **requirement** stage to **specification** stage) and level (from **tactical** to **strategic** level) at which the assessment is carried out.

(2) The decision environment

This dimension is defined by four factors in two matrixes.

1. Decision process (**standard** or ***ad hoc***);
2. Type of benefits the project is expected to bring (**quantifiable** or **qualitative**);
3. Importance of number (need to **attach number** to all costs and benefits or **not**);
4. Cost of the system justification (cheap and **simple** or expensive and **sophisticated**).

(3) **The system underlying the IT investment**

Two factors are involved in this dimension. The first is the purpose of the system. The system may be used as a **specific** application or it may provide an **infrastructure** where a range of application can run. The second is the connection between the system and the business. The system can be in a **supporting** role or at the **core** of the business.

(4) The organisation making the investment

The first factor is the industry position of the organisation (**stable** or **turbulent**). This is because the characteristics of the industry may also affect the assessment. The second factor is the leadership role of the organisation in the industry (**pioneer** or **follower**).

(5) Cause and effect relationships

This dimension has also two factors. First, the impact of the new system may be **certain** or totally **uncertain**. Secondly, the impact of the system may be **direct** or **indirect**.

After the characterisation process, the characteristics of various assessment techniques are identified according to the dimensions above and located at some point on a 2x2 matrix. Finally, the matrices are overlaid to match project with technique. The clustered or dispersed points in the matrix signify the range of techniques that might be applicable (as shown in Figure 7.3).

Figure 7.3 Techniques Matrix (developed by Farbey et al 1992; 1994)

	Direct **Tactical** **Quantifiable** **Simple** **Support** **Follower**	**Indirect** **Strategic** **Qualitative** **Sophisticated** **Core** **Pioneer**
Predictable **Specification** **Standard** **No. is important** **Specific** **Stable**	Return on Investment SESAME Cost/Revenue	Cost Benefit Analysis
Unpredictable **Requirement** ***Ad Hoc*** **No. is not important** **Infrastructure** **Turbulent**	Experimental methods Multi-objective, Multi-criteria	Boundary Value Information Economics Return on Management Value Analysis

For some projects, the points may fall within the same quadrant to give a certain indication of a suitable technique; for other projects, the points may spread around to indicate that several techniques may be applicable. This methodology was developed through 16 case studies, without any theoretical validation. Further research is needed to refine and verify this method.

There is a prevailing attitude that methods of IT investment assessment should be kept as simple as possible (Whiting et al 1996). Complex numeric approaches cannot compensate for the unreliable nature of the input values and the ignored intangible IT benefits. Different IT investment may have different values for an organisation. However, the essential criterion of the IT assessment is to meet the needs of the organisation which is performing the assessment (Whiting et al 1996).

Hirschheim (1988) and Iivari (1988) indicate that since assessment contains a large measure of subjectivity, due consideration should be given to the political and social domain in which it is performed. IT assessment must take into account both the technical and social aspects of a system. In this situation of subjectivity, it is obvious that the selection of the IT investment involves a social negotiation and bargaining process. Consequently, Hirschheim (1988) suggests that measuring the level of user satisfaction might be a more appropriate parameter for success than that derived from cost benefit analysis because of the subjective definition of success.

Also, most of the IT assessment approaches focus on the cost/benefit analysis and there is a tendency to address economic issues only. Technical and operational issues are not assessed, or at best, are transferred into economic terms and incorporated into the cost/benefit analysis. Therefore, these approaches cannot really identify the best IT investment that can meet the organisation's technical, operational and economic requirements.

Consequently, appraising IT project in an *ad hoc* way seems to be the favourable approach because the selection of assessment criteria is flexible and can be customised to suit the organisation's needs. Unlike the traditional approaches discussed previously, this approach does not only focus on financial considerations.

Other requirements related to technical or operational issues can also be selected as criteria for project assessment. Moreover, different organisations may have different purposes for their IT investment. For example, the use of requirement as assessment criteria in Elliot and Melhuish's model (see section 7.3.3) can reflect the organisation's assessment priority. In summary, this kind of approach can provide a balance between utilising both quantitative and qualitative forms of IT assessment.

Little empirical verification has been done for using criteria in IT investment selection and assessment (Bacon 1992). The Kobler Unit framework and the methodology developed by Elliot and Melhuish (refer to section 7.3.3) are examples. However, The Kobler Unit's framework is designed only for assessment at the feasibility stage and the classification of IT systems in this model is too complicated.

Elliot and Melhuish's model uses the organisation's requirements as selection criteria and identifies the most suitable project by evaluating technologies against each criterion. However, this model is only for feasibility stage assessment and does not provide clear guidelines to identify the selection criteria. Also, the role of external stakeholders in this model is not considered.

7.4.4 Risk Assessment

IT innovations have provided organisations with opportunities for both accelerating change and for creating the demand for changes in their business activities. However, change is always associated with risks. The failures to deliver systems effectively, to obtain the expected benefits or to develop systems within budget and time constraints are examples of risks in IT investments.

Willcocks and Margetts (1994) argue that risk in IT projects is surprisingly under-managed in both the private and public sectors, especially when the large financial commitment for IT investments and the history of disappointed expectations are considered. There are many cases of IT project failure such as the London Stock Exchange System or the National Health Service Reforms to support the point of view that risk in IT innovation projects needs to be assessed and managed effectively.

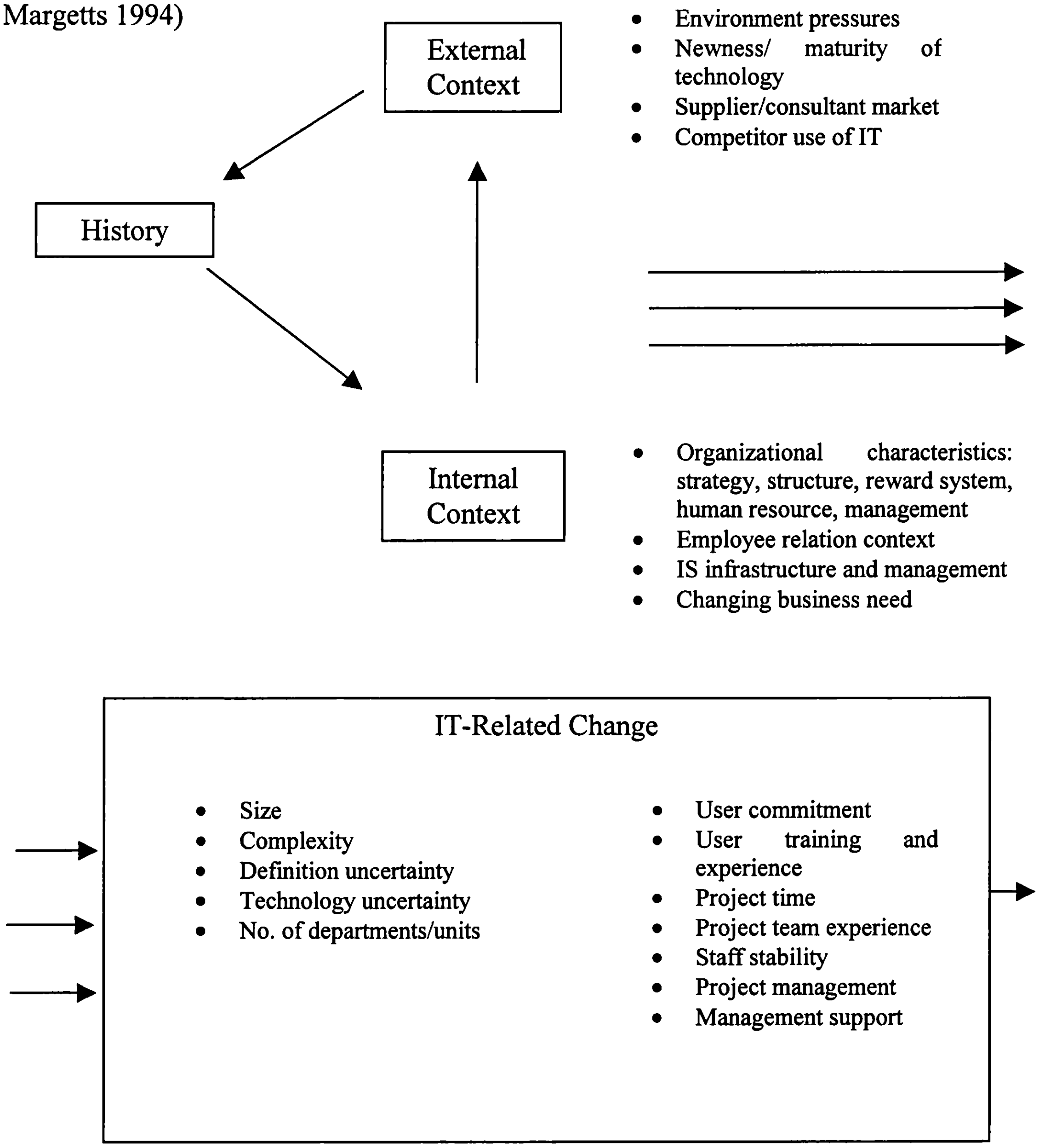
Risk assessment can be defined as a systematic process to assist management to understand the potential risks involved in a particular project, plan for those risks which may be controlled and take into account any residual and unexpected risks. Willcocks and Margetts (1994) have developed a framework to assist risk analysis from their case studies, as shown in Figure 7.4. In this framework, six conceptual categories are brought into the analysis:

- Context (external): refers to the factors which the organisation and its members need to respond to and accommodate such as economy, politics, structure, competition or markets.

- Context (internal): refers to the characteristics of the organisation itself such as business strategies, organisation structure or management.

- History: refers to the organisation's experiences in dealing with IT projects. Willcocks and Margetts (1994) argue that previous IT success experience might

Figure 7.4 A framework for IT Project Risk Analysis (developed by Willcocks and Margetts 1994)



contribute to new IT system development. However, it may also lead management to underestimate risks in future IT system development.

- Content: refers to the proposed changes itself (the system), including their substance such as complexity of technology, size and technical issues.

- Process: refers to factors associated with the implementation of the IT system such as user commitment, staff training and management support.

- Outcomes: refer to the assessment of expected or unexpected outcomes of the system such as cost, time, technical performance and user acceptance.

Willcocks and Margetts's (1994) framework has demonstrated that many types of risks that could arise in different ways in IT projects. They suggest that computerisation remains a high-risk process but the organisation's environment, context and pressure may also exert considerable influence on the degree and types of risks encountered. Their framework could be used to complement, rather than replace, other methods for risk analysis.

7.5 IT assessment in construction

Churcher et al (1996) in their case studies found that there were three main approaches to the appraisal of IT projects in the UK construction industry. They are (1) no specific assessment; (2) informal assessment; and (3) formal cost benefit analysis.

(1) No specific assessment

There are some cases where a formal structured assessment is not necessary or impossible to implement. Two situations are included: Firstly the IT project is requested by the client. In this situation, the cost of the IT project is built into the contract so that it is unnecessary for the organisation to carry out a feasibility study. However, the clients may favour the organisation which already has the system they require, as this will eliminate need to incorporate the cost of installing the new IT system instalment into the contract. Secondly, the IT costs are very low. Assessments usually are ignored for small-scale IT projects where cost is so low that the benefits to be gained will be outweighed by the cost of carrying out any evaluation.

(2) Informal assessment

Compared to the formal structured evaluation, informal assessment is relatively quick, easy and cheap to carry out. However, informal assessment has the risk of being inaccurate because not all the costs and benefits are identified and assessed. Churcher et al (1996) suggest that informal assessment should be used in cases where the scope for major error is reduced, such as when the system has already been applied by other companies.

(3) Formal cost benefit analysis (CBA)

This is the least common method of assessing IT projects in the construction industry because it is complex and time consuming to carry out. (Churcher et al 1996) Moreover, benefits and costs which cannot be quantified or forecasted will reduce the reliability of the analysis result. The confidence with which the estimates have been made for the benefits and costs will also influence the result of the analysis. Consequently, it is dangerous to place too much credence on numerical figures without really understanding what elements have been involved in the calculation.

However, Churcher et al (1996) argue that a formal cost benefit analysis is a useful tool for the IT project justification. It can also be used with the benchmark approach to measure the success of the IT project after implementation. Moreover, the result of a formal cost benefit analysis is more convincing when persuading the potential investors about IT's feasibility. The CBA can provide a comprehensive overview of the project with details of the assumptions used in the analysis and conditions of the project.

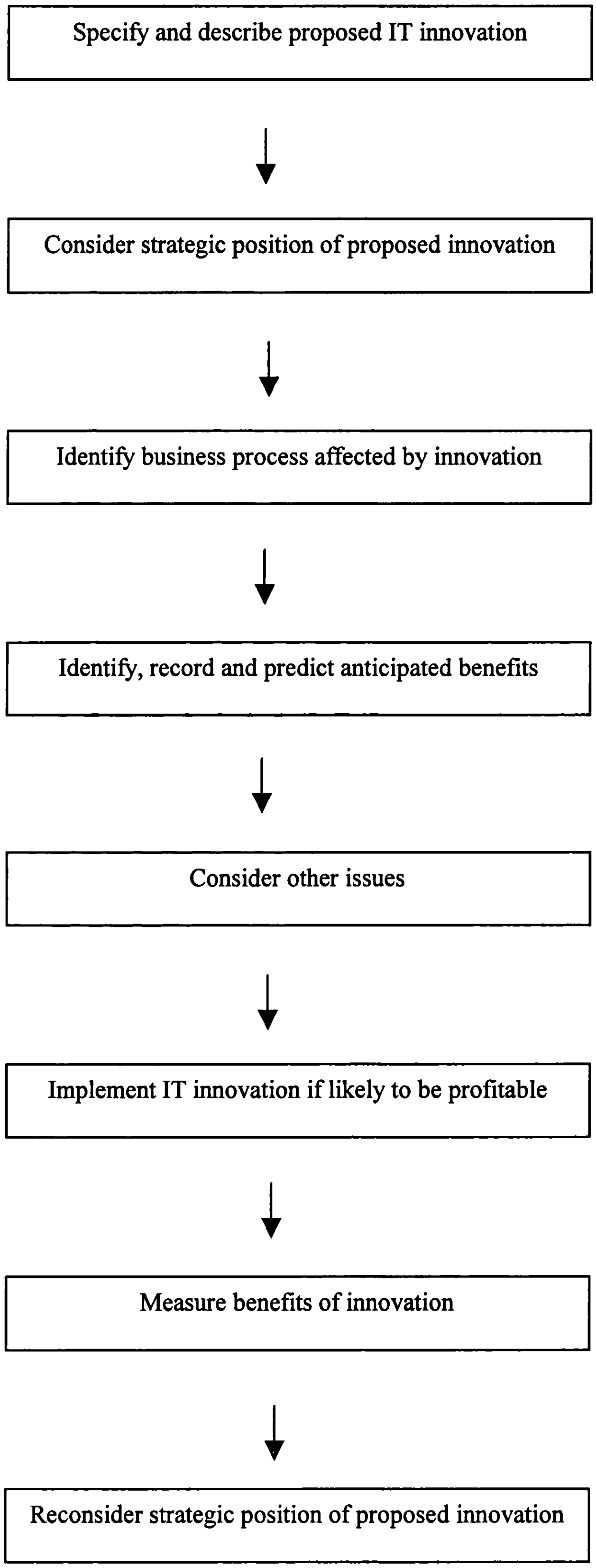
A formal cost benefit analysis is more applicable to cases where a large proportion of costs and benefits can be quantified and predicted accurately and where there are few unquantifiable cost and benefits (Churcher et al 1996). This tends to be the case for system substitution such as by replacing an existing manual system or updating an old IT system. On the other hand, cases with a high proportion of costs and benefits which cannot be quantified or predicted are likely to be assessed by informal assessment. Indeed, systems which introduce new areas of business or have a great impact on operation are likely to be good examples.

Much of the literature discusses the measurement of IT benefits. For example, Hitt and Brynjolfsson (1996) studied the three different measures of IT value: productivity, profit and consumer welfare from 370 large firms in USA. IT Centre of Excellence (1997) found that many construction organisations in the UK prefer using the formal Cost Benefit Analysis (CBA) approach to appraise their IT investments. This is because CBA approach can provide the decision-maker with the outcomes of the investment in monetary terms. However, this approach may be unreliable since many IT benefits are not quantifiable or difficult to assign a money value. Thus, Construct IT Centre of Excellence (1998) has developed a framework (as shown in Figure 7.5) for IT innovation assessment in construction firms. This framework is designed for use both before and after an IT innovation has been implemented. The main approach taken in this framework is to suggest that IT innovation can improve "business processes" within the construction firms. Consequently, the "business processes" are used as the means to measure the IT innovation benefits.

The generic business processes of construction firms suggested in this framework are as follows:

- *Business Planning*: refers to strategic management of the firms such as new business ventures.
- *Marketing*: refers to market selection, public relations activities and so on.
- *Information Management:* refers to the communication links between organisations and project sites, information archives, distributions and other information processing activities.
- *Procurement:* refers to all activities associated with the organisation's input to projects such as bidding, tendering tasks.
- *Finance* refers to activities associated with financial transitions and management on projects and the organisation itself.
- *Client Management:* refers to the activities associated with managing relationships with project clients.

Figure 7.5 The framework of IT Innovation Assessment Developed by Construct IT Centre of Excellence (1998)



- *Design:* refers to the tasks associated with project design activities undertaken on projects such as project briefing and sketching.
- *Construction:* refers to the activities associated with production support on projects, construction technology and knowledge.
- *Occupation and Maintenance:* refers to the activities associated with occupancy and maintenance phases of buildings and projects.
- *Human Resources:* refers to the activities within the organisation and projects concerning the management of people.

Moreover, this approach classified IT benefits into three different types:

- *Efficiency benefits* "doing things right": efficiency is measured in monetary terms.
- *Effectiveness benefits* "doing the right things": effectiveness is seen as measurable but unable to assign a money value.
- *Performance* "doing better things": performance is not measurable but can be of great consequence in influencing long-term business benefit.

The potential benefits of a proposed IT project can then be identified by means of the ten "business processes" described above and be assessed by the three types of IT benefits individually. The efficiency benefits assessment examines the financial value of the benefits, the effectiveness benefits assessment examines the benefits which cannot be measured in monetary terms by predicting the likelihood and weight of the relative benefits of those identified. The performance assessment rates and describes the impact of the performance benefits conceived.

The overall assessment of the benefits includes the monetary sum derived from "efficiency benefits", a score from the "effectiveness" benefits, and a qualitative description and rating from "performance" benefits. These figures can be used for comparisons between different IT innovation projects, or expected and measured benefits after implementation.

Construct IT's (1998) approach concentrates mainly on the method of measuring IT innovation benefits. It attempts to identify the benefits both in financial (quantitative) and non-financial (qualitative) ways. The advantages of this approach are that it permits the exploration of both tangible and intangible benefits of IT innovation, and uses monetary values to measure the efficiency benefits that will be easily noticed by the decision-makers.

However, the methodology used for measuring qualitative benefits involves comparing the predicted benefit score (the sum of likelihood multiply weighting in each benefit) and measured benefit score (the sum of realised relative weighting in each benefit). The problem with this approach is that the prediction of likelihood in each potential benefit relies entirely on personal conceptions and subjective opinion. The danger of this method is that it can be used to build political support for favourite projects.

7.6 Discussion and conclusion

The role of IT assessment is discussed in this chapter. The role of IT project assessment varies between the stages of development and the purpose of assessment. During the early stages, the main issues in assessment concern only general requirements and scope. The management has to be persuaded of the feasibility of the proposed system and the scope of the strategy. During the later stages, more issues of concern are involved and more details expected. The management has to be informed of the precise impact of the system.

Some traditional, modern and *ad hoc* assessment approaches are also introduced in this chapter, as well as those approaches developed specifically for the construction industry. Most of the traditional approaches deal with the direct economic tangibles only, while the modern approaches are designed to cope with the intangibles and intended to calculate the project benefits other than financial value. On the other hand, *Ad hoc* approaches originate partly from the traditional ones, but are modified to suit a particular situation or to meet special requirements. The selection of an IT assessment approach is a difficult issue since business strategy, environments and organisation characteristics play important roles in the decision making process.

The problems encountered in IT project assessment are mostly rooted in the assessment approach itself. Assessment approaches focusing only on the financial return of the investment may mislead the organisation in the decision process. The other problems are related to the measurement of intangible benefits derived from the IT system. Many intangible benefits are difficult to identify and several steps away from the actual achievement of benefits. Organisations unaware of this situation may consider their project as a failure from the result of such assessment. Computerisation remains a high-risk process, however the degree and types of risks vary according to the different environment and structure of organisations. Thus, risk assessments should also be considered and included in the whole IT project assessment activities.

Chapter 8: Research Methodology

8.1 Introduction

As illustrated in previous chapters, IT can be highly beneficial for an organisation seeking to improve its internal performance and gain competitive advantages as a result. Unfortunately, IT innovations are not found to be very pervasive in the construction industry. Indeed, there are certain unique features in construction, such as the fact that construction projects are typically "one-off", which may hinder IT innovation in the industry. However, Construct IT (1997) has argued that the absence of a proper model for IT investment appraisal is the main cause for the lack of progress of IT innovation in the construction industry.

Consequently, the Construct IT Centre of Excellence (1998) has developed a framework to measure the benefits of IT innovation in construction firms, as described in Section 6.6. This framework provides a different approach to measure both the financial and non-financial benefits of IT innovation separately. A working example is also provided to demonstrate the use of this framework in their report.

However, a proper IT benefit assessment approach is not the sole requirement for achieving IT project success. Other factors involved in the context, content and process of change may also influence the outcome of the change. This research aims to identify which organisational variables can influence the diffusion and implementation of IT innovation in construction firms, as well as to investigate the relationship (if any) that may exist between IT implementation performance outcome and organisational variables. In addition, the research aims to identify if there is any critical factor for successful IT implementation in construction organisations.

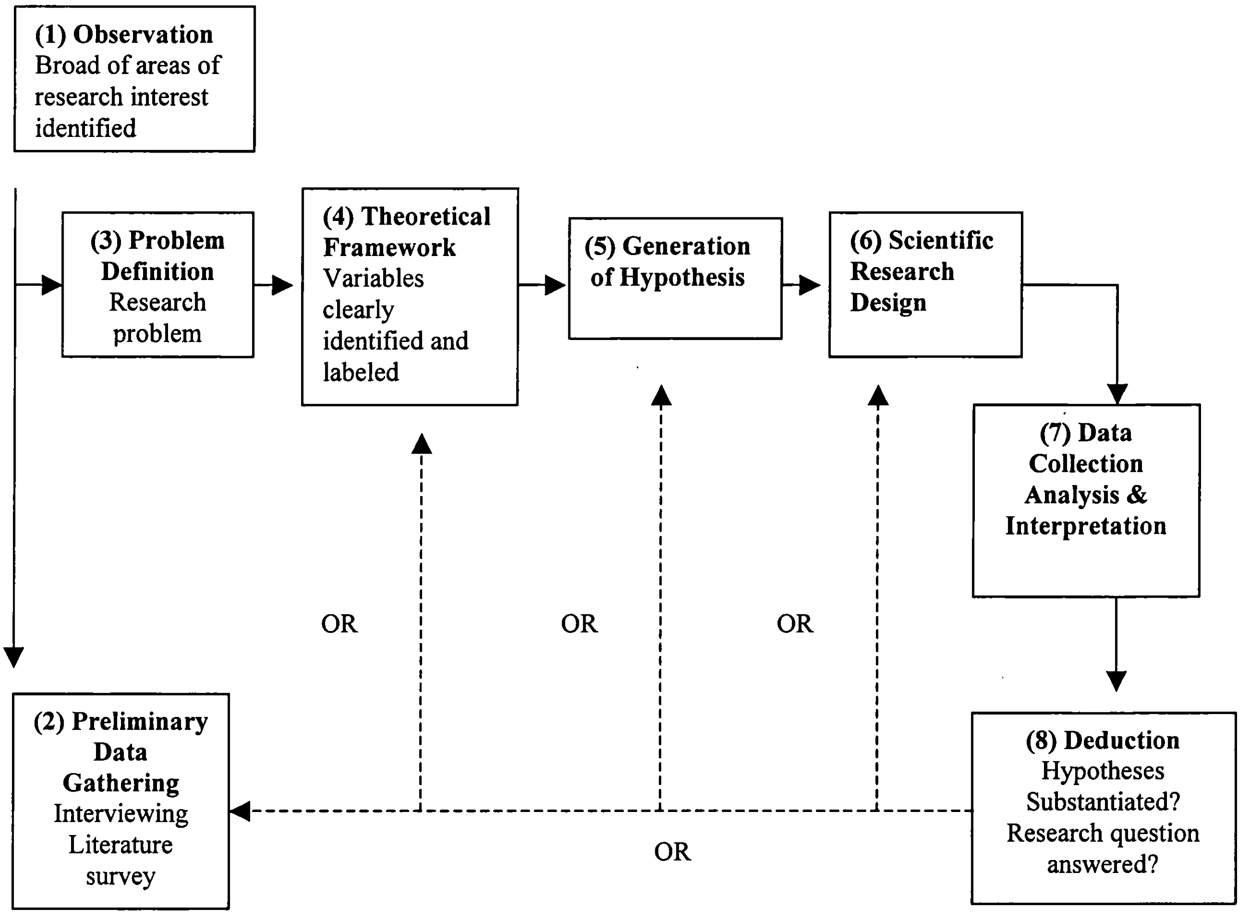
This chapter firstly introduces a general model for the research process. Secondly, the methodology for data collection and the contents of the instrument used in the interviews are reviewed. Thirdly, an analytical framework developed for this research is introduced. This framework was used to identify the potential organisational variables which may contribute to IT implementation performance. Fourthly, the research questions and hypothesises are discussed. Lastly, the instrument designed to collect required data in this research is reviewed. Indicative scores were assigned to each variable in the instrument in order to reflect the degrees of strength of these variables in each organisation interviewed.

8.2 Research Approaches

8.2.1 The research process

It is essential to understand the theories underlying the conduct of research before the research questions can be developed. A research process developed by Sekaran (1992) for basic applied research is first drawn upon, and then followed by a discussion of the debate between quantitative and qualitative data collection approaches.

Figure 8.1 Research Process for Basic and Applied Research (developed by Sekaran 1992)



Sekaran (1992) has provided a useful model for conducting basic and applied research (as shown in Figure 8.1). This model clearly sets out the steps to follow in the research process. This process starts with a vague idea of potential research interest. Then preliminary data is gathered from relevant literature reviews or interviews to define more clearly the research questions. After the formulation of the research hypotheses, a proper experimental method should be designed to gather field survey data, together with data analysis and interpretation to provide a preliminary insight into the whole research process.

The data collection methods include both qualitative and quantitative approaches such as interview, questionnaire and observation. Analysis of the experimental results provides answers to the research questions together with explanations which can contribute knowledge to the relevant research topic. However, data analysis requires the researcher to interpret the data using an appropriate analysis method. Analysis methods can be quantitative or qualitative such as statistical techniques or interpretive approaches.

8.2.2 Quantitative and qualitative data collection approaches

Philosophers and methodologists have been engaged in a long-stand debate about how best to collect required data in research works. Methods for research data collection can be divided into two schools: positivism and phenomenological (interpretive significant). Silverman (1998) argues that logical positivism uses quantitative and experimental methods for hypothesis testing, while phenomenological (interpretive significant) inquiry uses qualitative and naturalistic approaches in context-specific settings for hypothesis generation. Easterby-Smith (1991) and Remenyi et al (1998) assert that positivism's search for causal explanations generally reduces the whole into simple possible elements in order to facilitate analysis. On the other hand, phenomenological researches try to understand and explain a phenomenon rather than search for external causes.

According to these two perspectives, research may be categorised into two types: qualitative and quantitative. The former concerns on words and observations to express reality and attempts to describe people in nature situations, in contrast the latter places considerable trust in numbers that present people's opinions and concepts (Remenyi et al 1998). There are differences exist between the quantitative approach and the qualitative approach to data collection, with each encompassing its own strengths and weaknesses (Bryman1988, Easterby-Smith 1991). Table 8.1 shows some differences between these two approaches. Table 8.2 shows the strengths and weaknesses of these two approaches.

The most widely used method for quantitative data is the structured questionnaire survey. The close-end format of questionnaire was suggested as the most effective and simple way to obtain answers in uniform frames when the concepts of the respondents were investigated (Weisberg and Bowen 1977). Quantitative surveys attempt to answer questions such as "how much? How many?" (Yin 1994). Thus, quantitative data is most appropriate when a rate or proportion related to the target population needs to be estimated. The data collected by a quantitative approach are mainly numerical and can be used for complex statistical analysis. It is believed that the quantitative approach is more suitable in social science research when the model, theory and hypothesis have been developed with careful consideration (Yin 1994).

However, the weaknesses of the quantitative approach lie mainly in its failure to ascertain deeper meanings and expectations in measurement. Also a further weakness

Table 8.1 Some Differences Between Quantitative and Qualitative Research (Bryman 1988)

	Quantitative	Qualitative
(1) Role of research	Preparatory	Means to explore actors' interpretations
(2) Relationship between research and subject	Distanced	Close
(3) Researcher's stance in relation to subject	Outsider	Insider
(4) Relationship between theory/concepts and research	Confirmation	Emergent
(5) Research strategy	Structured	Unstructured
(6) Scope of findings	Nomothetic	Ideographic
(7) Image of social reality	Static and external to actor	Processual and socially constructed by actor
(8) Nature of data	Hard, reliable	Rich, deep

lie in its tendency to take a "snapshot" of a situation at a specific moment in time (Easterby-Smith 1991).

Qualitative data, on the other hand, is needed when the attitude, beliefs and perceptions of the target population need to be understood. Yin (1994) asserts that qualitative research is exploratory in nature, and tends to deduce answers to "how?

Table 8.2 Comparisons of Strengths and weaknesses (Easterby-Smith 1991)

Theme	Strengths	Weaknesses
Positivist (Quantitative Paradigm)	• They can provide wide coverage of the range of situations • They can be fast and economical • Where statistics are aggregated from large samples, they may be of considerable relevance to policy decisions	• The methods used tend to be rather inflexible and artificial • They are not very effective in understanding processes or the significance that people attach to actions • They are not very helpful in generating theories • Because they focus on what is, or what has been recently, they make it hard for policy-makers to infer what changes and actions should take place in the future
Phenomenological (Qualitative paradigm)	• Data gathering methods seen as more natural rather than artificial • Ability to look at change processes over time • Ability to understand people's meaning • Ability to adjust to new issues and ideas as they emerge • Contribute to theory generation	• Data collection can be tedious and require more resources • Analysis and interpretation of data may be more difficult • Harder to control the pace, progress and end-points of research process • Policy-makers may give low credibility to result from qualitative approach

and why?" questions. The qualitative approach is based on an attempt to avoid prior commitment to any theoretical model and is suitable in theory or model building by using close-up detailed observation of the natural world (Yin 1994, Maanen et al 1982). Both vocal and non-vocal behaviours are examined in qualitative study, hence the qualitative approach mainly produces literal data. However, Richards (1987) outline four major perceived constrains in the use of qualitative approaches in practice, they are (1) volume of data; (2) complexity of analysis; (3) details of classification records; and (4) flexibility and momentum of analysis.

There are six major techniques used in qualitative data collection: documentation, archival records, interviews, direct observations, participant observation, and physical artefacts (Yin 1994). There are strengths and weaknesses in each method (as shown in Table 8.3 below). Documentary information can take many forms such as newspapers, reports or agendas. For case studies, the use of documents is to corroborate any argument evidence from other sources. Archive records can be derived from service records, organisation records or past survey data. Archive records can be used for extensive retrieval and analysis.

Interviews include individual interviews and group interviews. In individual interviews, the interviewer probes the respondent and permits the data to flow freely in their communication. Group interviews involve a number of invited participants. Discussions may occur between the interviewer and participants. In such interviews, the interviewer needs to stimulate the discussion and keep it focused on the proposed topic.

Table 8.3 Six Sources of Qualitative Collection: Strengths and Weaknesses (Yin 1994)

Source of Data	Strengths	Weaknesses
Documentation	• Stable-can be reviewed repeatedly • Unobtrusive-not created as a result of case study • Exact-containing, e.g. exact name, reference, data • Broad coverage-long span of time, many events	• Retrievability-can be low • Biased selectivity, if collection is incomplete • Reporting basis-reflects (unknown) bias of author • Access-may be deliberately blocked
Archival Records	• (Same as above for documentation) • Precise and quantitative	• (Same as above for documentation) • Accessibility due to private reasons
Interviews	• Targeted-focuses directly on case study topic • Insightful-provides perceived causal inferences	• Bias due to poorly constructed questions • Response bias • Inaccuracies due to poor recall • Reflexivity-interviewee gives what interviewer wants to hear
Direct Observation	• Reality-covers events in real time • Contextual-covers context of event	• Time-consuming • Selectivity-event may proceed differently because it is been observed • Cost-hours needed by human observers
Participant Observation	• (Same as above for Direct Observation) • Insightful into interpersonal behaviour and motives	• (Same as above for Direct Observation) • Bias due to investigator's manipulation of events
Physical Artefacts	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

Direct observation can be made by a field visit to the case study "site". Observation evidence is often useful to provide additional information for the topic studied. To increase the accuracy and reliability of observational data, using multiple observers in an observation activity is helpful. Participant observation involves direct, extensive observation of an activity or behaviour. The difference between direct observation and participant observation is that the observer is not only in a passive role but is actually a participant in the events being studied. The merit of this approach is that the interviewer can get a real picture of those involved in the situation. A physical artefact is a technological device, tool, instrument, or other physical evidence. Such artefacts may be collected or observed as part of field study. It is suggested that physical artefacts have less potential relevance in most typical kinds of case study (Yin 1994).

As noted previously, there is a convention that quantitative research is associated with the test of theory, while qualitative research is associated with the generation of theory. However, Bryman (1988) argues that this convention has little to do with either the practice of many researchers within these two traditions or the potential of the methods of data collection themselves. The decision concerning whether to gather data by a quantitative or qualitative approach should be made according to the scale of the research and the nature of data required in the research.

There is a suggestion that both qualitative and quantitative should be mixed in research of many kinds. Fellows and Liu (1997) argue that the use of both qualitative and Quantitative techniques together is very powerful to gain insights and results in drawing conclusion. Winch (1994) supported this point of view and used a data collection methodology advocated as the "case survey" in this study. He states that the essence of this method is "*pattern recognition across cases*". This method aims to combine both the strengths of the case study and the survey. This method is based on a case study approach, but the output of data is in quantitative form.

However, Winch argues that the use of case survey for organisational assessment may be beyond the resource of academic research projects in terms of researchers' time and budget if the amount of organisations for investigation is large. Alternatively, the organisational assessment approach used by Van de Ven and his associate (Van de Ven and Ferry 1980) provides a more comprehensive and sophisticated approach to the study of structure and dynamics in organisations. Winch (1994) contends that their "organisational assessment (OA)" approach utilises a much more detailed empirical methodology and produces extensive quantitative data by implementing a questionnaire based survey within an organisation. It also emphasises the importance of interpreting data with a deep qualitative knowledge of the organisational context and dynamic.

Van de Ven and Ferry (1980) argue that questionnaires not only provide a more efficient and standardised method of measurement, they also eliminated some of the basic problems in qualitative survey research such as the loss of information occurring in the transmission of verbal responses into writing answers and the variability in responses due to interviewer styles and skills. Van de Ven chose the numerical rating scale technique (e.g. Likert-type scale) rather than the verbal anchored one to measure respondents' perceptive judgements [e.g. the "friendliness and cooperativeness" of the respondent's co-workers (p468)]. He argues that the former is more practical and reliable than the latter. Tuff and Albaum (1973) also assert similar point of view.

Moreover, Van de Ven argues that the number or point on a rating scale used to answer questions can significantly influence respondents' "frames of reference". Many researches have discussed the optimum number of scale points. For example, Lissitz and Green (1975) suggest that the optimum number of scale points is 5 since their tests show that the increase in reliability levels off after 5 scale points. Van de Ven also supports this argument. He has varied the number of scale points in his various OA surveys and found that five-scale points "not only reduced the complexity of answering questions for respondents by one-half, it also permitted us to develop clear distinguishable anchors or cues to represent the intended meaning of each number on the 5-point scales" (pp.65).

This research project aims to identify the relationship between the organisational characteristics and IT implementation performance, thus an exploration of construction organisations' interpretations of IT is required. From the debates between quantitative and qualitative approaches discussed previously, the quantitative questionnaire survey would seem to be the most appropriate method for data collection in this research since the results of questionnaire survey can produce valuable data on correlations between variables to the formal hypothesis of the relationship between organisational variables. However, this research aims not only to test the relationship between variables but also to investigate and explore in greater detail the current IT application developments and problems encountered by contractors in Taiwan in empirical cases. In this sense, the approach also justified the adoption of qualitative interviews to supplement the survey data obtained. Thus quantitative and qualitative data are both required in this study.

In order to fulfil these requirements, quantitative questionnaire survey by interview seems to be the preferred method of data collection rather than a merely postal questionnaire survey for this study as the interpretation of the data generated from the interviews can also demonstrate the linkage and mutual influence between the variables and the outcome of the IT project. Consequently, Van de Ven's organisational assessment approach was chosen since it provides a practical basis for data collection and analysis in this research. A five-point scale instrument based on Van de Ven's approach was also designed and used in the interviews. Interviews with the structured research instrument can offer participants the freedom to use their own words and imagery to communicate their experience, while the quantitative outputs can be tested using statistical methods. In addition, the use of the structured research instrument in the interviews enables the standardised collection of key items of data. In testing the associations between these variables and IT implementation performance, consistency in method between cases is required. The details of the research instrument are discussed in the next section.

8.3 Research Questions and Hypotheses

8.3.1 Main research questions and hypothesises

IT provides opportunities for organisational change. Managers in organisations are becoming more aware of IT potential and are keen to implement IT in their business.

Business process re-engineering (BPR), as discussed in Chapter 2, is a good example of creating major changes in an organisation through the implementation of IT.

However, not all of the results of IT innovations are satisfactory. Lyytinen and Hirschheim (1987) argue that there are examples of IT systems which clearly meet their design objectives, but could hardly be considered successful. These systems continued to remain in existence and operating, yet the organisations concerned are not convinced of their inherent value.

Strategic Information System Planning (SISP), as discussed in Chapter Two, is usually seen as a route to gaining competitive business advantages through IT implementation. However, SISP techniques mostly focus on the linkage between IT and organisational context factors such as business strategies or core business goals. Other organisational factors which can influence IT innovation outcome are seldom discussed in SISP. Thus, the mere use of SISP is no guarantee that organisations will achieve successful IT innovation.

Much research has been undertaken to develop a better understanding of IT diffusion and implementation, such as Kwon and Zmud (1987) and Cooper and Zmud (1990). However, no research has been undertaken to investigate the relationship between organisational characteristics and IT implementation outcome in the construction sector. Consequently, this research aims to identify if the outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics, as well as to determine what factor(s) can influence the outcome of IT implementation in construction organisations. The research questions in this study are as follows:

Main research questions:

(1) Are the outcomes of IT implementation performance in construction organisations influenced by their different organisational characteristics?

(2) If the outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics, does any alignment exist between these organisational characteristics and IT performance in business success?

(3) Is there any organisational factor that can critically influence the outcome of IT implementation in construction organisations? What are they?

This research also aims to investigate the current use of IT in Taiwan's construction industry, as well as any IT implementation problems and barriers they encountered. Thus, the minor research questions are:

(4) What is the current use of IT applications in Taiwan's contractors? And;

(5) Is there any IT implementation barriers and problems encountered by Taiwan's contractors? What are they?

After the identification of the research questions, the next step is to build research hypothesises to solve these questions. From the literature reviews discussed in previous sections, it seems that organisational change concepts can help to answer the main research questions. Consequently, the main hypothesises in this research are:

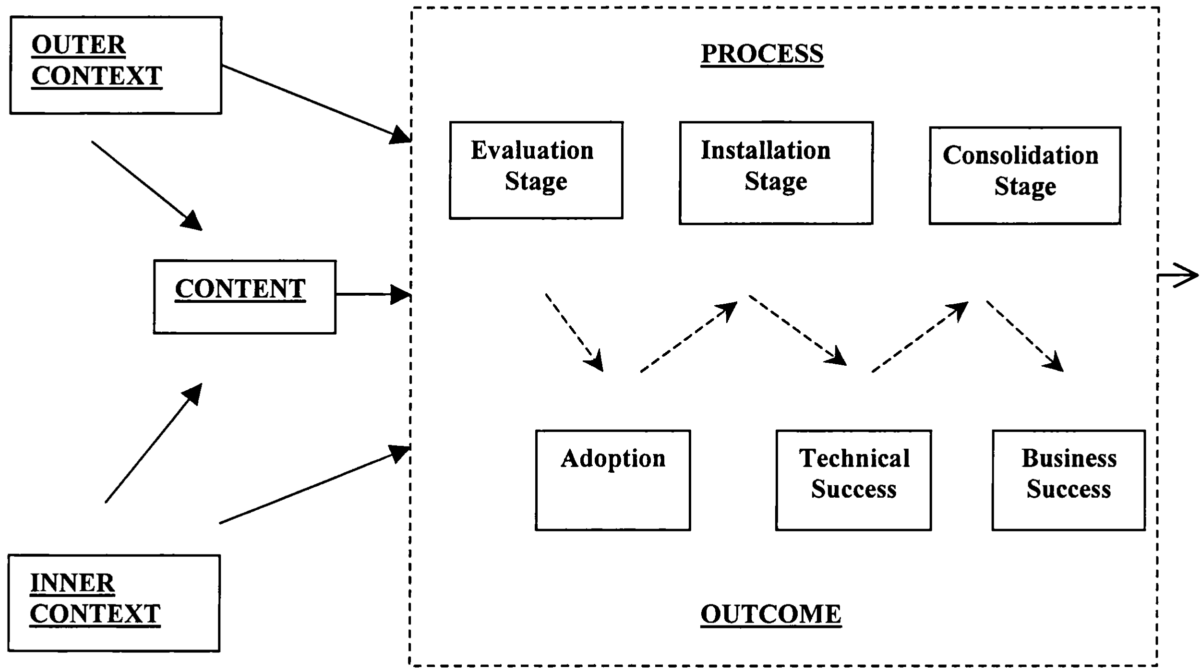
- The successful outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics.
- There is an alignment between these organisational characteristics themselves and the outcomes of IT implementation performance in construction organisations. The alignment can help to lead to better IT implementation performance in organisations.
- There are certain organisational factors which have significant impacts on the outcomes of IT implementation performance for business success in construction organisations.

In order to test these hypothesises, an analytical research framework was proposed. This analytical framework may be used to explain that why some contractors can achieve better IT performance than others, as well as to facilitate the identification of potential variables in organisational characteristics for better IT performance.

The analytical research framework (as shown in Figure 8.2) was mainly developed from Pettigrew's organisational change conception and the innovation implementation model developed by Winch (refer to Chapter 6). As discussed in Chapter Three, Pettigrew and his colleagues (1985, 1990, 1991, 1992) conclude that research on organisational change should involve the interplay between the context, content, and process of change. This theoretical conception rightly provides a sound and practical basis for developing the analytical framework.

As discussed previously, the "inner context" refers to the characteristics of the organisation itself including strategy, culture, management, human resource and

Figure 8.2 The Analytical Framework



policy. The "outer context" refers to the industry, economy, politics, markets, and competitive environment in which the organisation operates. The "content" element refers to the particular features of change under examination (in this case, the particular choice of IT system). The "process" element refers to the implementation of the change and the reaction from the participants involved in the change. The development of this framework is based on the premise that variables inherent within the organisation's outer context and inner context may affect the content of change and the process of change. The interplay between these variables can influence the performance of the IT implementation project. The evaluation stage, installation stage and consolidation stage are the three stages of the implementation process. The successful outcomes of these three stages are adoption, technical success and business success separately.

This analytical framework was used to identify potential organisational variables which may influence the outcomes of IT performance in construction organisations, as well as to test the alignment between these variables and IT performance in construction organisations. A total of 27 variables were proposed for test in this research. The following section will discuss the details of these variables.

8.3.2 Variables in the IT innovation of construction organisations

From the previous review of IT management, innovation theory and organisational change theory literature, some potential variables within the elements of the analystical framework were proposed. They are discussed below:

(1) Variables within the outer context of change

The "outer context" refers to the industry, economy, politics, markets, and competitive environment in which the organisation operates. Aouad and Price (1994) have argued that the construction industry is slow to accept and implement change. Some construction firms may doubt the functions and benefits of new IT systems and adopt a "wait and see" attitude.

However, pressures from the project environment may force construction organisations to adopt new IT systems. Following Winch's (1998) model for construction innovation processes, these pressures can come from top-down adoption/implementation dynamics and bottom-up problem solving/learning dynamics (refer to Chapter 4). Top-down adoption/implementation dynamics may be the outcome of formal R&D processes, copied from leading innovators in the sector, or the perception of a performance gap in relation to competitors; whatever the source, it is external to the innovating firm. Bottom-up problem solving dynamics may come from the result of solving a particular problem identified on the construction site or meeting the client's specific needs.

Consequently, these environmental pressures can come from:

(a) Top-down adoption/implementation dynamics

- **Government influences (GI)**: the government may initiate an IT promotion programme and offer rewards or subsidies to encourage construction organisations to adopt new technology. On the other hand, construction organisations may be forced to install new technology to satisfy new government regulations.
- **Competitors' IT advantages (CIA)**: Construction organisations may consider IT innovation if they recognise the performance gap in relation to competitors due to their IT advantages in the industry.

(b) Bottom-up problem solving/learning dynamics

- **Project coalition's use of IT (CU)**: On each construction project, a number of specialists from different corporate entities co-operate at different stages of the project. Construction organisations may consider initiating new IT projects by copying a project coalition's advanced IT systems.

- **Project client's requirements (CR)**: Project clients may request construction organisations to install new IT systems. In such cases, construction organisations need to fulfil the requests or they may lose contracts.
- **Project challenges (PC)**: Construction organisations may be forced to install new IT systems in order to solve complex problems in specific construction projects.

The above five dynamics are measured separately. The average value of these five dynamics is assigned as "Environmental Force" and calculated below. Construction organisations facing higher degree of impact of Environmental Force may be more likely to adopt IT innovation.

Environmental Force = Average (GI+CIA+CU+CR+PC) (Var. o1)

(2) Variables within the inner context of change

Variables in organisational characteristics have probably received the most attention in organisational innovation literature. Organisational innovation researchers such as Zaltman et al (1973) and Rogers (1985) all emphasise the importance of organisational characteristics in the diffusion and implementation of the innovation process. There are four organisational variables proposed in this research: (a) organisational structure; (b) business strategy; (c) IT policy; and (d) top management's mindset.

(a) Organisational structure

Table 8.4 Organisational Types (Lansley et al 1974, 1982)

Organisational Types	Degree of control	Degree of integration
Bureaucratic	High	High
Mechanistic	High	Low
Organic	Low	High
Anarchic	Low	Low

The methodology developed by Lansley et al (1974, 1982) is followed in this research to determine the structure variables of the construction organisations (refer to Chapter Four). Two dimensions of variable are used in the investigation, they are: Degree of Integration and Degree of Control.

These two variables can also be used to determine the organisational type of a construction firm, as shown in Table 8.4.

The indicators developed by Lansley and Quince (1982) are also applied in this research, as shown in Table 8.5. The measurement results of these indicators constitute the two variables: degree of Control and degree of Integration within each construction organisation. The calculations are shown below:

Degree of Integration =Average (GS+C+JI) (Var. i1)

Degree of Control = Average (S+RR+USP+PS) (Var. i2)

Table 8.5 Indicators of Organisation Structure (adapted from Lansley and Quince 1982)

Variable	Indicator	High Value	Low Value
Integration	Grouping of staff (GS)	Team structures based on task	Vertical structures based on function
	Communication (C)	External reliance on formal methods of communications, e.g. meeting, circulars, etc.	External reliance on informal channel
	Job information (JI)	Reliable, rarely conflicting	Unreliable, often conflicting
Control	Specification (S)	High degree of differentiation between functional tasks;	Low degree of differentiation between functional tasks;
	Reporting Relationships (RR)	Narrow chain of command	Broad chain of command
	Use of system and procedures (USP)	Extensive and obligatory use of well defined financial and non-financial systems	Informal and *ad hoc* systems
	Performance Standard (PS)	Strict and well defined short term performance objectives set at department and project level	No clear performance objectives below operating unit level

(b) Business strategy

According to Ramsay (1989), there are two effective business strategies for competitiveness in the construction industry: one is cost leadership and the other is differentiation. The decision as to which of the two basic strategies to follow is important since organisations who try to do both can often end up with neither a cost advantage nor any distinct values. Hillebrandt and Cannon (1990) have explained that the competitive advantage of construction firms cannot be linked to a standard product as in the manufacturing industry since there is no standard construction product.

Construction organisations with different major business strategies may have different perceptions of IT innovation. For example, organisations based on cost leadership may pursue cost reduction by exercising tight overhead control and minimising 'unnecessary' costs such as R & D or strategic IT innovation. Consequently, business strategy may influence the adoption of IT innovations in construction organisations. The variable proposed at this category is:

Type of Business Strategy for Competitiveness (Var. i3)

(c) IT policy

Six variables are proposed for this category. They are:

Previous IT experience (Var. i4)

IT justification method (Var. i5)

IT risk assessment (Var. i6)

IT sourcing tendency (Var. i7)

IT development and control policy (Var. i8)

IT technology preference (Var. i9)

- Influence from previous IT experience

The degree of influence of previous IT experience on an organisation's future IT investments and developments is proposed as a variable in this category. This variable was highlighted since it was found that an organisation's previous IT experiences could, in some cases, influence the outcome of their IT investments (Willcocks and Margetts 1994). Such an influence, according to Willcocks and Margetts, can be positive or negative to the IT implementation outcome.

- IT justification methods

The previous literature review section (Chapter Seven) has introduced a number of assessment techniques for IT investment. Some of these techniques are traditional quantitative calculations in the financial sphere, while others are based on more qualitative ways for assessing intangible benefits. This variable is proposed since different IT justification methods applied by construction organisations may result in different outcomes of IT implementation.

- Risk assessment

Risk assessment concerns construction organisations' attitudes toward risk taking in IT innovation. Different risk taking policies in construction organisations may result in different IT implementation performance. For example, organisations conducting comprehensive risk assessments for their IT innovations may have a higher chance of success than those which do not conduct any risk assessment.

- Sourcing method

Sourcing method concerns how construction organisations acquire their IT systems: whether they are developed in-house, purchased as a package from software retailers or outsourced to external IT suppliers. As discussed in Chapter Two, there are both advantages and disadvantages in outsourcing and in-house IT project development, which may influence the outcome of the IT project.

- IT development and control policy

As discussed in Section 5.2, a centralised IT management style is good for management culture, business vision and decision making, while the decentralised approach is good for departmental and user support. In this sense, the choice of centralised or decentralised IT management styles in organisations may influence the performance of IT systems.

- Technology preference

When considering IT investments, some organisations may focus on state-of-the-art technology for their IT systems, while others may insist on using simple and matured systems. The selection of the technical standard for IT systems may influence their performance. For example, IT systems with new high-end technology may provide more comprehensive functions. However, they may not be as stable as those developed with mature technology. Also, the problem of system incompatibility may occur when using new technology.

(d) Organisational culture and climate about the use of IT

As discussed in the previous literature review chapters, organisational culture and climate are antecedents of successful innovation and organisational change. Consequently, a supportive environment is vital to the effective implementation of IT innovation in organisations. The creation of such an environment should begin with top management. However, support from other members of the organisations is also required since users' resistance to change is regarded as one of the common IT innovation barriers in organisations (refer to Chapter Two). As a result, two variables are proposed in this category, they are:

Top management's support for IT innovation (Var. i10)

IT users' attitude toward the use of IT (Var. i11)

The degree of support from both the top management and the IT users may influence the implementation performance of the IT.

(3) Variables within the content of change

Content refers to the particular features of change under examination (in this case, the particular choice of IT system). Consequently, the type of IT project itself is the main metric for measurement. Ward's (1994) application portfolio approach (refer to Chapter Five) is used in this research to classify IT projects. This classification is based on a manager's judgement of the "value" of the project in order to determine the criticality of the relationship between the IT project and business needs. The judgement of the "value" of the IT project may vary in different organisations due to disparities in the organisation contexts described previously. Also, the perceived "value" of the IT project by management may influence the decisions on how the IT project should be managed or how the investment should be evaluated. These determinations may have a significant influence on the outcome of the IT implementation.

Two variables are used to identify the values of the IT systems used by the construction organisations, they are: the degree of **business strategic importance** and the degree of **business operation importance**. A list of twenty-six types of common IT applications identified from the literature review (Chapter 6) was initially developed to help measure these two variables. The pilot tests of the instrument with two construction professionals and one senior member of academic staff at The Bartlett, University College London also help to refine this list. The twenty-six common IT systems are shown in Table 8.6. Organisations are asked to rate all their existing IT systems in terms of strategic importance and operational importance for their organisations separately. The overall scores of these two variables in each organisation can then be calculated below:

Overall **Business strategic importance** = $\Sigma\,(Si/N)$, $_{i=1 \text{ to } N}$ (Var. c1)

Overall **Business operational importance** = $\Sigma\,(Oi/N)$, $_{i=1 \text{ to } N}$ (Var. C2)

Where: N= total number of IT systems used in the organisation

Si= the perceived business strategic importance of the IT system (i)

Oi= the perceived business Operational importance of the IT system (i)

Table 8.6 A list of Common IT Applications in Construction Organisations

Application types
(a). Word processing
(b). Desktop publishing
(c). Spreadsheets
(d). Image processing
(e). Construction equipment management
(f). Video Conferencing
(g). Management information system
(h). Decision support system
(i). Accounting system
(j). Human resource management system
(k). Material Procurement system
(l). Contract management system
(m). Estimating / Valuation system
(n). CPM schedule control
(o). Geographical information system
(p). Structure analysis system
(q). Fluid/Geological analysis system
(r). Electric data interchange
(s). Networking
(t). 2D CAD
(u). 3D CAD
(v). Virtual Reality (VR)
(w). Multimedia briefing
(x). WWW site homepage
(y). Construction law and regulations reference
(z). Property management system

The IT investment "tendency" in each construction organisation can then be identified from the measurement. For example, some organisations may generally adopt the IT applications which are perceived as of high strategic importance, while others may prefer those which are critical to their business operations. Moreover, Ward's application portfolio matrix can also be applied to identify the types of IT systems in the organisation. They are:

- Strategic- IT systems with high degree of business strategic importance and high degree of business operation importance,
- High Potential- IT systems with high degree of business strategic importance and low degree of business operation importance,
- Key operational- IT systems with low degree of business strategic importance and high degree of business operation importance,
- Support –IT systems with low degree of business strategic importance and low degree of business operation importance.

(4) Variables within the process of change

Process refers to the implementation of IT change and the reaction from the participants involved in the change. Eight variables are proposed in this category. They are categorised into the three stages of IT implementation: evaluation, installation and consolidation (refer to Figure 8.2).

(a) Variables at evaluation stage

The variables proposed for this stage are:

The degree of IT user involvement in evaluation (Var. p1)

The degree of Top management's IT knowledge and competence (Var. p2)

First, IT users are the ones who operate the IT systems, thus their involvement in the development of new IT systems may help the organisations to achieve the expected outcome. Second, the degree of top management's IT knowledge and competence can influence the decision on how IT should be evaluated and developed, which can also effect the adoption and implementation results of the IT.

(b) Variables at installation stage

Four variables are proposed for the IT installation stage, they are:

Use of IT project champions/directors (Var. p3)

Use of external IT expert (Var. p4)

Change of organisational structure for IT (Var. p5)

Change of working process for IT (Var. p6)

- Use of IT project champions/directors

A lot of innovation literature emphasises the importance of the project champions and directors in the innovation process (e.g. Farbey, Targett and Land 1995, Nam and Tatùm 1997). Consequently, the use of a project director or champion in the development of IT system can be critical for better IT innovation results.

- Use of external IT expert

This variable is proposed because the use of external IT experts in the IT development and installation stage can help the organisations, for example, to solve any problem encountered during system installation. Thus, organisations that frequently hire external IT experts for IT developments may be able to obtain better IT implementation performance.

- Organisational structure and working process change for new IT

The last two variables in this section relate to whether the contractors will change their organisational structure or working processes in order to optimise their new IT systems. These two variables are proposed because much of the literature shows that Business Process Re-engineering with IT is a proven method for organisations to improve their business performance. In order to get an effective IT implementation performance, organisations may need to consider changing their organisational structure or working process. However, a change in organisational structure may have a great effect on business operations in the whole organisation. Thus, some organisations may only be willing to accept changes to certain working processes as this has less pervasive effects on the organisation as a whole.

(c) Variables at consolidation stage

Two variables are proposed at this stage:

Focus of IT implementation performance measurement (Var. p7)

Identification of unforeseen IT benefits (Var. p8)

These two variables are proposed since they may affect the organisations' perceptions about the value of their IT systems.

(5) IT implementation performance

The measurement of IT implementation performance involves two criteria: technical success and business success. As defined by Winch (1994), technical success assesses whether the expected functions of the IT project have been successfully achieved, while business success assesses whether the business performance of the organisation has been improved by the IT innovation. Technical success is usually measured at system installation stage, while business success is measured at system consolidation stage. The indicators used in this research to measure technical success and business success are described as follows:

(a) Technical success

Two variables were proposed to measure Technical success in implementation process:

Degree of user satisfaction (Var. s1)

Degree of expected function achievement (Var. s2)

According to Winch (1994), user satisfaction is concerned with whether the IT users are satisfied with the new IT system (e.g. easy to operate, user friendly interface or system stability), while function achievement is about whether the expected functions of the new system are achieved after installation.

(b) Business success

Business success is measured by three variables:

Degree of improvement in **business efficiency**	(Var. s3)
Degree of improvement in **business effectiveness**	(Var. s4)
Degree of achievement in **competitive advantage**	(Var. s5)

These three business success variables were chosen since they were approved and used by Construct IT's (1998) to evaluate IT benefits in the construction industry.

The five success variables described above are measured separately by using the twenty-four types of common construction IT applications list (as shown in Table 8.5). The overall score of each success variable can then be calculated as shown below:

$$\text{Overall perceived IT implementation performance} = \Sigma\,(Pi/N),\ _{i=1 \text{ to } N}$$

Where: N= total number of IT systems used in the organisation
Pi= the perceived performance of the IT system (i)

After the identification of research questions and hypothesises, the next section will discuss about the data collection method used in this research.

8.3.3 The instrument

As discussed previously, a structured research instrument consisting of a five-point scale measurement approach was designed and applied in the interviews, following the organisational assessment approach developed by Van de Ven and Ferry (1980). The instrument was first developed in the English language and then translated into Chinese mandarin by the author. A pilot test of the structured research instrument was conducted in the UK with one construction professional and one senior member of academic staff at the Bartlett School. A second pilot test was conducted in Taiwan with one local contractor after the instrument had been translated into Chinese. Both the English and Chinese version instruments are attached as Appendix A and B respectively. The main purpose of these pilot tests was not only to solicit their options regarding the potential organisational variables proposed in this research but also to test the viability and clarity of the questions in the instrument. For example, some IT applications in construction were suggested and added to the instrument (as Table 8.6) after the pilot tests. Table 8.7 summaries the variables discussed at previous section and their related questions for measurement in the research instrument.

The instrument consists of eight main sections. They are:

(a) Company Demographics

(b) IT Infrastructure

(c) Organisational Characteristics and Management Style

(d) Project Environment and IT

(e) IT strategy

Table 8.7 The Variables and Their Related Questions in the Instrument

Variables				Question No.
Outer Context	Var. o1	Degree of project environmental forces	GI*	D1
			CIA	D2
			CU	D3
			CR	D4
			PC	D5
Inner Context	Var. i1	Degree of organisational integration	GS**	C1
			C	
			JI	
	Var. i2	Degree of organisational control	S**	C1
			RR	
			USP	
			PS	
	Var. i3	Business strategy for competitiveness		C2
	Var. i4	Previous IT experience		E1
	Var. i5	IT development and control policy		C3
	Var. i6	IT sourcing method		E2
	Var. i7	T technology preference		E6
	Var. i8	IT justification method		E4
	Var. i9	IT risks assessment		E5
	Var. i10	Top management's support for IT innovation		F2
	Var. i11	IT users' attitude toward the use of IT		F4
Content	Var. c1	Strategic importance of the IT systems in the organisation		F5 (a)
	Var. c2	Operational importance of the IT systems in the organisation		F5 (b)
Process	Var. p1	IT users involvement		F3
	Var. p2	Top management's IT competence and knowledge		F1
	Var. p3	Use of IT project directors/champions		G1
	Var. p4	Use of external IT expert		G2
	Var. p5	Change of organisational structure for IT		G3
	Var. p6	Change of working process for IT		G4
	Var. p7	Focus of IT implementation performance measurement		G5

	Var. p8	Identification of unforeseen IT benefits	G7
Technical Success	Var. s1	Degree of user-satisfaction on IT	G8
	Var. s2	Degree of expected function achievement on IT	G9
Business Success	Var. s3	Efficiency improvement	G10
	Var. s4	Effectiveness improvement	G11
	Var. s5	Business competitiveness advantage	G12

Note:

* Innovation process dynamics (refer to Section 8.3.2)

** Indicators of organisational structure (refer to Section 8.3.2)

(f) IT Development and Profile

(g) IT Implementation and Performance

(h) Further information (Open questions)

The first seven sections include questions relating to company demographics and the proposed variables discussed previously. The quantitative scale approaches (e.g. five-point Likert scale and differential scale) were mainly applied to measure the required data. IT Managers were interviewed and asked to elaborate on their answers to clarify their choice of answers. Questions in the last section were mainly open ended ones. This is to encourage managers to talk freely about their IT systems, IT implementation processes and problems encountered in their IT cases. The contents of the instrument are discussed below:

Section (a) Company Demographics

Four questions are asked in this section. They are:

(1) business/working type (e.g. building engineering, civil engineering, engineering consultant or architecture design);
(2) distributions of project turnover and their percentages;
(3) number of full time employees, and;
(4) annual turnover.

These questions are designed to help the researcher understand the background of the construction organisations interviewed, which is essential for data classification and the subsequent data analysis.

Section (b) IT infrastructure

This section examines the IT infrastructure of the organisations interviewed in four respects:

(1) the amount spent on IT in the organisation;
(2) the number of full time staff devoted to IT in the organisation;
(3) the number of computers used in the organisation, including mainframes, minicomputers and portable computers, and;
(4) the type(s) of network installed in the organisation.

These questions are designed to investigate the current usage of IT systems in the construction organisations in Taiwan. Additional information such as IT expenditure as a percentage of turnover of the selected Taiwanese construction organisations can also be derived from these questions.

Section (c) Organisational characteristics and management style

This section aims to identify the organisational structure and management styles of the Taiwanese contractors. As discussed in Section 8.3.1, variables within the inner context of change may influence the outcome of the change. Three questions are asked in this section. They are related to:

(1) Type of organisational structure,

(2) Business strategy for competitiveness; and,

(3) IT management style.

Section (d) Project environment and IT

Questions in this section primarily investigate the outer context variable "**Environmental Force** (EF)" of the contractors in Taiwan. As discussed in Section 8.3.2, pressures from project environments may force the construction organisations to adopt new IT systems. Following the model developed by Winch (1998), five sources of influence are investigated using the five-point Likert scale. They are government regulation or promotion programmes, competitor's IT advantage, project coalition's IT advantage, project client's request, and construction project challenges. The overall degree of influence (assigned as EF) from these five sources for IT innovation in each organisation was calculated with Formula F1 (refer to Section 8.3.2).

Section (e) IT strategy

This section is designed to investigate the IT strategies applied by the contractors in Taiwan. Five different variables related to organisational IT strategy were measured in this section. They are: **The influence of previous IT experience, IT sourcing method, IT technology preference, IT justification method and IT risk assessment**. Five-point scale approach was applied in the measurement. The results can be analysed with other variables to identify if they have any influence on the organisation's IT implementation performance.

This section also investigated the criteria applied by the contractors to select their external IT suppliers for further reference. The contractors were asked to indicate the levels of importance of seven different variables when selecting their IT outsourcing suppliers. These seven criteria are:

1). Cost;

2). Quality;

3). Supplier's reputation;

4). Speciality;

5). Lead time;

6). Service, and;

7). Maintenance.

Section (f) IT development profile

The main objective in this section is to investigate the contractors' IT development profiles. Five variables were measured by five-point scale at this section. They are **Top management's IT competence and knowledge, Top management's support**

for IT innovation, IT user's involvement", IT users attitudes toward the use of new IT systems and The perceived value of IT systems in the organisations.

The perceived value of IT systems in the organisations were measure by two factors. They are the degrees of the "**business strategic importance**" and "**business operational importance**". These two factors were measured using the twenty-six IT systems list (as shown in Table 8.6). The five-point Likert scale was applied in the measurement and the overall scores of these two variables were calculated (refer to Section 8.3.2).

Section (g) IT implementation and performance

This section investigates the IT implementation process and performance outcome of the contractors interviewed in Taiwan. Twelve questions are deployed in this section to measure eleven proposed variables.

These variables are **IT project directors/champions, Use of external IT expert, Change of organisational structure for IT, Change of working process for IT, Focus of IT implementation performance measurement, Identification of the unforeseen IT benefits, Degrees of user-satisfaction, The achievements of expected functions of the IT applications,** and the three business success variables: **efficiency, effectiveness and competitive advantage improvement.** The five point Likert scale and differential scale were used in the measurements.

This section also identified IT benefits in the contractors in nine different business-process areas. These nine business-process areas are developed by Construct IT of

Excellence (1999) for the benchmark of IT benefits in the construction industry. They are:

1) Marketing;
2) Information Management;
3) Procurement;
4) Finance
5) Client Management;
6) Design;
7) Construction;
8) Operation and Maintenance, and;
9) Human Resources.

The five-point Likert scale was applied to indicate the degree of significance of the IT benefits realised by the contractors. The answers for this question can provide further information regarding the business process areas which benefit more through implementing IT in Taiwanese contractors.

The last question is an open one. The interviewees were requested to provide further information regarding their current IT applications, implementation process, and any problem encountered in IT cases.

The five-point ranked data collected from the instrument was statically analysed by multivariate techniques. Multiple correlation and regression tests were selected and conducted by the computer software: SPSS for Windows. The statistical tests will be discussed in greater detail in chapter 10.

8.4 Discussion and Conclusion

This chapter described the research methodology of the study. The main research questions were identified. An analytical framework was also developed to help answer the research questions. From the framework, 22 variables associated with organisational characteristics and 5 variables associated with IT implementation performance were identified and proposed.

The main data collection method for this study is by interview. A quantitative research instrument has been developed to help collect the required data. The five-point Likert and differential scales are applied in the instrument so that the data can be analysed using statistical methods. The full details of the interviews in Taiwan will be discussed in the next chapter.

Chapter 9: The Interviews

9.1 Introduction

This chapter reports the results of interview sessions conducted in Taiwan in the summer of 1999. The principal objectives of the interviews were to: (1) identify the relationship between contractors' organisational characteristics and their IT performance; (2) investigate the current use of IT in Taiwan's construction industry; and (3) identify the common IT problems encountered by the contractors.

The first part of this chapter describes the results of the interviews conducted in Taiwan. A descriptive statistical analysis of the data provided by the selected contractors is also conducted. The second part of this chapter provides further information regarding the current use of IT by Taiwanese contractors. Some common IT implementation problems encountered by the contractors are also discussed in this chapter. The identification of these common IT problems provides further information for understanding the implementation of IT innovation in construction organisations in Taiwan.

9.2 The interviews in Taiwan

9.2.1 The selection of contractors

The interviews were conducted during the period of May 1999 to January 2000. A list of the top Taiwanese construction organisations (A-class contractors) provided by the Taiwan Contractors' Union in Taipei was used as the basis for selecting contractors for interview. The selections were based on the ranking of their turnover in 1998 since large contractors may be more likely to adopt IT for business improvement. The potential contractors on the list were contacted by telephone first to ascertain their willingness to participate and then appointments were made. A total of 50 contractors were interviewed during the period in Taiwan due to a trade-off between limited time and enough samples for statistical analysis.

The interviewees were mainly IT managers in the organisations. However in some cases, the IT managers were not able to answer certain questions relating to general management such as business strategies, etc. Thus, the general manager or management director in the organisations was also interviewed. Therefore, a total of 67 people were involved in the interviews and the average time taken for each interview was one hour and forty minutes.

In the interviews, the research instruments (questionnaire) designed to collect required data were completed together by the author and the interviewees so that any misunderstanding and bias within the survey process can be eliminated. The author could also request any further information regarding their answers for data verification. Moreover, completing the questionnaires by both the author and interviewees can avoid the occurrence of any missing data that is often happen in the postal questionnaire survey. The data derived from the research instrument applied in the interviews were categorised and input to the statistics software SPSS V.10 for Windows.

9.2.2 The descriptive statistics results

The descriptive statistics results of the data collected from these interviews are discussed below:

(1) Company Demographics

Of the fifty contractors sampled in Taiwan, 32 organisations are primarily building engineering contractors, 4 organisations are mainly civil engineering and the other 14 organisations are involved in both building and civil engineering works. 5 contractors have an engineering consultancy section and 8 contractors have an architectural design section within their business. In terms of geographical distribution of projects, 3 contractors have international projects, 37 organisations have projects all over Taiwan and the other 10 organisations are mainly local contractors.

The average number of full-time employees in the organisations interviewed is between 50 to 200 staff. However, four organisations have more than 1200 full-time employees and most of them are site operatives imported from the Philippines, Indonesia or Thailand in order to save labour costs. The average annual turnover (in 1998) of the organisations interviewed was between 500M to 1500M New Taiwan Dollars (the exchange rate of NT$ to £ is about 46:1). The demographic details of the organisations interviewed are shown in Table 9.1.

(2) IT Infrastructure

Although the results of the interviews show that the average amount spent on IT in the organisations per year was between $NT 0.5M to 1M (17 organisations), there were 14 organisations who spent between NT$ 1M to 5M on their IT system

Table 9.1 Details of Number of Full-time Employees and Turnover in 1998 in the Organisations Interviewed.

Company Demographics		Amount (N=50)
Full time employees (person)	Under 50	8
	50 to 200	28
	200 to 700	10
	700 to 1200	0
	Over 1200	4
Turnover 1998 (NT$)*	Under 500M	8
	500M to 1500M	17
	1500M to 3500M	9
	3500M to 6000M	7
	Over 6000M	9

*(the exchange rate of NT$ to £ is about 46:1)

annually. However, IT expenditure for the year of 1999 was expected to increase tremendously due to the requirements of solving Y2K problems.

The average number of full-time staff devoted to IT functions in the organisations is under five people. This figure is lower than expected. A possible explanation for this, as provided by many IT managers in the interview is the difficulty of recruiting IT professionals to work in the construction industry. According to the managers, IT professionals prefer to work for the highly paid electronic or computer sectors in Taiwan. Consequently, some companies choose to buy off-the-shelf packages and recruit one or two IT professionals for hardware and software maintenance in-house. Others have signed contracts with local computer experts for assistance on IT issues. This problem will be discussed in further detail in the next section of this Chapter.

The average number of computers (including mainframes, minicomputers and portable computers) used in the construction organisations interviewed ranged between 30 to 70. As for networking connection, all of the organisations interviewed have installed LAN (local area networks) for internal data transferrals. Of these, 18 contractors (36%) have installed WAN (wide area networks) to transfer data between headquarters, branch offices and project sites and 44 contractors (88%) have Internet connections and email. Table 9.2 shows a summary of the IT infrastructure of the contractors.

(3) Variables within the outer context of change

- Project Environment and IT

The average score for the influence of "governmental regulation or promotion programmes" is 2.18; only 34% of the organisations selected "3" points or above. Most of the organisations in the interviews indicated that the Taiwanese government did not do much to encourage IT innovation in Taiwan's construction industry, and the only government influence related to IT systems was the Y2K crisis inspections.

The average score for the influence from "competitor's IT advantages" is 2.78. Up to 28 contactors (56%) selected "3" points or above on the five-point scale. Some of the contractors who selected low scores indicated that "competitors' IT advantage" did

Table 9.2 Summary of IT Infrastructure of the Contractors Interviewed

IT infrastructure		Amount (N=50)
Average IT budget per year	Less than NT$ 0.5M	9
	0.5M – 1M	17
	1M – 5M	14
	5M – 10M	4
	More than 10M	6
Full-time staff devoted to IT	Under 5	35
	5 – 7	7
	7 – 10	4
	10 – 15	2
	Over 15	2
Computers used in the organisations	Under 30	14
	30 –70	20
	70 – 120	5
	120 – 150	3
	Over 150	8
Networks installed	LAN only	5
	LAN + WAN	1
	LAN + Internet	27
	LAN + WAN + Internet	17

make them think of using IT for business improvement, but it was not the main reason for them to decide to adopt IT.

The influence of "other companies' use of IT in the project" is also low. The average score for this question is only 2.1. Only twelve contractors (24%) selected "3" points or above on the five-point scale. The average score of the "influence from project client for IT innovation" is only 2.36 and only twenty contractors (40%) selected more than "3" points for this influence.

However, the results show that the influence of "project challenges" is relatively high. The average score for this influence is 4.0. More than forty-five contractors (90%) selected "3" points or above. A summary of these results is shown in Figure 9.1.

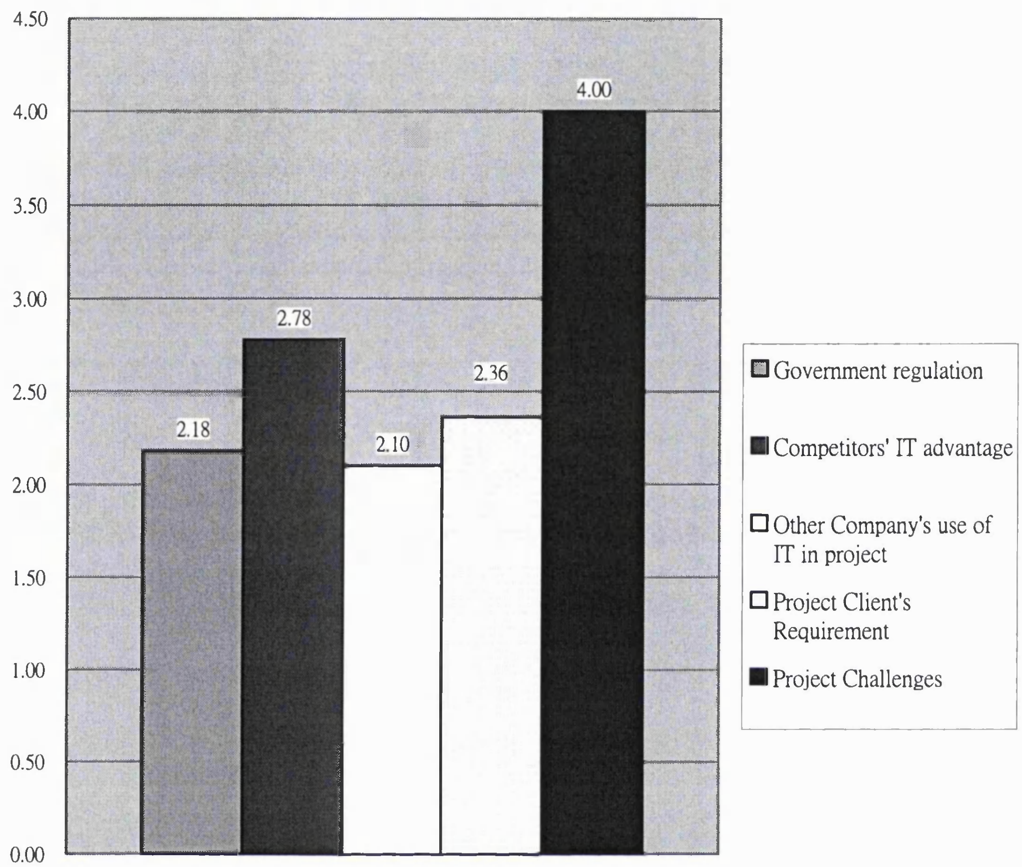
These results suggest that most of the construction organisations in Taiwan tend to adopt a reactive approach to IT innovation. They usually only decide to invest in IT if it is really needed (such as solving project problems). According to the managers in the interviews, the building construction market in Taiwan has been in recession for more than 6 years. Consequently, construction organisations are more conservative in their investments.

(4) Variables within the inner context of change

(a) Organisational structures and management style

The approach developed by Lansley et al (1974, 1982) was applied to identify the contractors' organisational structures. The result shows that forty-three organisations (86%) have "high control" characteristics and thirty-one contractors (62%) have "high integration" characteristics. Furthermore, the organisational structure types of these contractors can be categorised using Lansley's methodology (refer to Fig. 4.3). They are:

Figure 9.1 A summary of the Mean Average of the Degree of Influences from Different External Sources on the Contractors' IT Investment Decisions



*Five-point ascending scale from "1:not at all" to "5: very strong"

- 27 Bureaucratic organisations (high control and high integration);
- 16 Mechanistic organisations (high control and low integration);
- 4 Organic organisations (low control and high integration);
- 3 Anarchic organisations (low control and low integration).

This result indicates that most of the contractors in Taiwan have a traditional bureaucratic structure. Authority and power are still based on seniority in the organisational hierarchy. Systems and procedures in the organisations are well organised and applied. However, many organisations were found to adopt a team structure for grouping of staff rather than a traditional hierarchy. This can be explained by the fact that construction organisations sometimes require flexible staff grouping in order to cope with the complexity and uncertainty of some construction projects.

(b) Business strategy for competitiveness

Contractors were then asked to indicate their business strategy for competitiveness. Only eight contractors (16 %) claimed that their main business strategy is mainly focus on cost reduction (scored "1" or "2" points). Two contractors indicated that they apply both of these two business strategies frequently. The other forty organisations (80%) claimed that they achieved business competitiveness mainly by providing different services/products (scored "4" points or above). However, of these forty organisations, twenty-three contractors indicated that they sometimes still need to apply cost reduction in order to win certain governmental contracts (e.g. public housing projects). Table 9.3 shows the results of business strategies applied by these organisations.

When asked about their policy for IT development and management, up to forty organisations (80%) indicated that all or most of their IT systems were developed and managed centrally. Only six organisations (12%) managed and developed all or most of their IT systems in a decentralised way. The others developed and managed their IT systems partly in a centralised way and partly in a decentralised way.

Table 9.3. The Results of Business Strategies Applied in These Organisations

Business Strategy	Amount (N=50)
Score 1 (Focus entirely on cost reduction)	3
Score 2 (Focus on cost reduction mainly, providing different services/products occasionally)	5
Score 3 (Focus on both cost reduction and different services/products)	2
Score4 (Focus on providing different services/products mainly, cost reduction occasionally)	23
Score 5 (Focus entirely on different services/products)	17

(c) IT Strategy

The following section illustrates the contractors' IT strategies as revealed in the interviews:

(i) The influence of previous IT experience on future IT strategy and plan

The average score for this question from the contractors is 3.62. Up to forty contractors (80%) scored "3" points or above. This result suggests that previous happy or unhappy IT experiences are likely to have an influence on future IT strategies and plans of the contractors in Taiwan. However, some contractors in the interviews indicated that they have a clear and well-defined plan and documented policy for IT development strategy. One big contractor even developed a so-called "IT White Paper" to guide the company's strategy, policy and direction for future IT development. According to the interview data, the IT plans and proposals in these organisations seem to be less influenced by their previous IT development cases. As one IT manager explained "it's their documented IT policies and strategies providing a clear and systematic guideline to lead their future IT development, not their previous IT success and failure experiences."

(ii) IT sourcing

This question examines whether the IT procurement policies applied by the contractors are primarily in-house development/using software packages or outsourcing to external IT suppliers. The result shows that although up to 45 contractors (90 %) have outsourced their IT systems, with only 6 contractors (12%) outsourcing **all** of their IT systems to external IT suppliers. Two possible reasons were offered. First, most of the organisations indicated that the costs of outsourcing IT to external IT suppliers are too high. They can hardly afford to outsource all their IT to external IT suppliers. Second, they found from their experience that external IT suppliers usually do not really understand the construction industry and the business process in this sector. Thus when outsourcing IT, it may take more time than expected for the suppliers to design and modify the systems to suit the organisation's needs.

(iii) Criteria for IT supplier selection

The levels of importance of seven different criteria used to select the suppliers were also investigated in the interviews. "Service" was selected by most of the contractors as "very important" criterion. Whereas "supplier's reputation" and "cost" were the least important criteria selected by the contractors. The lack of importance given to "cost" may be due to the fact that price is usually negotiable (e.g. by Dutch Auction) in the high-competition IT market in Taiwan. The average score of each criterion used to select IT outsourcing suppliers is shown in Table 9.4.

(iv) IT justification and risk assessment

The results show that justifications for major IT investment proposals by these Taiwanese construction organisations tends to focus mainly on "long-term strategic opportunity assessment". Up to thirty-eight contractors (76%) selected "4" or "5" points for this question. It was surprising to find that only the traditional CBA approach was applied by few contractors (4 firms) to evaluate their major IT investments, other approaches reviewed in the literature (Chapter 7) were not found in the interviews. The contractors usually adopted *ad hoc* ways to evaluate new potential IT proposals. Some IT managers explained to the author that the decision to implement a proposal is taken by the chairman or president of the company, and they like to evaluate the IT investments by their own methods (as they feel that formal assessment approaches usually cannot fulfil their needs and do not consider the special characteristics of the construction industry, some approaches are also too complicated to understand and conduct).

Table 9.4 The Average Score of Each Criterion Used to Select IT Outsourcing Suppliers

Criteria used for selecting outsourcing IT suppliers	Average score (1 to 5, 1=not important; 5=very important)
Cost	3.49
Quality	4.58
Supplier's reputation	3.56
Speciality	4.56
Lead time	3.78
Service	4.62
Maintenance	4.33

Note: Five organisations did not answer this question since they never outsourced their IT

Furthermore, fourteen contractors (28%) admitted that they did not apply any risk assessment to their IT investment. The other contractors indicated that they applied some simple risk assessment. None of the fifty organisations conducted a formal risk assessment that considers financial, technology, business and strategic risks.

Two reasons were given by these contractors to explain why they do not apply formal IT risk assessment approaches: first, the amount of their IT investment was usually not very large (e.g. off-the-shelf packages). Thus, they did not think a formal assessment was necessary. Second, some IT systems were required to keep the business operating. Consequently, they felt that there was no need to carry out any risk assessment for those IT systems.

(v) Technology preference for IT

The IT managers were asked what kind of technology they prefer for their IT systems. The result shows that up to 41 contractors (82%) prefer highly mature systems with industry-standard technology. According to some of the IT managers interviewed, the use of highly mature and industry-standardised systems cannot only prevent incompatibility problems between systems but also help to reduce the risks of technical failure.

(d) Top management's IT competence and support

The IT managers were requested to identify their top management's IT competence and knowledge. The average score is 2.72 on a five-point ascending scale. A total number of forty IT managers (80%) selected "3" points or less. This indicates that the level of top management's IT competence and knowledge in these construction organisations is low.

However, the results show that IT innovations in the organisations are highly supported by the top management. The average score for the degree of support from top management for IT innovations is 3.94. This suggests that top management in Taiwan's construction organisations are quite aware of the potential of IT and are likely to support IT innovation although they do not have sufficient IT knowledge. In such circumstances, the IT managers in these organisations play very important roles in IT development and need to take all responsibility for the results of their IT innovations.

(5) Variables within the content of change

- Business strategic importance and business operational importance of IT

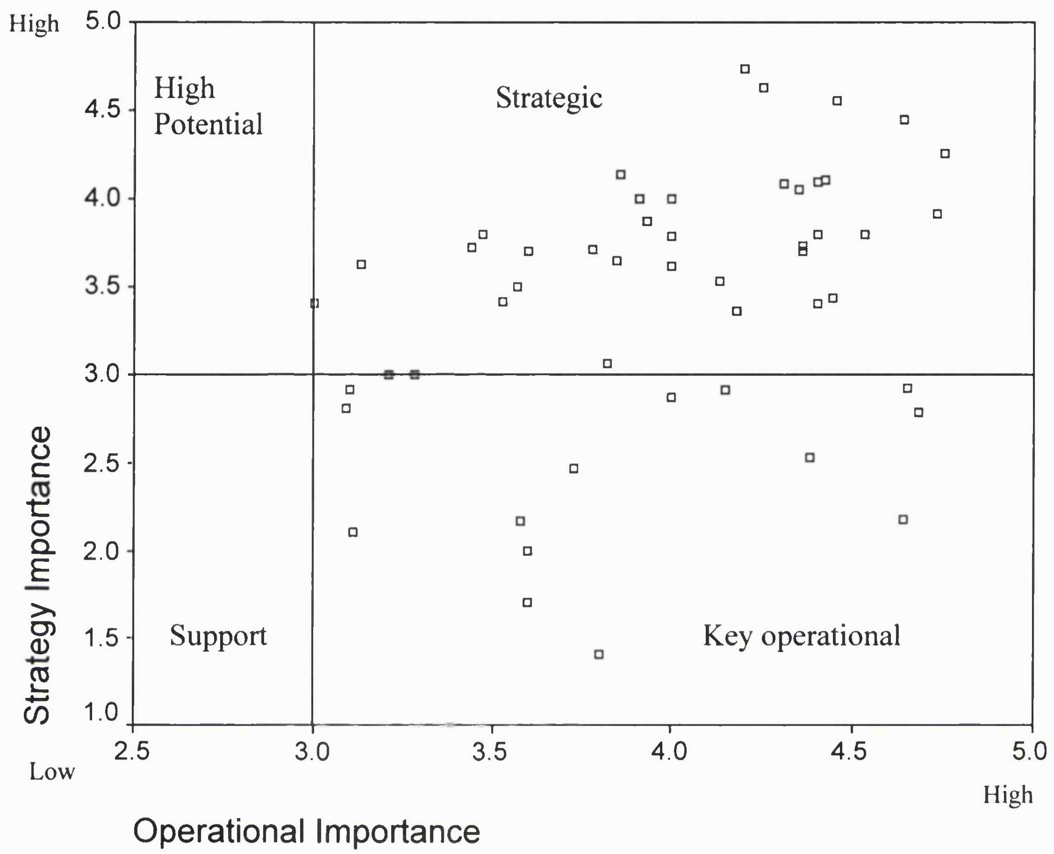
IT managers were asked to identify the systems they were currently using and grade their strategic importance and operational importance separately by using the list of construction IT applications illustrated in Table 8.4. The means of the scores of the IT systems were then calculated for each organisation.

Ward's (1994) application portfolio approach (refer to Chapter 8.4.3) was also applied to determine the managers' judgements on the "value" of their IT systems. The result shows that sixteen of the contractors (32%) regarded the average value of their IT investments as "key operational" (low degree of business strategic importance and high degree of business operation importance) and thirty-four of them (68%) regarded them as "strategic" (high degree of business strategic importance and high degree of business operation importance). This result suggests that most of the IT systems adopted by these Taiwan's construction organisations are perceived as either strategic for sustaining further business strategy and success, or key operational for current business survival. Figure 9.2 shows the result of the portfolio for the interviews.

(6) Variables within the process of change

(a) IT users

Figure 9.2 The Result of Ward's (1994) Application Portfolio Approach for the Interviews



Two questions in the instrument are related to IT users. The first question investigates how often the IT users are involved in the decision making process on IT investment. The results show that 40 contractors (80%) always or often involve IT users in their decision-making processes (scored "4" points or above). The second question investigates the attitudes of staff toward the use of new IT systems in the organisations. Forty-one organisations (82%) interviewed indicate that most of their staff are highly committed to the use of new IT systems. However, some IT managers also claim that older employees are unlikely to accept the use of a computer for their work. Also, most IT managers have indicated that it is difficult to overcome this attitude of resistance towards the use of IT. This problem will be discussed in detail in the next section of this Chapter.

(b) Project champions/directors and external experts

Two questions were designed to investigate whether the contractors appointed full-time project champions/directors to monitor new IT projects and whether they hired any external IT expert for their new IT system procurement and development. The results show that thirty-two organisations (64%) usually appoint project champions/directors to monitor their IT projects (scored "4" points or above), and twenty-five contractors (50%) usually hire external IT experts for consultation. Previous research in IT implementation has emphasised the importance of project champions in the innovation process. Consequently, these two variables will be tested and discussed in the next chapter to see if they influence the outcome of IT implementation among the contractors in Taiwan.

(c) Change of organisational structure and working process

The third and fourth questions investigate if the construction organisations have ever changed their organisational structure and working process in order to improve the performance of their IT systems. The average scores for these two questions are 1.66 and 2.42 separately. There are twenty-seven organisations (54%) which have never changed their organisational structure for their IT implementation (scored "1") and sixteen organisations (32%) which have done this very rarely (scored "2"). This suggests that these contractors are quite unwilling to change their organisational structure to improve their IT systems. They prefer to make their IT systems "match" their existing organisational structures and working process.

Many IT managers in the interviews explained that top management is very reluctant to change the existing organisational structure for IT. They feel that it is too risky to make such a structure change because of the many mediating factors involved, for example: staff positions, business process, etc. Also, they believe any failure of the change could bring disaster to their business. However, some organisations can accept the need to change certain working processes for new IT systems. The results show that thirteen organisations (26%) have never changed their working processes while adopting new IT systems. Some IT managers explained that a change in working process has less of an effect if anything goes wrong.

(d) IT implementation measurement

This question investigates how the contractors measure the IT implementation performance. The results show that the contractors focused on both the quantifiable and non-quantifiable benefits obtained from their IT systems. The next question investigates which business process areas are improved significantly by implementing IT in the contractors. The average scores for each business process are shown in Table 9.5. The business process where IT benefits are most significant in the organisations is "Finance", followed by "Information management" and "Client management". The results also reveal that benefits from the use of IT in financial issues in these organisations are the easiest to obtain. The benefits of IT in "Marketing", on the other hand, are the most difficult to achieve.

Table 9.5 The Average Scores for Benefits Found from IT in Nine Business Process Areas

Business Process	No. of contractors found benefits	Average Score
(1) Marketing	22	2.4
(2) Information management	50	4.0
(3) Procurement	40	3.58
(4) Finance	49	4.08
(5) Client management	39	3.82
(6) Design	17	3.76
(7) Construction	36	3.17
(8) Operation and maintenance	8	3.13
(9) Human resources	47	3.72

(e) Unforeseen benefits from IT investments after installation

The results show that fifteen organizations always or often found unforeseen IT benefits after implementation (scored "4" or "5" points). However, most of these unforeseen IT benefits are intangible. As one of the IT managers in the interview argued, they are primarily concerned with the question whether the new IT system can deliver their desired functional benefits. Other minor intangible IT benefits are always ignored. The unforeseen IT benefits mentioned by the IT managers are listed below:

- Improving staff's computer knowledge and skills;
- Establishing staff's confidence in operating computers;
- Helping to search for extra information;
- Helping to achieve the ISO 9000 certificates;
- Obtaining rapid and effective internal communications;
- Improving company reputation/image;
- Encouraging staff to share resource/data.

(7) IT performance

(a) Technical Success

Two questions were asked in the interviews to identify the degree of technical success of the IT systems. The first question investigates the degree of user-satisfaction with the IT systems installed by the contractors. The IT systems in the construction IT list (as shown in Table 8.4) are used. The result shows that the average scores of user-satisfaction of IT in forty-two contractors (84%) are more than "3" points. This suggests that most of the IT systems installed by the contractors are generally satisfactory to the users. The next question asks whether the expected functions of their IT systems were achieved. The results show that forty-five contractors (90%) scored more than "3" on the five-point scale. This indicates that the expected functions of the IT are generally achieved in the organisations. These two variables will be used to represent the degree of technical success and tested with other organisational variables in the next chapter.

(b) Business success

Questions in this section examine IT performance in terms of efficiency, effectiveness and long-term competitive advantage for these fifty contractors in Taiwan. These three variables were developed from Construct IT's (1998) model on IT benefit assessment in the construction industry. The construction IT systems list (in Table 8.4) was also applied to the IT managers to score the extent of improvement in business performance due to their existing IT systems. The results are discussed below:

(i) Efficiency

The total average score of "efficiency" due to IT implementation in these fifty organisations is 3.77 on a five-point scale from "not significant" to "very significant". There are forty-seven contractors (94%) whose average scores for this question are over "3" points. This result suggests that most of the contractors in the interviews believe that IT has improved their business efficiency. Of the twenty-six IT systems, "spreadsheets", "accounting system", "networking" and "word processing" were considered to be the most significant in improving business efficiency.

(ii) Effectiveness

The total average score of "effectiveness" due to IT implementation in the organisations is 3.74. This is slightly lower than the score of "efficiency" discussed above. There are forty-five contactors (90%) whose average scores for this question are more than 3 points on the five-point scale. Certain IT systems such as "spreadsheets", "accounting system", "contract management system" and "multimedia briefing" were considered by the IT managers to be much significant in improving business effectiveness.

(iii) Competitive advantage

The improvement of competitive advantage due to IT implementation in the organisations is not immediately apparent as it usually takes a long time for a significant change to occur. The total average score of "competitive advantage" due to implementing IT in the organisations is 3.30 on the five-point scale. There are only thirty-five contractors (70%) whose average scores are more than "3" points. The IT systems that were considered to contribute to highly significant improvements in competitive advantage by the IT managers were "video conferencing", "EDI", "networking", "multimedia briefing". The average scores of each IT system for improvements in the contractors' business performance are shown in Table 9.6.

9.3. Further information regarding IT implementation in the construction organisations

The contractors were also requested to give further information regarding the implementation of their IT systems in the interviews. Two main topics are included:

(1) Types of IT system installed in the Taiwanese contractors, and;

(2) Common problems encountered in the use of IT.

9.3.1 Types of IT systems installed in the Taiwan's contractors

All the IT systems on the list are used by the contractors, except VR (Virtual Reality). Two reasons for this were identified from the interviews. First, VR applications are not mature yet and are costly and time consuming to develop. Second, many IT

Table 9.6 The Average Score of Each IT Application for Improving Business Performance

Application types	(N)*	Efficiency	Effectiveness	Competitive Advantage
Word processing	50	4.00	3.94	2.76
Desktop publishing	17	3.63	3.69	2.88
Spreadsheets	47	4.33	4.12	3.31
Image processing	38	3.24	3.55	2.79
Construction equipment management	9	3.11	3.33	2.67
Video Conferencing	3	4.00	4.00	4.00
Management information system	26	3.85	3.85	3.81
Decision support system	10	3.60	3.40	3.70
Accounting system	50	4.12	4.10	3.34
Human resource management system	46	3.80	3.78	2.89
Material Procurement system	36	3.86	3.84	3.65
Contract management system	37	3.92	3.79	3.61
Estimating / Valuation system	47	3.80	3.72	3.57
CPM schedule control	34	3.65	3.56	3.26
Geographical information system	1	4.00	3.00	3.00
Structure analysis system	11	3.82	3.55	2.64
Fluid/Geological analysis system	2	4.00	4.00	3.00
Electric data interchange	1	3.00	3.00	4.00
Networking	45	4.04	3.89	3.83
2D CAD	45	3.93	3.87	3.27
3D CAD	16	3.38	3.25	3.25
Virtual Reality (VR)	0	N/A	N/A	N/A
Multimedia briefing	29	3.79	3.93	3.79
WWW site homepage	30	3.07	3.03	3.63
Construction law and regulations reference	22	3.41	3.32	3.05
Property management system	26	3.38	3.38	3.12

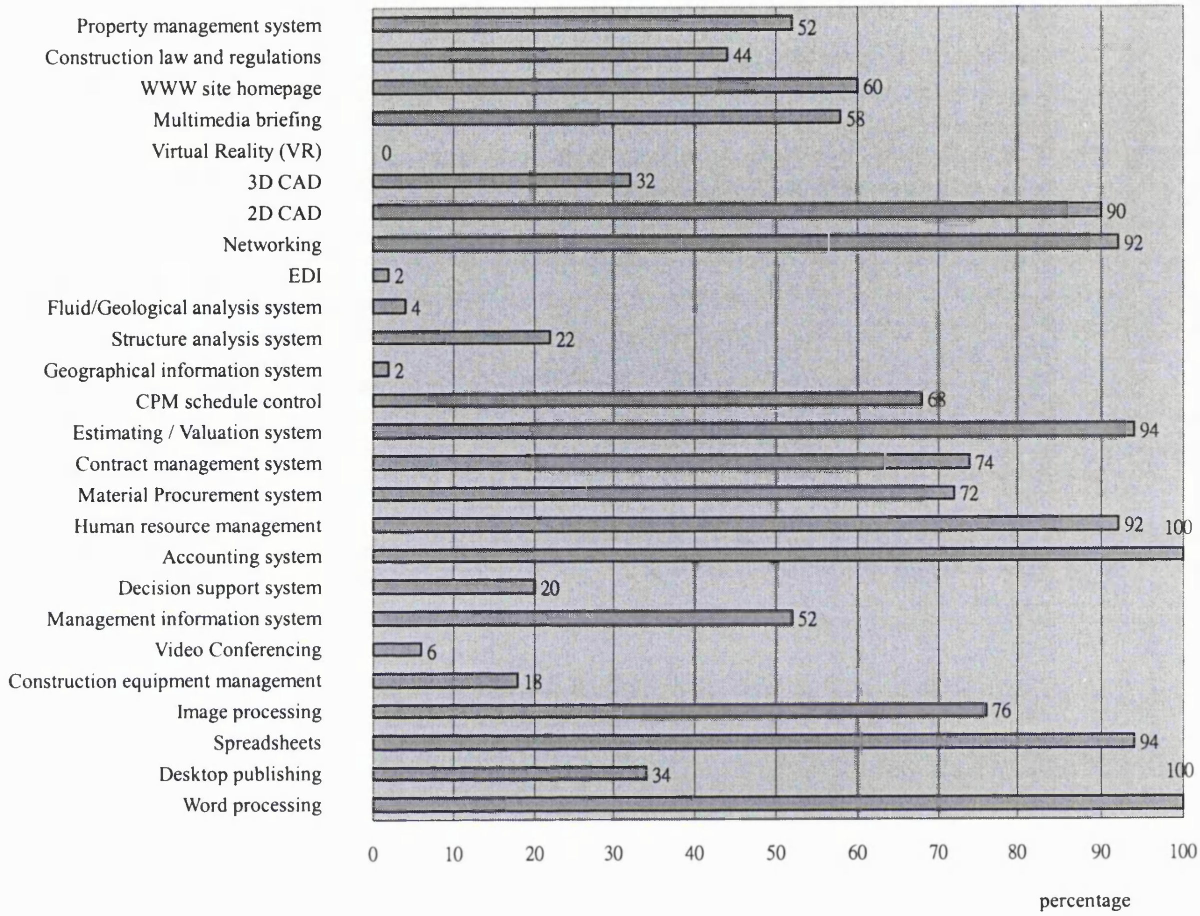
(* N= the number of contractors using the system) managers in the interviews indicated that VR is more suitable for architectural practices rather than contractors, thus the absence of VR in the contracting organisations interviewed is not surprising. The percentage of contractors using each IT system is illustrated in Figure 9.3.

All of the contractors interviewed have word processing and accounting systems for their business. Microsoft Word 98 is the most popular choice for word processing. SunAccount developed by System Unions is widely used by the contractors in Taiwan for accounting due to its high flexibility. However, a number of contractors preferred to develop their own accounting systems using in-house IT professionals or made-to-order from external IT suppliers. This is because they feel that the functions provided by off-the-shelf accounting software in the IT market usually cannot meet their requirements.

Estimating / Valuation systems, Spreadsheets, 2D CAD and Networking are also found to be widely used by the contractors. The Estimating / Valuation systems used by the contractors were mostly developed by the contractors in-house or made-to-order from external IT suppliers. This is because each contractor has its own coding table for each material and working part. The spreadsheets used by the contractors, on the other hand, are all from software packages.

Microsoft Excel 98 is the most popular spreadsheet software used by these organisations. Many IT managers indicated that a spreadsheet is a handy tool as it is easy to use and can be used for multiple purposes. 2D/3D CAD applications such as SoftCAD 2D/3D, AutoCAD and MicroStation are the most popular CAD software

Figure 9.3 Percentage of Contractors Using Each IT System



packages used by the contractors. All of the contractors have installed LAN (Local Area Networking) and some of them have WAN (Wide Area Networking) connecting their branches and construction sites. Email and Internet connections are also widely used by the contractors.

Human resource management systems, Image processing, Contract management system, Material Procurement systems and CPM schedule control (project management) are also used widely by the organisations. Many of the contractors purchased off-the-shelf packages for these systems since these packages are common and more suitable for use in the construction industry. For example, the project management software "Microsoft Project 98" is widely used not only by the construction industry but also by other sectors for project control and management.

Management Information Systems (MIS), Property management systems, WWW homepages, Multimedia briefing systems and Construction law and regulations systems are all used by nearly half of the contractors interviewed. MIS is the computer system in an enterprise that provides information regarding its business operations for management purposes. Organisations need to develop their own MIS in order to meet their specific needs. The contractors who developed an organisational Internet WWW homepage claimed that the expected benefits of WWW homepages were not really achieved since they found that few people had visited their homepages on the Internet.

Multimedia briefing was selected in the interviews as the application type with the high capability to improve business performance. However, due to the expensive software (e.g. 3D modelling, rendering and animation applications), hardware (e.g. hi-resolution colour projector for computer) and design costs, many organisations still use traditional methods for presentations such as slides and transparencies. The Construction laws and regulations system used by the contractors is actually a compact disk containing all of the Taiwan's construction regulations and laws. However, some contractors indicated that they preferred to acquire the information from the Government's Internet web site since the data is more frequently updated there.

Only 34% of the contractors interviewed have desktop publishing systems. The system is mainly used by large contractors to publish internal newsletters or journals. Structural analysis systems, Decision support systems and Construction equipment management systems were rare among the organisations interviewed; only about 20% of the contractors have installed these systems. Structural analysis systems are only found in large contractors who have their own structural design section. For other organisations, structure analysis and calculation work is always outsourced to external structural engineering consultants. The popular software packages used for construction structural analysis and design in Taiwan's construction industry are SAP2000, ETABS and SAFE2000.

Decision support systems were considered by many IT managers in the interviews to be a powerful tool since they can provide critical information to assist top management in their decision-making process. However, a possible reason why this system is not widely used by these contractors may also stem from top management itself. More details regarding this problem will be discussed in the next section of this chapter.

Video conference systems, Geographical information systems, Fluid/Geological analysis systems and EDI are rarely found in the contractors. The video conference system is a new technology for on-line, multiple-ways communications via the Internet or private networking (e.g. WAN). The cost of the system can range from hundreds to millions of pounds depending on its functions and specifications (e.g.

number of simultaneous channels for communication, resolution of the video camera and bandwidth of networking). According to some IT managers in the interviews, video conferencing by Internet is not popular because its quality is not satisfactory.

Geographical information systems and Fluid/Geological analysis systems are only used by civil engineering contractors. Only one contractor in the interviews uses GIS. According to the IT manager in this organisation, the Taiwanese government has developed a GIS database for industries to use but they found that the accuracy of the data was low. Fluid/Geological analysis systems are not popular either since the analysis work is usually outsourced to external geotechnical engineering specialists in Taiwan.

The use of EDI is just starting in the Taiwan's construction industry. Although only one contractor in the interview has started to experimentally use EDI for business transactions with its suppliers, lots of contractors in the interviews indicated that they were interested in adopting EDI for business transactions.

9.3.2 Common problems encountered by the contractors in Taiwan

The IT managers interviewed were also asked to describe any IT implementation problem they had encountered. Seven common problems found from the interviews are discussed below:

(1) IT software Procurement

Many IT managers stated in the interviews that the most convenient and cheapest method of IT procurement is the use of off-the-shelf software packages. However, they also indicated that some software packages could not fully meet their requirements since they were general packages and designed to be used by all sectors. Although some packages were developed specially for the construction industry, they might still be incompatible with the contractors' business operation processes. Thus some contractors developed their own software using in-house IT staff or they outsourced the systems to external IT suppliers. However, many IT managers also indicated that in-house IT staff usually do not have the ability to develop the whole new system and outsourcing usually takes longer and is more expensive. Some of them even complained in the interviews that their external IT suppliers took very long to revise the software as they could not fully understand the specific business operation processes in the organisations in a short time.

Moreover, there is another disadvantage of outsourcing IT systems to external suppliers- they will not upgrade the IT system unless you ask and pay for it. Conversely, off-the-shelf software packages are upgraded frequently and all registered users can usually receive upgrading information by letter or Email. Some software companies even provide upgrading patches for free downloading on their Internet homepages. Consequently, some IT managers indicated that they preferred to use off-the-shelf packages if possible.

(2) Recruitment for IT staffs

As mentioned in the previous section, most of the contractors interviewed hired less than 5 full-time IT staff in their organisations. The main reason is that IT professionals are difficult to keep in the construction industry in Taiwan. The computer and semi-conductor industries in Taiwan are currently very prosperous.

They offer high benefit packages (e.g. high pay, flexible working time and a certain percentage of company shares for bonuses every year) to attract experienced IT professionals. Thus IT professionals are difficult to retain in the construction sector in Taiwan.

According to one of the IT managers interviewed, only a few large and famous contractors are able to keep experienced IT professionals. The IT staff recruited in most of organisations usually have a civil engineering background and certain computer skills. Consequently, the in-house IT staff in most of the companies usually do not have the ability to develop a whole new system. However, the advantage is that the IT staff, in certain circumstances, can support engineering work in construction sites.

(3) The resistance to using IT

Two groups of personnel in Taiwan's construction organisations were found to be most likely to refuse to use IT. The first one is senior staff. Senior staff in the contractors are usually older and have received no previous computer training in school. Since they have worked for their company for many years, they have become accustomed to their everyday working procedures. Thus the use of IT easily becomes a threat to them since they need to learn new computer skills and new ways of working.

The second group likely to refuse to use IT is top management, although the results of the interviews showed that top management was highly supportive for IT innovations. Many of the IT managers indicated that the top management of their organisations never worked with computers.

This situation can be explained by the finding that most top management in the construction organisations has a low IT competence and knowledge. They may not have sufficient skills and confidence to use computers. Another important reason, indicated by the IT managers, is that they do not "trust" computers. They prefer to read information on a paper document with someone's signature rather than read it on the computer screen. The "signature" is a very important factor in traditional Chinese organisations since it means that someone has taken full responsibility for the validity of the data. Consequently, this also explains why some IT systems that were designed specifically to be used by top management (e.g. Decision support systems) are rare in these Taiwanese construction organisations.

(4) The full benefits of IT cannot be achieved in the construction organisations

This research found that the full potential benefits of IT usually could not be achieved by the contractors for the following two reasons. Firstly, IT is regarded as merely a tool for automation by most of the contractors. As discussed in the previous section, most of the contractors were unwilling to change their organisational structure and business process to optimise their IT systems. Rather, they wanted their IT systems to be compatible with their existing working procedures. This circumstance limited the benefits of the IT. As discussed in Chapter 2, business process re-engineering (BPR) with IT is a powerful approach to improve business performance. Unfortunately, BPR is rarely found in these construction firms.

Secondly, some managers in the interviews indicated that they sometimes needed to temporarily re-organise their work group and change the working process in order to meet certain project requirements (as discussed previously, some organisations adopted a team organisational structure in order to obtain flexibility). This situation is common in the construction industry due to the unique feature of construction that nearly every project is a "one-off" product, each one has its own specification, design and different levels of quality required by different clients, and construction work is mostly done manually. Consequently, the construction project is more complex and difficult to predict than those in other sectors. In such circumstances, some IT benefits found in other sectors may not be achieved in the construction industry.

(5) The development of computer technology is too rapid to keep up

Many IT managers indicated that they could hardly keep up with the rapid development of computer technology. For example, one of the contractors developed their IT systems on a DOS platform in 1993. Two years later, they found that the Windows platform was superseding the DOS but they did not pay much attention to this because their DOS systems were still advanced. In 1998, they found that one of their DOS applications was no longer powerful enough to cope with complex project specifications and decided to change to a new system. However, they could not find suitable software since all systems on the software market were developed on the Windows platform.

Since it was not worth hiring an external computer supplier to develop obsolete DOS systems as well as the consideration that their DOS systems would not pass Y2K tests, they decided to change all of their DOS systems to Windows. Of course, the conversion included all their hardware as the five-year-old X386 machines could not run Windows 98 smoothly. Training for the new systems was also required. The total amounts of these expenses were much more than they expected initially. Most of the contractors interviewed encountered similar problems, which made some top managers feel that the costs of IT were too high and subsequently they became very conservative in approving new IT investments.

(6) The role of IT in the construction industry is misunderstood

Although the results of the interviews show that most of the contractors are aware of IT potential and support the use of IT for business improvements, many managers in the interviews claimed that they feel the use of IT is not of much importance to the construction industry. The main reason they provide is that construction is a traditional industry and nearly all parts of the project work are completed manually by site operatives. Consequently, the use of computers does not affect the results of the work much. One contractor even claimed that their business strategy for competitiveness was to provide a high-standard building quality guarantee to its customers, so that the use of IT would not really improve their business.

The reason these managers have such ideas may be because they misunderstand the role of IT in construction organisations. These managers may regard IT as merely a tool and do not see the potential of using IT to re-engineer their whole business process in order to gain competitive advantages. They may not realise that the increasing use of IT is a global trend. Indeed, in the near future IT will possibly dominate most of the business processes in all sectors, especially in B2B (business-to-business) transactions. Currie (2000) indicates that B2B electronic commerce is growing rapidly as it produces four business advantages: reduced transaction costs, reduced inventory, more efficient logistics and lower sales and marketing costs, and new sales opportunity. The Gartner Group in the USA estimates B2B e-commerce in Asia will represent 13.6 percent of the forecasted $7.3 trillion in total global B2B transactions (Gartner Group 2000). Consequently, companies who ignore the potential of IT for business may find it difficult to compete and survive in the nearly future.

(7) The potential problem for data exchange through IT between construction organisations

Another potential problem regarding IT in Taiwan's construction industry is the coding systems used in IT databases. It was found that all of the contractors have developed their own codes for IT infrastructure. These codes are used to represent different types of material, work parts, sub-contracts, financial transactions, bank accounts, etc. There are hundreds of these codes and their numbers are growing since every new project may generate new codes. In such a situation, it will be a problem for organisations to exchange data through IT (e.g. Internet) for business transaction since those codes are different. For example, one contractor may use code "10021" to represent a certain construction material in their IT systems, however its sub-contractors or suppliers may use a total different one to represent the material in their IT systems. Consequently, if the contractor wants to develop an IT system to exchange data with other parties automatically, it will face such coding incompatibility problems.

Each construction project is usually "unique" and new construction materials and working methods are constantly invented, it is difficult for the Government to establish standard codes and ensure they are all updated. Also, because most construction organisations have established their own coding systems for IT databases over many years, it is difficult just ask them to use standard codes (if there are any) since any change of codes means that the code tables set up in their IT systems also need to be changed.

The coding incompatible problem is very likely to be a challenge and a barrier for the further development of data exchange through IT (EDI, WWW) between construction organisations in Taiwan. This research suggests that the establishment of an interface to "communicate" the different codes may be more practicable than merely asking contractors to unify their codes. However this issue is out of the research range of this study. Further research in this area is suggested.

9.4 Discussion and conclusion

This chapter has described the results of the interview sessions conducted in Taiwan. It has provided information regarding both the contractors' internal and external organisational characteristics, such as business strategy, organisational structure, IT policy and so on. It has also demonstrated the current use of IT and common IT problems encountered by the contractors in Taiwan.

Most of the IT systems listed in the research instrument are found to be used by these contractors, with the exception of VR (virtual Reality). Some of the IT systems such as accounting, spreadsheets and networking were considered to enable highly significant improvements in business performance by the contractors. The business process which is believed to be most improved by IT in the contractors interviewed is "finance issues". It was also found that the contractors usually adopt *ad hoc* approaches to IT justification. No contractor applied formal risk assessment to new IT investments.

This study has also investigated the current use of IT in Taiwan's construction industry. The most widely used IT systems are word processing and accounting systems. Off-the-shelf software packages are believed to be the most convenient and cheapest IT source by the contractors. However, standard software packages usually do not meet all the organisations' requirements since they are designed to be used by all sectors. Bespoke systems developed in-house or outsourced to external IT suppliers are more likely to meet the organisation's requirements. However, it is argued that such software is usually expensive and time-consuming to be developed.

Seven common IT problems in Taiwan's construction industry are also identified from the interviews. The major cause of the problems has "human" roots, such as lack of IT professionals, resistance to IT use and a misunderstanding of the role of IT on the part of the managers in the organisations. This research suggests that IT education for construction professionals is vital and urgently required since education can help construction professionals to establish more constructive ideas about IT, as well as reduce the IT resistance problem.

In the next chapter, the relationship between organisational characteristics and IT performance in the construction organisations in Taiwan will be discussed. Multivariate statistical methods are mainly used for the analysis work.

Chapter 10: IT Implementation Performance and Organisational Characteristics

10.1 Introduction

This chapter mainly discusses the findings of the statistical analysis of the data derived from the interview sessions conducted in Taiwan. There are three sections included in this chapter. Firstly, correlation tests between different categories of variables are conducted and their results are discussed. The main purpose of the correlation tests is to test hypotheses in the relationship between different categories of organisational variables and IT implementation performance. Variables with significant correlation coefficients are identified and highlighted.

Secondly, a generic model describing the relationship between organisational characteristics and IT implementation performance outcome was developed. This model was mainly developed from the original analytical framework designed in this research (refer to Chapter 8.3) and the results of correlation tests discussed previously. This model can be applied as a diagnostic tool for contractors to find the source of problems and possible solutions to improve their IT outcome.

Finally, the critical factors for successful IT implementation performance for the contractors in Taiwan are identified and discussed. A multiple regression technique was applied for this analysis. These critical factors can help to understand why some contractors in Taiwan can achieve better IT implementation performance than others.

10.2 The correlation analysis

As discussed in chapter 8, one of the main objectives of this research is to identify the relationship between IT implementation performance and organisational characteristics in Taiwan's construction organisations. Three different definitions of business success, as discussed in Chapter 8, were used as IT implementation performance variables and tested with other organisational variables on a separate basis for each contractor. The relationship between different categories of organisational characteristics was also examined.

The statistical technique used to find the relationship between different categories of organisational characteristics and IT implementation performance is multiple correlation analysis. Multiple correlation analysis is capable of providing indications of both the strength and direction of the relationship among two or more variables. Spearman's rho correlation approach was chosen because it is widely used to test correlations of ordinal data. It is also a convenient approach to test the strength of the monotonic relationship between variables without being concerned whether the relationship is linear or not (Iman and Conover 1983).

The analytical framework (as shown in Figure 8.2) developed in this research was used to guide the selection of categories of variables for correlation tests. According to the framework, three different combinations of variable categories should be tested. They are: (1) correlations between IT technical success variables and all organisational variables, (2) correlations between business success variables and all categories of organisational variables (outer and inner contexts, content and process), and (3) correlations between different categories of organisational characteristics. The full results of Spearman's rho correlation matrix between all the variables are shown in Appendix C.

There is one particular phenomenon which should be examined in the correlation matrix: multicollinearity. Multicollinearity usually happens when the correlation coefficients between independent variables exceed 0.80 (Bryman and Cramer 1997). The correlation coefficients between variables would become spurious if the independent variables are highly correlated to each other. Moreover, the regression coefficient calculated for the identification of critical factors in the next section may become unstable if multicollinearity is exhibited in the correlation matrix. However, it is clear from the Spearman's rho correlation matrix shown in Appendix 3 that none of the correlation coefficient between independent variables exceeds 0.8. In other words, multicollinearity is unlikely to occur in these tests.

10.2.1 Correlations between IT technical success variables and organisational variables

The two IT technical success variables: user satisfaction and expected function achievement proposed in this research were firstly tested with other categories of organisational variables to examine their relationship. The results of Spearman's rho correlation between technical success and different categories of organisational variables are shown in Table 10.1. The results show that six organisational variables are moderately correlated with user satisfaction; they are:

- Degree of control,
- IT justification method,
- Users' attitude,
- IT project champions/directors,
- Strategic importance of the IT systems
- Operational importance of the IT systems

There are also six organisational variables that moderately correlated with expected function achievement:

- IT development and control policy,
- Previous IT experience,
- Users' attitude,
- IT project champions/directors,
- Strategic importance
- Operational importance of the IT systems

These correlations are all significant at the 99% confidence level or better.

Among these variables, IT development policy is negatively correlated with expected function achievement. This result suggests that contractors with a centralised IT development policy have better results in expected function achievement.

Table 10.1 Variables With Significant Correlation Coefficients With IT Technical Success Variables

(1) User Satisfaction			
Variables		Correlation Coefficient	P Value
Outer Context	Environmental force	.254	.075
Inner Context	Degree of Integration	-.005	.975
	Degree of Control*	.437	.002
	Business Strategy	.084	.562
	IT Development and Control Policy	-.274	.054
	Previous IT Experience	.322	.022
	Sourcing method	.115	.428
	IT Justification Method*	.373	.008
	IT Risk Assessment	-.144	.319
	IT Technology Preference	.191	.183
	Users' Attitude *	.422	.002
	Top Management Support	.096	.505
Process	User Involvement	.179	.213
	Top Management IT Competence	.098	.499
	IT Project Champions/Directors *	.471	.001
	Use of external IT Experts	.207	.148
	Change of Organisational Structure	-.084	.562
	Change of Working Process	-.095	.511
	Focus of IT implementation performance Measurement	.172	.231
	Unforeseen IT Benefits	.183	.204
Content	**Strategic Importance of the IT systems***	.476	.000
	Operational Importance of the IT systems*	.577	.000

(2) Expected Function Achievement			
Variables		Correlation Coefficient	P Value
Outer Context	Environmental force	.123	.396
Inner Context	Degree of Integration	-.105	.469
	Degree of Control	.262	.066
	Business Strategy	.153	.289
	IT Development and Control Policy*	-.407	.003
	Previous IT Experience*	.493	.000
	Sourcing method	.046	.749
	IT Justification Method	.275	.053
	IT Risk Assessment	-.110	.448
	IT Technology Preference	-.008	.959
	Users' Attitude *	.485	.000
	Top Management Support	.143	.322
Process	User Involvement	.215	.134
	Top Management IT Competence	.003	.981
	IT Project Champions/Directors *	.362	.010
	Use of external IT Experts	.167	.245
	Change of Organisational Structure	-.149	.301
	Change of Working Process	-.183	.202
	Focus of IT implementation performance Measurement	-.065	.656
	Unforeseen IT Benefits	.147	.307
Content	**Strategic Importance of the IT systems***	.388	.005
	Operational Importance of the IT systems*	.488	.000

* Significant at the 99% confidence level or better (2-tailed)
** N=50 for all variables

10.2.2 Correlations between business success variables and organisational variables

This section examines the relationship between IT implementation performance in terms of improving business success and other categories of organisational variables listed previously. Three business success variables: efficiency, effectiveness and competitive advantage were tested with all the other variables separately.

(1) Business efficiency improvement through IT

There is a total of 7 organisational variables identified to have significant correlation coefficients with business efficiency improvement through IT by Spearman's rho correlation (at 2-tailed 99% confidence level). Table 10.2 shows the details of correlation coefficients and P values of all the variables. The organisational variables which are significantly correlated ($p < 0.01$) with business efficiency improvement are highlighted. The results show that seven organisational variables are significantly correlated to contractors' IT implementation performance in terms of business efficiency improvement. These organisational variables are:

- Degree of control,
- Previous IT Experience,
- IT Justification method,
- Users' attitude,
- Strategic importance of IT,
- Operational importance of IT and,
- Use of project champions/directors.

Table 10.2 Variables With Significant Correlation Coefficients with Business Efficiency Improvement

Variables**		Correlation Coefficient	P Value
Outer Context	Environmental force	.230	.108
Inner Context	Degree of Integration	-0.20	.888
	Degree of Control*	.478	.000
	Business Strategy	.141	.328
	IT Development and Control Policy	-.357	.011
	Previous IT Experience*	.489	.000
	Sourcing method	.104	.474
	IT Justification Method*	.416	.003
	IT Risk Assessment	-.070	.629
	IT Technology Preference	.082	.571
	Users' Attitude*	.559	.000
	Top Management Support	.173	.231
Process	User Involvement	.123	.394
	Top Management IT Competence	.017	.907
	IT Project Champions/Directors*	.475	.000
	Use of external IT Experts	.219	.126
	Change of Organisational Structure	-.155	.283
	Change of Working Process	-.099	.493
	Focus of IT implementation performance Measurement	.131	.366
	Unforeseen IT Benefits	.048	.743
Content	**Strategic Importance of the IT systems***	.427	.002
	Operational Importance of the IT systems*	.536	.000
Technical Success	**User Satisfaction***	.713	.000
	Expected function Achievement*	.780	.000

Notes:
* Significant at the 99% confidence level or better (2-tailed)
** N=50 for all variables

Other organisational variables are not significantly correlated with business efficiency improvement in this survey. They have very low values of correlation coefficients and do not reach the statistically significant level (99% confidence level) to indicate that the correlations are unlikely to have occurred by chance.

The two technical success variables: user satisfaction and expected function achievement, as might be expected, are also highly correlated (rho=0.713 and 0.780 separately) with business efficiency improvement. This suggests that the contractors who achieved better technical success in their IT systems were more likely to obtain better business efficiency improvement by IT.

(2) Business effectiveness improvement through IT

The results of Spearman's rho correlations between business effectiveness improvement variables and other organisational variables are shown in Table 10.3 (variables with significant correlation coefficient ($p < 0.01$) are highlighted). The results show that 4 organisational variables are significantly correlated with effectiveness improvement variable. They are:

- IT Justification,
- Users' attitude,
- IT project champions/directors,
- Operational Importance.

All the above variables were found in the previous efficiency test but their correlation coefficients are lower here. This may be because business effectiveness

Table 10.3 Variables With Significant Correlation Coefficients With Business Effectiveness Improvement

Variables**		Correlation Coefficient	P Value
Outer Context	Environmental force	.129	.372
Inner Context	Degree of Integration	-.004	.978
	Degree of Control	.246	.085
	Business Strategy	.229	.110
	IT Development and Control Policy	-.290	.041
	Previous IT Experience	.322	.022
	Sourcing method	.169	.242
	IT Justification Method*	.413	.003
	IT Risk Assessment	.053	.713
	IT Technology Preference	.003	.986
	Users' Attitude *	.429	.002
	Top Management Support	.124	.392
Process	User Involvement	.237	.098
	Top Management IT Competence	.104	.474
	IT Project Champions/Directors*	.400	.005
	Use of external IT Experts	.069	.632
	Change of Organisational Structure	-.100	.492
	Change of Working Process	-.067	.644
	Focus of IT implementation performance Measurement	.024	.868
	Unforeseen IT Benefits	-.009	.949
Content	Strategic Importance of the IT systems	.250	.080
	Operational Importance of the IT systems*	.465	.001
Technical Success	**User Satisfaction***	.614	.000
	Expected function Achievement*	.707	.000

Notes:

* Significant at the 99% confidence level or better (2-tailed)
** N=50 for all variables

improvement is more difficult to realise and identify than business efficiency improvement by the contractors.

The relationship between the two technical success variables and the business effectiveness variable is also examined. The results show that both the expected function achievement and user satisfactory variables are also significantly correlated with business effectiveness improvement variable.

(3) Competitive advantage improvement through IT

Only two organisational variables were found to have significant (99%) correlation coefficients when tested with competitive advantage improvement by implementing IT (as shown in Table 10.4). This may be explained by the fact that IT is unlikely to improve business competitive advantage in a short time. Moreover, most of the contractors interviewed in Taiwan did not find much improvement in competitiveness from IT implementation.

These two organisational variables are:

- IT justification
- Strategic importance

As might be expected, while operational importance was correlated with business effectiveness, strategic importance was correlated with competitive advantage. This result suggests that only the contractors whose IT justification and investments based

Table 10.4 Variables With Significant Correlation Coefficients With Business Competitive Advantage Improvement

Variables**		Correlation Coefficient	P Value
Outer Context	Environmental force	-.016	.915
Inner Context	Degree of Integration	.053	.717
	Degree of Control	.049	.734
	Business Strategy	-.110	.446
	IT Development and Control Policy	-.140	.332
	Previous IT Experience	.300	.034
	Sourcing method	.067	.646
	IT Justification Method*	.570	.000
	IT Risk Assessment	-.119	.408
	IT Technology Preference	-.052	.721
	Users' Attitude	.284	.045
	Top Management Support	.201	.162
Process	User Involvement	.140	.332
	Top Management IT Competence	.208	.146
	IT Project Champions/Directors	.320	.024
	Use of external IT Experts	.195	.176
	Change of Organisational Structure	.038	.794
	Change of Working Process	.181	.207
	Focus of IT implementation performance Measurement	.112	.440
	Unforeseen IT Benefits	.132	.360
Content	**Strategic Importance of the IT systems***	.457	.001
	Operational Importance of the IT systems	.329	.020
Technical success	**User Satisfaction***	.365	.009
	Expected function Achievement	.276	.053

Notes:

* Significant at the 99% confidence level or better (2-tailed)
** N=50 for all variables

on long-term strategic goals are more likely to improve their competitive advantage as a result of implementing IT. Moreover, the two technical success variables are also tested and the results show that only user satisfactory is correlated with the competitive advantage variable (rho=0.365).

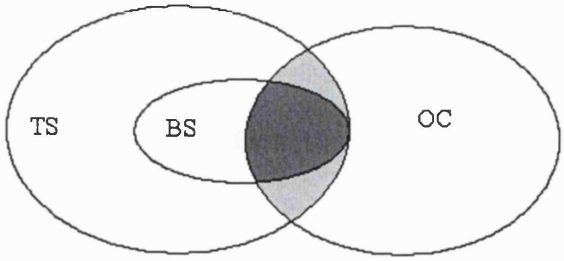
The results above show that the organisational variables which are significantly correlated with business success are a sub-set of those significantly correlated with technical success. The relationships between organisational characteristics, technical success and business success can be shown as Figure 10.1. This result is consistent with Winch (1994)'s argument that business success is a function of technical success. In other words, business success can only be gained after achieving technical success in innovation process; however, the achievement of technical success cannot guarantee that business success can finally be obtained.

The details of findings from the correlation tests are summarised below:

(1) Context variables

The degree of control in organisational structure was found to be moderately associated with user satisfaction in technical success (rho=0.437) and business efficiency improvement (rho=0.478) in business success. This suggests that contractors with tight control in organisational structure are more likely to achieve user satisfaction and business efficiency improvement by implementing IT. Some variables in the organisation's IT strategy are also correlated with IT implementation performance variables. The influence of previous IT experience was found to

Figure 10.1 The Correlations Between Organisational Characteristics, Technical Success and Business Success Variables



OC: Organisational Characteristics Variables

TS: Technical Success Variables

BS: Business Success Variables

correlate with expected function achievement (rho=0.493) and business efficiency improvement (rho=0.489). The contractors who learnt from their previous IT implementation for future IT development are more likely to obtain expected IT function achievement and business efficiency improvement through implementing IT.

The justification method before the decision to adopt new IT was found to have a moderate correlation with users satisfaction in technical success (rho=0.373). This result suggests that the method applied for IT justification has a certain influence on the degree of user satisfaction with IT in these Taiwanese contractors. This variable is also found to have a positive correlation with all the three business success variables (rho=0.416, 0.413 and 0.570), which suggests that the contractors whose IT justification methods focus on long-term strategic opportunity assessment are more likely to obtain business success through implementing IT systems.

Moreover, the policy for IT development and management was found to have a moderate correlation with IT implementation performance variables. This suggests that the contractors with a centralised IT development and management policy are more likely to obtain expected IT function achievements (rho=-0.407).

Users' attitude towards the new IT is positively associated with the two technical success variables (rho= 0.422 and 0.485 for user satisfaction and expected function achievement respectively). It is also positively associated with efficiency improvement (rho=0.559) and effectiveness improvement (rho= 0.429) in business success. This result is to be expected since the cooperation and full commitment of IT users are vital for the operation and performance of IT systems.

(2) Content variables

The perceived strategic importance and operational importance of the IT systems installed by the contractors were found to correlate with IT performance. It was found that the contractors who mainly invested in IT systems which were regarded as of high strategic importance were likely to identify better user satisfaction (rho=0.476), business efficiency (rho=0.427) and competitive advantage improvement (rho= 0.457) through IT. On the other hand, contractors who mainly invested in IT systems which were regarded as highly operationally important were more likely to obtain user satisfaction (rho=0.577), expected function achievement (rho=0.488), business efficiency (rho=0.536) and effectiveness improvements (rho=0.465) through IT. This suggests that the content of IT innovation does have an influence on the outcome of IT innovation in the contractors.

(3)Process variables

IT project champions/directors also play an important role in IT innovation outcome in the contractors. The results show that use of IT project champions/directors is positively correlated with business efficiency improvement (rho= 0.475), effectiveness improvement (rho=0.400) for business success and User satisfaction for technical success (rho=0.471). This finding is also consistent with the literature which emphasises the importance of champions in the innovation process (e.g. Winch 1994, Frenzel 1996 and Nam and Tatum 1997).

(4) Technical success variables

Both the expected function achievement and user satisfactory in technical success were found to have significant correlations with business efficiency and effectiveness improvement through IT. However, it also shows that expected function achievement does not appear to significantly correlate with business competitive advantage. This can be explained by the argument in much of the literature that business competitiveness cannot be easily obtained by merely using IT.

10.2.3 Correlations between different categories of variables of organisational characteristics

The correlations between different categories of variables of organisational characteristics were also tested. The main purpose of testing associations between organisational variables themselves is to examine whether the variables in different categories can influence each other. The results were used to establish a generic model representing the relationship between organisational characteristics and IT implementation performance in the Taiwanese construction organisations. This model will be discussed in the next section.

Totally 13 different sets of variables from different categories were found to have statistically significant correlations at 99% confidence level. They are:

- Top management's support and IT project champions/directors;
- Top management's competence and knowledge and IT justification method;
- IT sourcing and hire of external experts;
- Environmental force and unforeseen IT benefits;
- Environmental force and Influence of previous IT experience, and;
- Strategic importance of the IT and Users' attitude.
- Users' attitude about the use of IT and IT user involvement in the decision process;
- Strategic importance of the IT and IT justification method;
- Operational importance of the IT and IT justification method;
- Degree of control and Use of IT project champions/directors;
- Degree of control and Use of external IT experts;
- Use of IT project champions/directors and IT justification method;
- Focus of IT implementation performance measurement and IT technology preference.

The detailed results of the correlation tests are shown in Table 10.5. A summary of findings from the intercorrelations between the organisational variables are discussed as follows:

Table 10.5 Variables With Significant Coefficients in the Correlation Tests Between Different Categories of Variables of Organisational Characteristics

Categories	Variables**	Correlation Coefficient	P value
Inner Context vs. Process	Top Management's Support Vs. Use of IT Project champions/directors	0.420	0.002
	IT Sourcing method Vs. Hire of External Expert	0.620	<0.001
	Users' Attitude Vs. IT User involvement in decision making process	0.389	0.005
	Degree of Control Vs. Use of IT Project Champions/Directors	0.378	0.007
	Degree of Control Vs. Use of External IT Expert	0.372	0.008
	IT Justification Method Vs. Top Management's IT Competence and Knowledge	0.385	0.006
	IT Justification Method Vs. Use of IT Project Champions/Directors	0.372	0.008
	IT Technology Preference Vs. Focus of IT Performance Measurement	0.366	0.009
Outer Context vs. Process	Environmental force Vs. Unforeseen Benefits	0.563	<0.001
Outer Context Vs. Inner Context	Environmental force Vs. Influence of previous IT experience	0.463	0.001
Content Vs. Inner Context	Strategic Importance Vs. Users' attitude	0.446	0.001
	Strategic Importance VS. IT Justification Method	0.391	0.005
	Operational Importance VS. IT Justification Method	0.386	0.006

* All variables are significant at the 99% confidence level or better (2-tailed)

** N=50 for all variables

(1) Outer context Vs. Inner Context and Process

The Environmental force (EF), as the major variable proposed in this category, was mainly identified from Winch's (1998) model for innovation adoption in construction organisations. It was found from the interviews that solving project problems/challenges was considered to be the factor with the strongest influence on the decision to adopt IT innovations. However, previous statistical tests also showed that there were statistically significant correlations between the outer context variable and variables in the "inner context" and "process" categories.

The results illustrate that the contractors encountering higher environmental pressure to IT adoption are likely to identify more unforeseen IT benefits after system consolidation (rho=0.563). This result is to be expected since organisations which are forced to adopt IT for problem solving or business survival are unlikely to apply detailed investment appraisals. Consequently, it is not surprising to find that the contractors have identified many unexpected IT benefits. This result is also consistent with Farbey et al's (1992) argument concerning the reason why organisations do not apply assessments for their IT investments.

Furthermore, the influence of previous IT experiences on future IT strategy and planning was found to be statistically stronger (rho=0.463) among the contractors encountering higher degree of environmental forces to adopt IT. This may be explained by the fact that solving unexpected project problems/challenges through IT innovation can be a trial and error process (as problem solving/learning dynamics in

Winch's model). Lessons from the trial procedure of IT innovation are certainly a useful directive for their future IT development.

(2) Inner Context Vs. Process

Six inner context variables were found to have moderate correlations (also at 99% confidence level or better) with variables at the process category. Top management's support for IT was found to be associated with the use of project champions/directors for IT development (rho=0.42). In other words, the contractors with more support from top management for IT innovation are more likely to appoint a full time project directors/champions for the development of IT.

IT sourcing method is significantly correlated (rho= 0.620) with the use of external IT experts. The contractors who prefer outsourcing their IT to IT suppliers were more likely to hire external IT experts for consultancy. This reflects the finding in the interviews that IT professionals are difficult to recruit in Taiwan's construction industry. Thus, the contractors whose main IT sourcing method is outsourcing to external suppliers usually have a contract with a local computer company.

IT users' attitude toward the use of IT and IT user involvement in the decision making process for IT projects are also moderately associated with each other (rho= 0.389). This result suggests that the contractors who frequently invite their IT users to be involved in the decision making process for new IT project may obtain a higher degree of user' commitment to the use of IT.

Degree of control, one of the organisational structure variables, is moderately correlated with IT project champions/directors and use of external IT expert in process of change category (rho=0.378 and 0.372 respectively). These results suggest that the Taiwanese contractors with tighter control over organisational structure are more likely to appoint project champions/directors and hire external IT experts for their IT projects.

IT justification method were found to moderately correlate with top management's IT competence and knowledge and the use of IT project champions/directors (rho= 0.385 and 0.372 respectively). Two findings are suggested. First, top management's IT competence and knowledge may influence the ways in which the organisations conduct their IT assessment before implementation. In other words, the contractors with higher degree of IT-competence/knowledge top management are more likely to assess their IT projects on a long-term strategic opportunity basis. Second, the contractors with higher degree of IT-competence/knowledge top management are more likely to appoint IT project champions/directors for their new IT projects. They may be keen to encourage the use of IT for their business since they are more aware of the advantages of using IT.

IT technology preference and focus of IT performance measurement were found to be moderately associated with each other (rho=0.366). This may suggest that the contractors who prefer to adopt new, powerful and high-tech IT systems are more likely to focus their IT post-installation assessment on non-quantifiable benefits.

(3) Content Vs. Inner Context

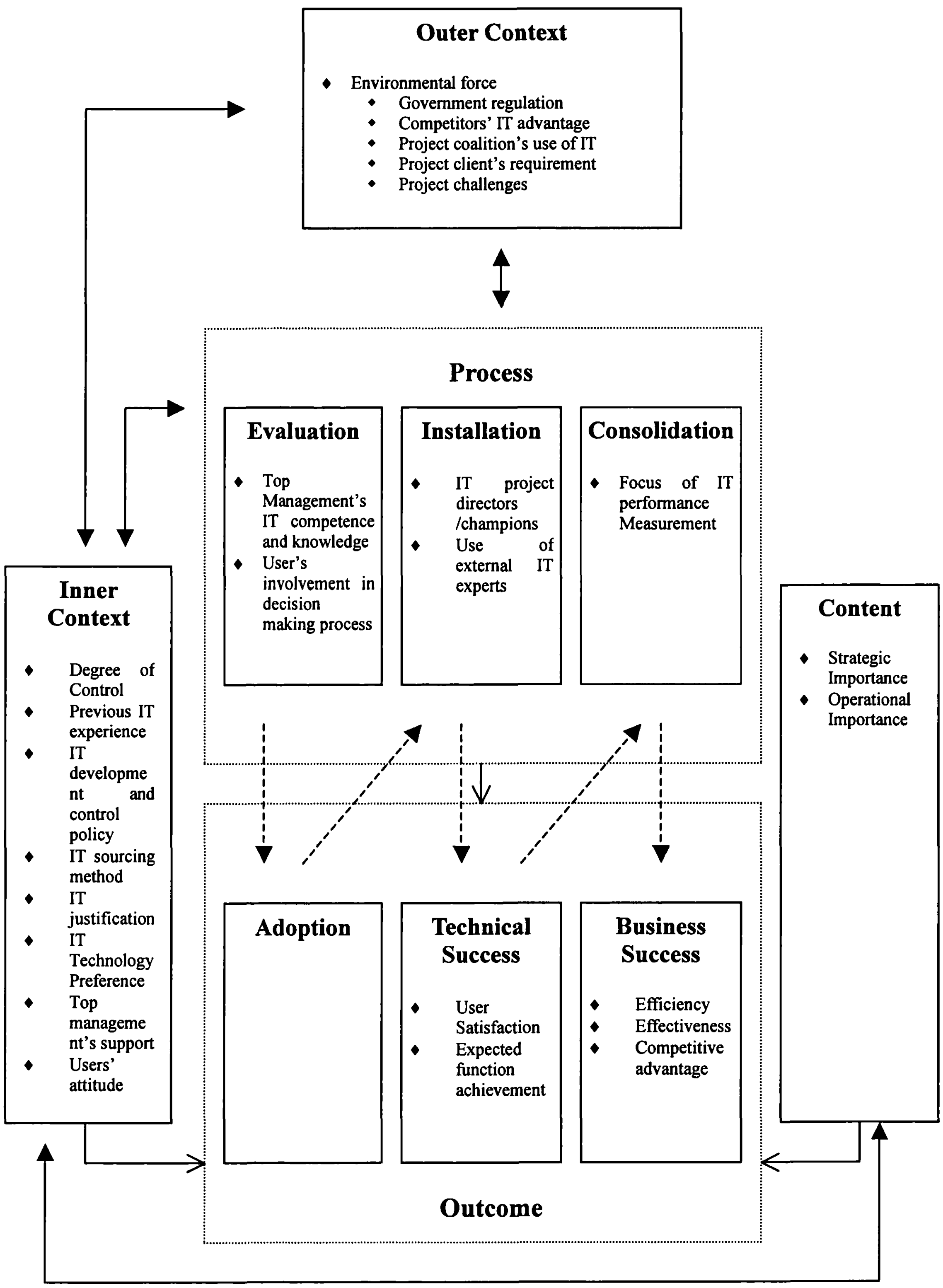
The perceived strategic importance and operational importance of the IT systems installed by the contractors were found to correlate with other variables. It was found that the contractors who mainly invested in IT systems which regarded to be of high strategic importance were more likely to identify better users' attitudes towards the new IT (rho=0.446). Moreover, it shows that both the content variables: strategic importance and operational importance were found to moderately associate with IT justification method (rho=0.391 and 0.386 respectively). This suggests that the contractors who mainly invested in IT systems which regarded to be of high operational importance or strategic importance to their business are more likely to assess their IT projects on a long-term strategic opportunity basis.

10.2.4 The alignment between organisational characteristics and IT implementation performance in Taiwan's construction industry

From the correlation tests above, the analytical framework developed in this research was revised into a generic model to explain the alignment of IT implementation and organisational characteristics in Taiwan's construction industry. As Mckersie and Walton (1991) argue, the alignment of organisational factors and technology is fundamental to achieving successful IT innovation. This alignment model, as shown in Figure 10.2, can help analyse and improve IT implementation performance in construction organisations in Taiwan.

This model portrays the intercorrelations of organisational characteristics and IT implementation in Taiwan's construction industry. The three organisational

Figure 10.2 The Alignment of IT Implementation Performance and Organisational Characteristics in Taiwan's Construction Industry



characteristics categories are illustrated in relation to IT implementation process and outcome. The variables, which were found to have significant correlation coefficients in the statistical tests, are also presented in this model. While the focus in this research is on IT implementation performance in construction organisations, the model emphasises the importance of the effects from organisational characteristics in IT implementation. These effects mainly stem from an organisation's external environment, internal structure, culture and climate, policies, strategies and the individuals comprising it. A sound coordination between these variables in one organisation can help to obtain a better outcome of the IT implementation in business success.

The model above described the relationship between IT implementation performance and organisational characteristics of the contractors interviewed. It can be used to study IT implementation performance and organisational characteristics in Taiwan's construction context. However, it does not provide information concerning the question of which variables are vital for business success through implementing IT. Consequently, further analysis to identify critical factors for IT innovation is required.

10.2.5 Critical factors for business success through IT

The statistical technique used in this research to identify the critical factors for business success achievement by IT is multiple regression approach. Multiple regression has been chosen since it is the most widely used and accepted method for conducting multivariate analysis, particularly when more than three variables are involved (Bryman and Cramer 1997). Variables for business success are the

Table 10.6 The Regression Model Results

Business Efficiency					
	Unstandardised Coefficients	Standardised Coefficients		t	Sig.
Model	β	B	Std. Error		
(Constant)	.369		.309	1.193	.239
EXPEFUNC	.574	.666	.069	8.270	.000
CONTROL	.246	.255	.078	3.152	.003
JUSTIFIC	.109	.222	.037	2.925	.005
R=0.863 R Square=0.745 F=44.754 Sig. =0.000					

Business effectiveness					
	Unstandardised Coefficients	Standardised Coefficients		t	Sig.
Model	β	B	Std. Error		
(Constant)	.991		.414	2.960	.005
EXPEFUNC	.643	.640	.093	2.393	.021
JUSTIFIC	.153	.267	.050	6.920	.000
ITPOLICY	-.103	-.198	.048	3.063	.004
R=0.811 R Square=0.657 F=29.408 Sig. =0.000					

Competitive Advantage					
	Unstandardised Coefficients	Standardised Coefficients		t	Sig.
Model	β	B	Std. Error		
(Constant)	1.533		.379	4.040	.000
JUSTIFIC	.247	.404	.077	3.196	.002
STRAIMPT	.242	.299	.102	2.367	.022
R=0.578 R Square=0.335 F=11.82 Sig. =0.000					

dependent variables and the other variables are the independent ones in the analogous equations.

Table 10.6 shows the results of multiple regression tests of these variables (the full outcome of the regression test completed by SPSS for Windows is shown in Appendix D). The stepwise method was applied in the multiple regression tests so that the best combination of these variables could be identified. Three variables were entered into the equation for business efficiency improvement: degree of control, IT justification and expected function achievement. The coefficient of determination (R^2) for this model is 0.75, which suggests that 75% of variance in "business efficiency improvement by implementing IT" in the organisations can be explained by these three variables. The F ratio of this model is 44.75 and is significant at 99% confidence level (F sig. = 0.000). This implies that it is extremely improbable that the multiple correlation (R) is zero in the population.

The information also reveals that the significance levels for degree of control, IT justification and expected function achievement are 0.000, 0.003 and 0.005 respectively. These are consistent with the F ratio analysis and suggest that the coefficients for these three variables are highly unlikely to be zero in the population. Furthermore, the tolerances for degree of control, IT justification and expected function achievement are 0.856, 0.845 and 0.963 respectively, suggesting that multicollinearity is unlikely to occur in this model.

Three variables were also entered into the equation for business effectiveness improvement: IT justification, IT development policy and expected function achievement. The coefficient of determination (R^2) for this model is 0.66, which suggests that 66% of variance in the outcome can be explained by these three variables. However, it should be noted that the standardised coefficient (β) of IT development policy is –0.13, which means that the influence of IT development policy is negative (towards centralised control). The F ratio of this model is 29.408 and is significant at 99% confidence level (F sig. = 0.000). The significant levels of these three variables are at 99% confidence level or better, which suggests that the coefficients for these three variables are unlikely to be zero in the population. Multicollinearity is also unlikely to occur in this model.

The result showed that only two variables entered into the equation for business competitive advantage: IT justification method and strategic importance of their IT systems. The cqefficient of determination (R^2) for this model is 0.34, which suggests that this model explained 34% of variance in the outcome. The F ratio of this model is 11.82 and is significant at 99% confidence level (F sig. = 0.000). The significant levels of these three variables are at 99% confidence level or better. Thus, multicollinearity is also unlikely to occur in this model.

The above regression analysis suggests that five organisational variables have a vital influence on the outcome of a contractor's IT implementation performance in terms of business success. A summary of these five variables is discussed below.

(1) Degree of control

The degree of control, as one of the factors to classify organisational structure developed by Lansley and Quince (1982), was found to have a vital influence on business efficiency improvement through implementing IT. According to Lansley and Quince, the indicators for tight control are a high degree of differentiation between functional tasks, narrow chain of command, extensive and obligatory use of well defined systems and procedure, and strict and well defined short-term performance objectives. The statistical results suggest that the Taiwanese contractors with these organisational elements are more likely to achieve better IT performance in business efficiency improvement.

(2) IT justification method,

The IT justification method before the decision to adopt new IT was found to have critical impacts on the achievement of business efficiency, effectiveness and competitiveness improvement through implementing IT. As discussed in Chapter 7, some of the IT assessment techniques are traditional quantitative calculations in financial sphere, while others are based on more qualitative way for strategic benefits. The result suggests that the contractors in Taiwan whose IT justification methods focus on long-term strategic opportunity assessment rather than on short-term financial payback are more likely to find those three IT benefits. This result is rational since organisations assessing IT on long-term strategic basis are more likely to link the IT projects to their core business strategies and goals.

(3) IT development policy,

As discussed in Section 5.2, a centralised IT management style is good for management culture, business vision and decision making, while the decentralised approach is good for department and user support. However, the regression tests show that the contractors whose IT development policies towards centralised control are more likely to obtain business effectiveness through implementing IT. This may be explained by the fact that a centralised IT development policy can help an organisation to integrate different IT systems used in different departments, as well as link the IT with their business visions and strategies.

(4) Strategic importance of IT system

As discussed in Section 8.3, the judgement of the value for the IT project may vary in different organisations due to disparities in the organisation's contexts. The perceived value of the IT project by management may influence the decision on how to manage it. The results show that the contractors who mainly invested in IT systems which were regarded as of high strategic importance were more likely to obtain business competitiveness improvement through implementing IT. This result is rational since that IT systems which are of high strategic importance to the organisations are critical to achieve future business success.

(5) Expected function achievement.

One of the IT technical success variables "expected function achievement" was found to have significant influence on business efficiency and effectiveness improvement. However, this variable is not found to have a significant impact on business competitive advantage. Perhaps this can be explained by the frequently stated argument in much of the literature that organisations should align their IT applications with corporate strategy in order to obtain competitive advantages.

This above finding suggests that a tighter control in organisational structure, a long-term strategic opportunity based assessment, a centralised IT development and control policy, a focus on IT systems with high strategy importance and a better expected function achievement in IT technical success are more likely to result in a greater impact of IT implementation on business success. Consequently, further research regarding IT implementation performance in Taiwanese contractors should pay much attention to these five critical variables.

10.3 Discussion and conclusion

This chapter has identified the relationship between IT implementation performance outcome and organisational characteristics in construction organisations. It was found that seven, four and two organisational variables were significantly associated with business efficiency, effectiveness and competitive advantage improvement respectively. This finding answered the first main research question that organisational characteristics have can influence IT performance in organisations. Some of these variables in different categories are also associated with each other. A generic alignment model representing the relationship between these variables and IT implementation performance was also developed in this chapter, which answered the second main research question described in Chapter 8. This alignment model can be used as a diagnostic tool to examine contractors' existing IT systems and organisational characteristics. Barriers to successful IT implementation for business success in construction organisations can then be identified.

Five critical factors for business success by implementing IT innovation were also identified using multivariate analysis techniques. These five variables were found to have a critical influence on the outcome of IT innovation, which answered the third main research question described in Chapter 8. Consequently, this research suggests that contractors should examine these variables much more closely while making new IT investment decisions in order to achieve better IT implementation performance.

Chapter 11: Conclusions and Recommendations

11.1 Summary

In this thesis, the concept of information technology (IT) was introduced. IT is the term that describes the computer-based technology that not only stores and transfers data but also actively processes and handles information. The technology encompasses computer systems, telecommunication networking and multimedia applications. Recently, organisations have become more aware of the potentials of IT and have started to apply IT to improve, downsize or optimise their business processes and organisational infrastructures in order to cope with the increasing competitive climate of the global economy.

IT can be used as an enabler for organisations to redesign and re-engineer their various missions and operations in business processes. IT also provides opportunities for integrating business functions at all levels within and between organisations. Innovative use of IT with the business re-engineering process (BPR) is a popular way to increase business efficiency and effectiveness in organisations. Organisations can either use IT as the enabler for their business re-engineering process, or apply BPR as part of their SISP process to enhance the implementation of IT innovation projects.

IT benefits can be categorised into three main objectives: to improve the efficiency of business operations, to increase the effectiveness of management, and to enhance competitiveness directly. Indeed, organisations that have successfully implemented IT within their systems often enjoy an advantageous edge over their competitors. However, the competitive edge may be easily narrowed since the same technology may be purchased with relative ease by their competitors. Consequently, organisations should strategically manage their IT according to their business processes to maximise the competitive advantages obtained by using IT. Strategic information system planning (SISP), as introduced in Chapter 2.6.1, helps organisations identify IT applications which support organisational strategies. SISP also provides frameworks and techniques for the effective implementation of IT.

There are also constraints in the implementation of IT in organisations. These constraints predominantly originate from the technology itself and the IT users. Technological constraints include, for example, compatibility problems of new technology with existing systems in the organisation and even with those across organisational boundaries to suppliers or customers. On the other hand, constraints imposed by IT users may refer to their resistance to IT implementation and its utilisation within organisations. The resistance may come from fear of change in work patterns or their lack of relevant skills for the new IT systems. These constraints can prevent the full implementation of the new IT or delay the time scale of the IT project. Consequently, assessments of new IT proposals to identify potential constraints are required.

There are many traditional and modern assessment techniques available for IT investments, as listed in Table 7.1. The traditional approaches, such as CBA and ROI, are based on classical cost accounting and focus mainly on financial aspects. The modern ones, such as Information Economics and SESAME, have been developed specially for IT investments. These modern approaches do not only measure IT investments in financial terms, they also provide assessments for other non-financial values. IT assessment provides organisations with the answers to potential questions concerning new and existing IT systems, as well as the possible outcome in terms of organisational interests. It also helps organisations to reduce uncertainty in IT innovation and provides reassurance that the proposed project is likely to have a predicable outcome.

However, SISP and IT assessment techniques cannot ensure the successful outcome of IT innovation implementation in organisations. There are many examples of IT projects which clearly met their design objectives and were well assessed, but could hardly be considered successfully implemented. In addition, no research has been undertaken to investigate the relationship between organisational characteristics and IT implementation outcome in the construction sector. Consequently, this research aims to identify if the outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics, as well as to determine the factor(s) that influence the outcome of IT implementation in construction organisations. The literature on innovation and organisational change has described the importance of individual and organisational characteristics as the antecedents of organisational innovation and change. These theoretical concepts may provide useful insights into the relationship between organisational characteristics and IT implementation performance in construction organisations.

This research has provided an explanatory framework for understanding the role of organisational characteristics in the process of implementing IT innovation. This framework, as shown in Figure 8.2, is used to identify the variables that may influence the implementation and outcome of IT innovation in construction organisations. Five elements were deployed in the framework. The "inner context" refers to the characteristics of the organisation itself, including strategy, culture, management, human resources and policy. The "outer context" refers to the industry, economy, politics, markets, and competitive environment in which the organisation operates. The "content" element refers to the particular areas of change under examination. The "process" element refers to the action and implementation of the change and the interaction and reaction from the participants in this change. The "outcome" element refers to the IT implementation performance.

The development of this framework was based on the concept that variables inherent within the organisation's outer context and inner context may affect the content of change, as well as the process of change. The interplay between these variables in the three elements of change can influence the performance of the IT implementation project. Evaluation, installation and consolidation are the three stages of the implementation process of IT innovation. The successful outcomes of these stages are adoption, technical success and business success respectively. This framework was used to answer the main research questions in this study.

This research has emphasised the importance of organisational characteristics for the successful outcome of IT implementation performance in business processes. The interviews with 50 Taiwanese contractors in this research identified 16 organisational variables which could statistically explain the interplay between IT implementation performance and organisational characteristics. Among them, 9 organisational variables were found to be statistically associated with achieving business success through IT implementation, as shown in Table 10.2,10.3 and 10.4.

Moreover, a further statistical analysis identified 5 critical factors which have a vital influence on the outcome of the contractors' IT implementation performance in terms of business success, they are "Degree of Control", "IT justification method", "IT development Policy", "Strategic Importance of IT system" and "Expected Function Achievement". This research found that IT implementation may contribute to a greater degree of business success in organisations that have a tighter control in organisational structure, a long-term strategic opportunity based assessment, a centralised IT development and control policy, more focus on IT systems with high strategy importance and a better expected function achievement in IT technical success. These five critical factors can be used to help diagnose the IT implementation process in construction organisations and can be applied to help achieve a better outcome from new IT innovations.

The descriptive statistical results from the instruments provide extra information regarding the organisational characteristics and IT implementation among the Taiwanese contractors. This research also investigated the current use of IT systems by Taiwanese contractors. Figure 9.2 showed the most common IT systems used by the contractors interviewed. However, VR (virtual reality) was not used by any of the contractors. Certain IT systems, such as accounting, spreadsheets and networking, were found to have a high impact on business performance for the contractors.

The research also found that financial and information management are the two business processes which benefit more from the use of IT. The benefit of marketing through IT, on the other hand, is most difficult to be achieved. Most of the IT systems acquired by the contractors were purchased off-the-shelf. This is because the contractors feel that outsourcing IT to external IT suppliers is usually expensive and requires a long time for system development and modification.

The research found that most of the contractors in Taiwan are reluctant to change their organisational structure for IT projects because they fear that any failure in the change of organisational structure can bring about disaster to their business. They prefer to adopt IT systems which are compatible with their current organisational infrastructure, working processes, data flows and business activities. Consequently, BPR is rarely found among the contractors. As advocated in the concepts of business process innovation and re-engineering, IT is unlikely to bring business competitive advantage unless the organisations adopt a company-wide business process improvement. As a result, it is not surprising to find that the achievements in terms of business competitive advantage through implementing IT among these contractors are not significant.

The research also identified seven common problems encountered by the contractors interviewed in Taiwan. The major causes of the problems relate to both "human" and "technology" issues. Nearly all contractors found that IT professionals are difficult to recruit in Taiwan. The resistance of senior staff to the use of IT is common among the contractors. IT sourcing and coding problems stem from the technology itself. These problems can prevent Taiwan's construction organisations from realising the full potential of IT innovations. This research suggests that IT education for construction professionals is urgent and vital. In addition, the government, research authorities and the industry should work together to remove barriers to IT innovation in the construction industry.

11.2 Generalisations

◆ About IT innovation

The increasing competitiveness of the global economy encourages organisations to consider adopting IT innovation for business survival. The use of IT ahead of competitors can bring initial competitiveness, however, such competitiveness may not last very long since competitors can easily purchase the same technology. Organisations which intend to maintain their competitiveness through IT innovation must develop and manage strategically and in line with business processes so that their competitors cannot merely copy the IT system since such innovation is exclusively designed for the organisation. There are many SISP technologies available to help organisations with their own IT innovation. IT innovation is risky; it also takes time to develop new systems. Organisations should evaluate their IT innovation proposals effectively to reap the expected IT benefits. Moreover, changes in organisational structures and business processes are required for effective IT innovation.

◆ About IT innovation in the construction industry

Construction organisations have become increasingly aware of the potential uses and benefits of IT. Many surveys show that the use of IT in the construction industry has been rapidly increasing in recent years. However, the diffusion of IT innovation in the construction industry still lags behind other sectors. This is due to the fact that certain unique features in the industry prevent the full implementation and development of IT innovations. In order to overcome these barriers, authorities in many countries have launched promotion schemes to support the diffusion of IT innovation in the construction industry. One of the best-known examples is the Construct IT Centre of Excellence in the UK. The Centre was set up by major clients, contractors, consultants, suppliers, IT organisations, universities and research institutes and the Department of the Environment Transport and the Regions. The project aims to co-ordinate and promote research in IT in the UK construction industry to improve competitive performance of the UK construction industry.

- About IT innovation in Taiwan's construction industry

The field studies show that most of the contractors interviewed in Taiwan give much credence to the vital role of IT innovation for improving business performance. However, IT systems are still regarded as separate tools by most of the organisations rather than integrated with core business functions. This can be explained by the engineering background of top management and the traditional working culture in the industry. Moreover, most top managers in the organisations lack sufficient IT knowledge and competence. Consequently, IT managers need to take full responsibility for the entire IT development process in the organisations. Some IT management tasks, which should normally be delegated to general business managers, are then deferred to IT managers. In such circumstances, IT managers need to have sufficient knowledge of construction business processes in order to facilitate effective IT innovations for business requirements.

The survey in Taiwan highlighted many common IT problems encountered by the contractors in Taiwan. These problems can prevent the diffusion of IT innovation in the industry. The establishments of sufficient knowledge of IT and a "correct" vision of IT innovation are the vital keys to improvement. Educators and construction organisations need to work together to define and implement sound IT education and practical IT skills training for both engineering students and construction professionals in Taiwan. The government should also establish policies and promotion schemes to encourage the diffusion of IT innovation in the construction industry.

◆ Organisational characteristics and business success through IT innovation

In order to obtain competitiveness in today's construction market, contractors have adopted information technology to improve their business processes. However, the results of IT innovation in different construction organisations were found to be different even when they had adopted the same IT systems. The findings of this research suggest that the outcomes of IT innovation for business success are influenced by the different organisational characteristics. Some critical factors are identified which have a vital impact on the outcome of Taiwanese contractors' IT implementation performance in terms of business success. Construction organisations in Taiwan should pay more attention to these five factors to achieve better business success through the implementation of IT.

11.3 Synopsis of findings

The following key points provide a final synopsis of the findings from this research:

- **Research Question (1): Are the outcomes of IT implementation performance in construction organisations influenced by their different organisational characteristics?**

Answer: From the correlation tests in Chapter 10, the statistical evidence suggests that there is a significant correlation between organisational characteristics and IT implementation performance in construction organisations. In other words, the outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics. This conclusion answers this main research question and supports the hypothesis that the successful outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics. The result also reveals that the analytical framework developed by this research can be used to study IT performance and organisational characteristics in construction organisations.

- **Research Question (2): If the outcomes of IT implementation performance in construction organisations are influenced by their different organisational characteristics, does any alignment exist between these organisational characteristics and IT performance in business success?**

Answer: The results of the correlation tests also show that there is an alignment between organisational variables themselves and the outcomes of IT implementation performance. Among the 22 organisational variables proposed in this research, 16 were found to have impacts in the interplays between IT implementation performance and organisational characteristics in the construction organisations. This result answers this research question and supports the hypothesis that there is an alignment between these organisational characteristics themselves and the outcomes of IT implementation performance in construction organisations. The statistical results suggest that the construction organisations that found better IT performance results have some similar organisational characteristics. In other words, it suggests that the alignment of these organisational variables can help to lead to a better IT implementation performance, enabling the contractors to obtain business efficiency, effectiveness and competitiveness improvements. A summary of these organisational variables is shown as follows:

Outer context

The results illustrated that the contractors encountering higher environmental pressures to adopt IT were likely to find more unforeseen IT benefits after system consolidation (rho=0.563). This result is to be expected since organisations which are forced to adopt IT for problem solving or business survival are unlikely to apply detailed investment appraisals. Moreover, the influence of previous IT experiences on future IT strategy and plan was found to be statistically stronger (rho=0.463) among the contractors encountering higher "environmental pressure" (e.g. solving construction project problems or competitors' IT advantages) to adopt IT.

Inner Context

Top management's support for IT was found to be associated with the appointment of project director/champion for IT development (rho=0.42). In other words, the contractors with more support from top management for IT innovation are more likely to appoint a full time project direction/champion for the development of IT. The appointment of IT project directors/champions was found to be associated with both IT technical success and business success.

The degree of control in organisational structure was found to be moderately associated with user satisfaction in IT technical success (rho=0.437) and business efficiency improvement (rho=0.478) in business success. In other words, contractors with tight control in organisational structure were more likely to achieve user satisfaction and business efficiency improvement through implementing IT. Some variables in the organisation's IT strategy were also correlated with other groups of variables. The influence of previous IT experience was found to be correlated with expected function achievement (rho=0.493) and business efficiency improvement (rho=0.489). The contractors who learn from their previous IT implementations for future IT development are more likely to obtain expected function achievement and business efficiency improvement through implementing IT.

The justification method before the decision to adopt new IT was found to have a positive correlation with all the three business success variables. In other words, the contractors whose IT justification methods focus on long-term strategic opportunity assessment are more likely to obtain business success through implementing IT systems.

The policy for IT development and management and IT sourcing strategy were also found to correlate with other categories of variables. This suggests that the contractors with a centralised IT development and management policy were more likely to obtain expected IT function achievements (rho=-0.407). As to the IT sourcing strategy, the contractors who chose outsourcing to external IT suppliers were more likely to hire IT experts to assist in system installation.

Content

The perceived strategic importance and operational importance of the IT systems installed by the contractors were found to correlate with other categories of variables. It was found that the contractors who mainly invested in IT systems which were regarded as of high strategic importance are likely to identify better user attitudes towards the new IT (rho=0.446), user satisfaction (rho=0.476), business efficiency (rho=0.427) and competitive advantage improvement (rho= 0.457) through IT. On the other hand, contractors who mainly invested in IT systems which were regarded as highly operationally important were more likely to obtain user satisfaction (rho=0.577), expected function achievement (rho=0.488), business efficiency (rho=0.536) and effectiveness improvements (rho=0.465) through IT. This suggests that the content of IT innovation does have an influence on the process and outcome of IT innovation in the contractors.

Process

Users' attitude and the appointment of project directors/champions are the two variables with statistical correlations with variables in other categories. Users' attitude towards the new IT was found to be positively associated with the two technical success variables (rho= 0.422 and 0.485 for user satisfaction and expected function achievement respectively). It is also positively associated with efficiency improvement (rho=0.559) and effectiveness improvement (rho= 0.429) for business success. Project directors/champion also play an important role in IT innovation outcomes in this study. The results show that use of a project director/champion is positively correlated with business efficiency improvement (rho= 0.475) and user satisfaction in technical success (rho=0.471).

- **Research Question (3): Is there any organisational factor that can critically influence the outcome of IT implementation in construction organisations? What are they?**

Answer: The regression analysis in Chapter 10 identified 5 critical organisational variables which have a great impact on IT performance in the contractors in Taiwan. The results showed that five variables: Degree of Control, IT justification method, IT development Policy, Strategic Importance of IT system and Expected Function Achievement have vital influences on the outcome of contractor's IT implementation performance in business success. On this evidence, it is suggested that a tighter control in organisational structure, a long-term strategic opportunity based assessment, a centralised IT development and control policy, focus on the IT systems with high strategy importance and a better expected function achievement in IT technical success are likely to result in a better IT implementation performance on business success. This result answers this research question and supports the hypothesis that there are certain organisational factors which have significant impacts on the outcomes of IT implementation performance for business success in construction organisations.

- **Research Question (4): What is the current use of IT applications in Taiwan's contractors?**

Answer: This research also investigates both the organisational characteristics and current use of IT systems in the Taiwan's construction organisations, which answers the fourth research question in this study. A summary of findings is shown as follows:

Organisational characteristics

It shows that more than half of the Taiwanese contractors in the survey still have a traditional bureaucratic structure. However, some companies adopt a mechanistic structure in order to cope with the uncertainty in construction projects. Most of the companies (80%) adopt "products/services differentiation" as their main business strategy for business competitiveness.

IT strategy, policy and assessment

Most of the companies (90%) in the survey have outsourced their IT systems to external suppliers, but very few of them outsource **all** their IT systems. "Solving project problem" is considered to be the primary reason for IT implementation in these organisations. The contractors in Taiwan assess their IT investments on a long-term strategic opportunity basis. However, they usually adopt *ad hoc* ways to evaluate new IT projects.

Moreover, most of the IT managers (80%) feel that the level of top management's IT competence and knowledge is low. However, their support for IT innovations is relatively high. About 80% of the companies frequently invite IT users to be involved in the decision making process of new IT. And most of the companies indicated that their staff are highly committed to the use of IT. More than half of the companies frequently appoint project directors/champions for new IT projects.

IT performance

Most of the companies (90%) believe that most of the IT systems they installed are generally satisfactory to the users. In addition, more than 94% of the contractors interviewed believed the expected functions of their IT systems are generally achieved. Moreover, "finance", "information management" and "client management" are the top three business process areas mostly benefited by IT implementation in these companies. The benefit of IT in "marketing", on the other hand, is most difficult to achieve.

- **Research Question (5): Is there any IT implementation barriers and problems encountered by Taiwan's contractors? What are they?**

Answer: This research has also identified some common IT implementation problems and barriers encountered by the contractors in Taiwan. These problems are listed as follows:

(a) The dilemma for IT sourcing;

(b) The difficulty of recruiting IT staff;

(c) The resistance to using IT;

(d) The full benefits of IT cannot be achieved in the construction organisations;

(e) The development of computer technology is too rapid;

(f) The role of IT in the construction industry is misunderstood;

(g) The potential problem for data exchange through IT between construction organisations.

It is suggested by this research that the industry, government and academic authorities should work together in order to remove these barriers for IT innovation in the construction industry in Taiwan.

11.4 Contributions of this research

This study has contributed to research on the implementation of IT in the construction industry, with the introduction and articulation of the concept that organisational characteristics have a major impact on achieving business success through IT implementation in organisations. This research attempts to bring the theoretical concepts of organisational change and the innovation processes together to explain the interactions between different organisational elements and innovation process steps as well as the outcome of IT innovation. This methodology is not found applied in the literature. By adopting such a perspective, this research changes the focus from viewing IT innovation assessment as merely project-orientated to a company-wide perspective and argues that research in IT implementation should not ignore organisational context factors. In other words, effective IT innovation assessment should also include a study of both organisational characteristics and project implementation processes.

In contributing to research practice, this research presents a working framework for analysing the interplay between the elements of organisational characteristics, innovation process and outcomes. This framework could be used to conduct further studies of IT implementation performance and organisational elements in the construction industry. It can be applied to analyse both the existing IT systems and future IT innovation projects. In addition, the results of this research support the argument that organisational characteristics have a major impact on IT implementation performance in terms of achieving business success. Some critical organisational variables which have a great impact on the IT implementation performance in these Taiwan's contractors have also been identified. The results provide IT managers in construction organisations with a way to understand the effects of organisational characteristics on their IT innovation project and a way of diagnosing their IT implementation performance problems and obtain better results from new IT innovation projects.

Moreover, the research adopted a hybrid approach in order to bring both richness and standardisation to the data collection. A structured research instrument was applied in the interviews to obtain quantitative data. Through the instrument, a standardised collection of key items of data for statistical analysis could be obtained. The semi-structured qualitative interview could also provide in-depth insights into the views of the IT managers interviewed, which provide a general, if somewhat personal, sense of the current situation of the implementation of IT in Taiwan's construction industry.

The interview process also helped to eliminate any misunderstanding of the questions in the instrument, which enhanced the clarity of the content of the questions. This approach combines the strengths of both quantitative and qualitative data collection methods. The interviews, conducted with 50 contractors in Taiwan, provided a large enough sample to allow the application of any statistical technique for data analysis. This study demonstrated the use of this data collection approach and the outcome underlined the appropriateness of this approach for similar research in the field of IT.

Research on the implementation of IT in the construction industry has grown in developed countries, particularly the UK and the USA. The literature is dominated by research highlighting investigations in a small number of developed countries. This research contributed to the IT research field in the UK by providing in-depth analysis of IT implementation in the construction industry of an Asian developing country. The information provided by this study enables IT researchers and professionals to understand the current IT applications and problems encountered by Taiwan's construction industry. The challenges that Taiwan faces are heightened by deficiencies in organisational vision, management style, organisational culture, and skilled IT personnel. The problems and challenges of IT implementation in Taiwan described here may also be found in other countries, and for which lessons can be drawn.

11.5 Limitations

There are limitations in this research work that should be noted. The research presents an attempt to explain the relationship between organisational characteristics and IT innovation performance in terms of improving business success in the construction industry. The concepts which incorporate from both organisational change and innovation process theories are relatively new in the domain of IT research for the construction industry. The application of the concepts to IT in construction is pioneering and original in many respects. Consequently, the proposal of this research should be regarded as an initial attempt to identify the key factors for business success improvement through IT implementation.

This research proposed 24 potential organisational variables and identified 9 of them to be the factors significantly correlated with achieving business success through IT. However, due to limits of time and finances, the researcher could not conduct a further longitudinal study to trace the development process of IT innovation projects in the organisations in Taiwan over a long period of time.

Furthermore, the field-work of this research was mainly conducted in Taiwan. The results of the data analysis in this research can only be considered to be representative of the situation in Taiwan's construction industry. The results may be different in other countries such as the UK or USA, due to a different culture, environment and business behaviour. Consequently, further research conducting similar investigations in different countries is recommended.

11.6 Recommendations for further research

As mentioned previously, there is a need to carry out similar investigations in other countries such as the UK or USA. More empirical investigations from different countries can provide additional support for the framework developed in this research.

Furthermore, comparisons between construction organisations in different countries with regard to their organisational characteristics and IT implementation performance are also suggested. Comparing empirical work can help to substantiate the concepts raised in this research and determine if there is a significant difference in the relationship of organisational variables and IT implementation performance between different countries.

This research identified some common IT problems encountered by construction contractors in Taiwan. Construction organisations in other countries such as the UK or USA may face similar problems. However, further investigation is needed in these countries. One of the problems of IT implementation in Taiwan concerns the incompatibility of "codes" between IT systems in different organisations. Such problems can limit the full potential of using IT to exchange data automatically. As discussed in Chapter 9, the contractors are unlikely to give up their own codes. Consequently, the use of an interface to communicate different codes between different organisations may be a key solution. Further research on this issue is also suggested.

IT education for the construction professions is suggested as a key factor for establishing the basis for IT diffusion in the construction industry. Education cannot only reduce the degree of resistance to using IT, but can also help top management to establish a more progressive vision of IT innovation. However, unlike other manufacturing industries, most construction site work is done manually. Automation in construction work is very rare. This unique characteristic of the construction industry is usually used by construction professionals as an excuse for their resistance to using IT. The links between IT education and the unique characteristics of the construction industry remain unclear. Further research specifically exploring this education issue should identify practical issues to be addressed by political and educational authorities and the industry.

The research finds that previous IT experience plays an important role in the IT implementation of the organisations. Some contractors learn from their previous IT history and adjust their future IT planning and strategies accordingly. Others claim that their future IT development plans will not be influenced by previous positive or negative IT cases. There is no doubt that learning from successful and unsuccessful IT cases are important for future IT success. However, learning from previous successful behaviour implicitly introduces rigidities into the IT development process. Such rigidities can prevent the innovative use of IT. Consequently, further research regarding organisational learning behaviour in the construction industry is recommended.

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APPENDICES

(A) The Research Instrument (English Edition)

(B) The Research Instrument (Chinese Edition)

(C) The Full Results of Spearman's rho Correlation Matrix Between all the Variables

(D) Full Result of Step-Wise Multiple Regression Test

APPENDIX (A)

Case No.________

AN INVESTIGATION OF INFORMATION TECHNOLOGY INNOVATION IN CONSTRUCTION

COMPANY NAME:..

ADDRESS...
....
....
....

INFORMANT'S
NAME...

JOB
TITLE...

NAME OF DIVISION / BUSINESS
UNIT:...

APPENDIX (A)

Section A: Company Demographics

1. What type of work is your organisation mainly involved in?

   ❒ Building Engineering ❒ Civil Engineering ❒ Engineering Consultant

   ❒ Architecture design

2. Please indicate the distributions of your project turnover and their percentages.

   ❒ Regional ________________%
   ❒ National ________________%
   ❒ International ________________%

3. How many full time employees are there in your company?

   ❒ Under 50 ❒ 50-200 ❒ 200-700 ❒ 700-1200 ❒ Over 1200

4. What was the turnover of your company last year (New Taiwan Dollar)?

   ❒ Under $ 500 M ❒ $ 500-1500 M ❒ $ 1500-3500 M ❒ $ 3500 M-6000 M ❒ Over $ 6000 M

Section B: IT infrastructure

1. What is the amount spent on IT in the organisation as per year (including hardware, software and staff training costs)?

   ❒ Under $0.5 M ❒ $0.5-1 M ❒ $1-5 M ❒ $5-10 M

   ❒ Over $10 M

2. How many staff are devoted full-time to the IT function in your organisation?

   ❒ Under 5 ❒ 5-7 ❒ 7-10 ❒ 10-15 ❒ Over 15

3. How many computers are used in your organisation currently (including mainframes, minicomputers, and portable computer)?

❒ Under 30 ❒ 30-70 ❒ 70-120 ❒ 120-150 ❒ Over 150

4. Does your organisation install any networking connection?
   - ❒ Local Area Networks
   - ❒ Wide Area Networks
   - ❒ Internet Connections

Section C: Organisational characteristics and management style

1. The followings describe different sets of opposite organisational structure characteristics. They maybe more or less appropriate to your organisation. Please indicate which position (5 scale) best matches your organisational structure:

Integration

Grouping of staff

Hierarchical structure with stable division/department based around function	1	2	3	4	5	Team structure with temporary work group/team based around task

Communication

Lateral and informal communication method	1	2	3	4	5	Vertical and formal communication method

Job information

Flexible job definition, unreliable and often conflicting	1	2	3	4	5	Rigid job definition, reliable and rarely conflict

APPENDIX (A)

<u>Control</u>

Specification

Low degree of differentiation between functional tasks	1	2	3	4	5	High degree of differentiation between functional tasks

Reporting relationships

Broad chain of command; authority based on circumstances	1	2	3	4	5	Narrow chain of command; authority based on seniority in hierarchy

Use of system and procedures

Informal and *ad hoc* systems and procedures	1	2	3	4	5	Extensive and obligatory use of well defined systems and procedures

Performance Standard

No clear performance objectives below operating unit level	1	2	3	4	5	Strict and well defined short term performance objectives set at department and project level

2. What is your major business strategy for competitiveness?

1 2 3 4 5

Note:

(1) Focus entirely on cost reduction;

(2) Focus on cost reduction mainly, providing different services/products occasionally;

(3) Focus on both cost reduction and different services/products

(4) Focus on providing different services/products mainly, cost reduction occasionally;

(5) Focus entirely on providing different services/products.

3. What is your policy for IT development and management?

Total Centralised development and control	1	2	3	4	5	**Total Decentralised development and control**

Section D: Project environment and IT

1. To what extent have governmental regulations or promotion programmes influenced your decision to adopt IT?

Not at all	1	2	3	4	5	**Very much**

2. To what extent have your competitor's IT advantages influenced your decision to adopt IT?

Not at all	1	2	3	4	5	**Very much**

3. To what extent have the other companies' uses of IT in the project influenced your decision to adopt IT?

Not at all	1	2	3	4	5	**Very much**

4. To what extent have your project client's requirements influenced your decision to adopt IT?

Not at all	1	2	3	4	5	**Very much**

5. To what extent have project challenges (e.g. solving project problem) influenced your decision to adopt IT?

Not at all	1	2	3	4	5	**Always**

Section E: IT strategy

1. In your opinion, do your early IT investment cases and experiences have any influence on your organisation's future IT strategy and plan?

Very Little	1	2	3	4	5	**Very Strong**

2. Please indicate whether the IT sourcing in your organisation is toward in-house development (including off-the-shelf package buy-in) or outsourced to external IT suppliers

Total developed in-house or purchased as package	◄ 1	2	3	4	5 ►	**Total Outsourced to external IT suppliers**

3. If your main IT procurement policy is outsourcing to external suppliers, what are the criteria used to select these suppliers? Please also indicate their importance in your consideration (from 1 to 5, 1= less important, 5= very important)

- ❑ Cost (importance level_______)
- ❑ Quality (importance level_______)
- ❑ Supplier's reputation (importance level_______)
- ❑ Speciality (importance level_______)
- ❑ Lead time (importance level_______)
- ❑ Service (importance level_______)
- ❑ Maintenance (importance level_______)
- ❑ Others ___________ (importance level_______)

4. How are major IT investments justified in your organisation before implementation?

Focus on short-term financial payback assessment	◄ 1	2	3	4	5 ►	**Focus on long-term strategic opportunity assessment**

4a. Please briefly describe the justification method you used for new IT investment proposal.

....

....

....

....

5. How do you assess the risks associated with your IT investment?

No specific risk assessment applied	◄ 1	2	3	4	5 ►	**Formal risks assessments including financial, technology, business and strategic risks**

6. What kind of technology do you prefer to be involved in your major IT investments?

Highly mature systems with industry-standard technology	◄ 1	2	3	4	5 ►	**Recent invented, powerful and high-tech system, may with or without industry-standard technology**

Section F: IT development and profile

1. Please indicate the top management's IT competence and knowledge in your organisation?

Low competence	◄ 1	2	3	4	5 ►	**High Competence**

2. Please indicate the degree of the top management's support for IT innovation in your organisation.

Low support	1	2	3	4	5	**High support**

3. Are the IT users involved in the decision making process on IT investment? (5 scale)

Never	1	2	3	4	5	**Always**

4. What are the staff's attitudes toward the use of new IT system in your organisation?

Reluctant to accept	1	2	3	4	5	**Highly committed**

5. Please select the systems used in tour company and identify their degrees of **business strategic importance** and **business operational importance** of the IT systems in your organisation separately.

(a) **Strategic importance**

Application types	Business strategic importance				
	1 (Not important)	2	3	4	5 (very important)
Word processing					
Desktop publishing					
Spreadsheets					

Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographical information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					
Law and regulations reference					
Property management system					
Others (please specify)					

(b) Operational importance

Application types	Business operational importance ←→				
	1 (Not important)	2	3	4	5 (very important)
Word processing					
Desktop publishing					

Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographical information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					
Law and regulations reference					
Property management system					
Others (please specify)					

Section G: IT Implementation and performance

1. When you start to install your new IT system, do you appoint a full-time project director/champion for the project?

Never ◄──────► **Always**

1 2 3 4 5

2. Do you hire any external IT expert for your new IT system development and installation?

Never ◄──────► **Always**

1 2 3 4 5

3. Do you change your organisational structure in order to improve a certain working IT system?

Never ◄──────► **Always**

1 2 3 4 5

4. Do you change your working process in order to improve a certain working IT system?

Never ◄──────► **Always**

1 2 3 4 5

5. How does your organisation measure the IT implementation performance?

Mainly on quantifiable benefits such as cost reduction ◄──────► **Mainly on non-quantifiable benefits such as client satisfaction**

1 2 3 4 5

6. In which of the following business process areas did you realise benefits were delivered by your IT investments? Please also indicate the degree of significance of the benefits.

Business Process	Benefits measured				
	1 (Not significant)	2	3	4	5 (Very significant)
(1) Marketing					
(2) Information management					
(3) Procurement					
(4) Finance					
(5) Client management					
(6) Design					
(7) Construction					
(8) Operation and maintenance					
(9) Human resources					

7. Have you gained any unforeseen benefits from your IT investments after installation?

Never ◄——————————► **Always**

1 2 3 4 5

7a. If so, please give example.

....

....

....

....

8. Please indicate the degree of user-satisfaction in your IT applications (e.g. easy of operation, user friendly interface and system reliability) (5 scale)

Application types	Very Low ←			→ Very High
	1	2	3	4	5
Word processing					
Desktop publishing					
Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographical information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					
Law and regulations reference					
Property management system					
Others (please specify)					

9. Were the expected functions of your IT applications fully achieved after they were installed? Please indicate the degree of satisfaction in the level of achievement for your IT projects

Application types	Very Low ← 1	2	3	4	→ Very High 5
Word processing					
Desktop publishing					
Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographic information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					
Law and regulations reference					
Property management system					

Others (please specify)					

10. Please grade the success of your IT investments according to the degree of contributions in improving your **business performance** after system installed and consolidated in term of **EFFICIENCY**? (5 scale)

Application types	**Not Significant** ←				→ **Very Significant**
	1	2	3	4	5
Word processing					
Desktop publishing					
Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographic information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					
Law and regulations reference					

Property management system					
Others (please specify)					

11. Please grade your IT investments according to the degree of contributions in improving your **business performance** after system installed and consolidated in terms of **EFFECTIVENESS**? (5 scale)

Application types	**Not Significant** ←		→		**Very Significant**
	1	2	3	4	5
Word processing					
Desktop publishing					
Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographic information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					
WWW site homepage					

Law and regulations reference					
Property management system					
Others (please specify)					

12. Please grade your IT investments according to the degree of contributions in improving your **business performance** after system installed and consolidated in terms of **BUSINESS COMPETITIVE ADVANTAGE**? (5 scale)

Application types	**Not Significant** ◄		────		► **Very Significant**
	1	2	3	4	5
Word process					
Desktop publishing					
Spreadsheets					
Image processing					
Construction equipment management					
Video Conferencing					
Management information system					
Decision support system					
Accounting system					
Human resource management system					
Material Procurement system					
Contract management system					
Estimating / Valuation system					
CPM schedule control					
Geographic information system					
Structure analysis system					
Fluid/Geological analysis system					
Electric data interchange					
Networking					
2D CAD					
3D CAD					
Virtual Reality (VR)					
Multimedia briefing					

WWW site homepage					
Law and regulations reference					
Property management system					
Others (please specify)					

13. Please give any further information regarding your IT systems, implementation process and any problem encountered. Thank you.

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APPENDIX (B)

Case No.________

THE BARTLETT SCHOOL OF GRADUATE STUDY
UNIVERSITY COLLEGE LONDON

台灣營造建築業 電腦資訊化研究調查

公司行號:

地址:

受訪者姓名:

部門:

職稱:

APPENDIX (B)

Section A: 公司概況

1. 貴公司主要經營項目爲何(可復選)?

   ❐ 營造建築　❐ 土木工程　❐ 工程顧問　❐ 建築設計

2. 貴公司工程案件分布狀況爲何?

   ❐ 貴公司所在縣市　______________%
   ❐ 貴公司所在縣市以外之地區　_______________%
   ❐ 國際性案件　_______________%

3. 貴公司有多少全職員工?

   ❐ 少於 50　❐ 50-200　❐ 200-700　❐ 700-1200　❐ 多於 1200

4. 貴公司去年總營業額爲(新台幣)?

   ❐ 少於 5 億　❐ 5 億 – 15 億　❐ 15 億 – 35 億　❐ 35 億 – 60 億
   ❐ 60 億以上

Section B: 電腦資訊架構

1. 貴公司每年花費在電腦上的費用爲何(包括軟硬體及人員訓練等費用)?

   ❐ 少於 50 萬　❐ 50 萬 – 100 萬　❐ 100 萬 – 班 500 萬
   ❐ 500 萬 – 1000 萬　❐ 多於 1000 萬

2. 貴公司資訊部門全職員工共幾人

   ❐ 少於 5 人　❐ 5-7 人　❐ 7-10 人　❐ 10-15 人　❐ 超過 15 人

3. 貴公司目前使用之電腦數量爲多少部 (包括伺服器及個人電腦, 筆記型電腦等)?

   ❐少於 30　❐ 30-100　❐ 100-150　❐ 150-200　❐超過 200

4. 貴公司是否有架設任何網路(可復選)?
   - ❒ 區域連線 Local Area Networks
   - ❒ 廣域連線 Wide Area Networks
   - ❒ 網際網路連線 (Internet)

Section C: 公司特性及管理方式

1. 以下描述兩種不同之公司結構特性, 請依貴公司結構狀況在(1 – 5):選出合適的位置

<u>整合性</u>

人員組別

傳統性公司結構, 各部門各司其職, 負責事務分類清楚	1	2	3	4	5	小組結構, 常依事務所需而組編臨時專案小組

聯絡溝通

平行且非正式性溝通方式	1	2	3	4	5	由上而下, 分層次之正式性溝通方式

職稱工作定義

各職稱的工作內容非常彈性	1	2	3	4	5	各職稱的工作內容單純且穩定

<u>控制性</u>

APPENDIX (B)

功能類別

各部門功能性事務之差異性小	1	2	3	4	5	各部門功能性事務之差異性大

上下層關係

上層可下達命令對象之範圍大, 選擇授權對象依實際狀況爲考量	1	2	3	4	5	上層可下達命令對象之範圍小, 選擇授權對象以資歷爲考量

體制與流程

採用非正式及彈性化之公司體制及工作流程	1	2	3	4	5	高度強調並要求遵守既定公司體制及工作流程

表現標準

執行部門以下階層並無設定明確之工作表現目標	1	2	3	4	5	各部門及工程案件均有設定明確及嚴格之工作表現要求

2. 貴公司的市場競爭策略爲何?

1	2	3	4	5

(1) 完全以低價位策略爲主

(2) 以低價位策略爲主, 提供獨特的產品及服務策略爲輔

(3) 低價位策略與提供獨特的產品及服務策略並用

(4) 以提供獨特的產品及服務策略爲主, 低價位策略爲輔

(5) 完全以提供獨特的產品及服務策略爲主

3. 貴公司電腦系統的發展及控制的政策爲何?

完全由公司統一規劃,開發及控制	1	2	3	4	5	完全由各部門依需要自行開發及控制

Section D: 經營環境與電腦資訊化

1. 政府制定的規範或產業提昇獎勵是否影響到貴公司進行電腦化發展的決定?

完全沒影響	1	2	3	4	5	很大的影響

2. 競爭對手電腦化優勢是否影響到貴公司進行電腦化發展的決定?

完 全 沒影響	1	2	3	4	5	很大的影響

3. 與貴公司合作之其他工程承包商的電腦化優勢是否影響到貴公司進行電腦化發展的決定?

完全沒影響	1	2	3	4	5	很大的影響

4. 貴公司是否因顧客要求影響而考慮進行電腦化發展?

完 全 沒影響	1	2	3	4	5	很大的影響

5. 貴公司是否因工程上的需要影響而考慮進行電腦化發展?

完全沒影響	1	2	3	4	5	很大的影響

Section E: 電腦資訊化策略

1. 請問貴公司未來電腦化投資的政策, 是否會受目前電腦化的結果影響?

完全沒影響	1	2	3	4	5	很大的影響

2. 請問貴公司的電腦化發展是偏向於自行採購發展或是全部委託給其它電腦顧問公司發展?

全部自行採購發展	1	2	3	4	5	全部委託給其它電腦顧問公司發展

3. 如果貴公司的電腦化是委託給其它電腦顧問公司發展, 請問選擇這些公司的標準爲何? 並請標示其重要性 (從 1 到 5.　1=不是很重要, 5=非常重要)

- ❑ 價格　(重要度______)
- ❑ 品質　(重要度______)
- ❑ 公司形象 (重要度______)
- ❑ 專業性 (重要度______)
- ❑ 所需之開發時間 (重要度______)
- ❑ 服務 (重要度______)

- ❑ 維護(重要度______)
- ❑ 其它 __________ (重要度______)

4. 貴公司如何評估計劃發展之電腦化案件?

偏向於短期的投資報酬率結果	◄—— 1	2	3	4	5 ——►	偏向於長期的產業策略性優勢

4a. 請簡略說明貴公司評估的方法.

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______

5. 貴公司如何評估計劃發展電腦化的風險?

沒有採用任何風險評估	◄—— 1	2	3	4	5 ——►	採用正式性的風險評估方法, 包括財務, 技術及營運策略上的風險評估

6. 貴公司電腦化系統偏好於何種科技標準?

高度成熟性/使用性的電腦系統, 採用業界標準(相容性高)	◄—— 1	2	3	4	5 ——►	新研發成功,功能強大的高科技系統, 可不具業界標準(相容性低)

Section F: 電腦化發展過程

1. 請問貴公司領導階層的電腦知識及能力爲何?

非常低 ←→ 非常高

1 2 3 4 5

2. 請問貴公司領導階層對於電腦資訊化的支持程度爲何?.

非常低 ←→ 非常高

1 2 3 4 5

3. 貴公司電腦資訊化的決策過程中是否要求未來將操作該系統的員工參與?

沒有 ←→ 時常

1 2 3 4 5

4. 請問貴公司員工對於工作環境電腦資訊化的接受程度爲何?

意願不高
免強接受 ←→ 非常有興趣

1 2 3 4 5

5. 以下列出一般常用的電腦系統, 請選出貴公司已採用之系統, 並分別指出該系統對於貴公司的營運策略及營運操作上的重要程度.

APPENDIX (B)

(a) <u>營運策略(</u>是指公司於經營上所採用的各種策略及方針以便於獲得最大的利益)

系統種類	重要程度 1 (非常不重要)	2	3	4	5 (非常重要)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					
k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					
s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					

x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它______________________					

<u>(b) 營運操作</u>(是指公司經營上各項工作流程的實際運作)

系統種類	重要程度 ←→ 1 (非常不重要)	2	3	4	5 (非常重要)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					
k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					

s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它______________________					

Section G: 電腦資訊化之執行與成果

1. 當貴公司該使執行電腦化案件時, 是否指派專案經理來監控整個過程?

從來沒有 ◄────────────────► 時常有

1　2　3　4　5

2. 當貴公司開始執行電腦化案件時, 是否聘用其它外界電腦顧問專家來協助發展及安裝?

從來沒有 ◄────────────────► 時常有

1　2　3　4　5

3. 貴公司是否曾改變公司組織結構, 以配合某套新電腦資訊系統?

從來沒有 ◄────────────────► 時常發生

1　2　3　4　5

4. 貴公司是否曾改變公司營運流程, 以配合某套新電腦資訊系統?

從來沒有 ◄——► 時常發生

1 2 3 4 5

5. 貴公司如何測量電腦資訊化後之成果?

以"量"的方面改善成果爲主(如減少支出等) ◄——► 以"質"的方面提昇成果爲主(如改善客戶滿意度等)

1 2 3 4 5

6. 貴公司於電腦資訊化後,對以下相關之各工作項目的改善程度爲何?

工作項目	改善度				
	1 (非常少)	2	3	4	5 (非常多)
(1) 市場分析					
(2) 資料管理					
(3) 採購					
(4) 財務管理					
(5) 客戶管理					
(6) 設計					
(7) 工程施工					
(8) 機具操作與維護					
(9) 人事管理					

7. 貴公司電腦資訊化後, 是否發現非預期性的益處?

沒有 ◄——————————————► 很多

1 2 3 4 5

7a. 如果有, 請舉例.

....

....

....

8. 請選出貴公司已採用之電腦系統, 並指出電腦操作人員對該系統操作使用上之滿意程度

系統種類	滿意程度 1 (非常不滿意)	2	3	4	5 (非常滿意)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					

k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					
s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它____________________					

9. 請選出貴公司已採用之電腦系統，並評估該系統是否達到安裝前所預期的效果.

系統種類	← 1 (非常低)	2	3	4	5 (非常高) →
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					

d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					
k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					
s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它________________________					

10. 請選出貴公司已採用之電腦系統，並指出該系統對於提升公司營運”效率”(efficiency)上的程度(例如:降低營運成本或縮短流程所需時間等)

APPENDIX (B)

系統種類	提高效率 ←→ 1 (非常低)	2	3	4	5 (非常高)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					
k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					
s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					

z. 財產管理					
其它________________					

11. 請選出貴公司已採用之電腦系統，並指出該系統對於改善公司營運”效果”(effectiveness)上的程度(例如: 改善產品品質或減低人爲錯誤等)

系統種類	提高效果 ←→ 1 (非常低)	2	3	4	5 (非常高)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					
k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					

s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它________________					

12. 請選出貴公司已採用之電腦系統，並指出該系統對於改善公司中長期性營運"競爭力"上的程度.

系統種類	改善競爭力 ←→ 1 (非常低)	2	3	4	5 (非常高)
a. 文書處理					
b. 桌上型印刷出版系統					
c. 試算表					
d. 圖像掃描處理					
e. 工程機具管理					
f. 網際視訊會議系統					
g. 管理資訊系統(MIS)					
h. 決策支援系統(DSS)					
i. 會計系統					
j. 人事管理系統					

k. 材料採購系統					
l. 發包合約管理系統					
m. 工程估價系統					
n. 工程流程管理系統					
o. 地理資訊系統					
p. 結構分析計算					
q. 大地/水利分析					
r. 電子資料自動交換系統(EDI)					
s. 網路規劃連線					
t. 2D CAD					
u. 3D CAD					
v. 虛擬實境					
w. 多媒體簡報					
x. 網際網路網頁					
y. 營建法律規範查詢					
z. 財產管理					
其它________________________					

13. 請約略簡述公司發展電腦化過程及所面臨的問題, 謝謝

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Correlation Tables (Appendix C)

			INTEGRAT	CONTROL	BUSTRA GY	ITPOLICY	ENVFOR CE	PREV.EX P
Spearman's rho	INTEGRAT	Correlation Coefficient	1.000	-.076	-.005	.229	.059	-.056
		Sig. (2-tailed)	.	.599	.972	.110	.684	.701
		N	50	50	50	50	50	50
	CONTROL	Correlation Coefficient	-.076	1.000	.168	-.155	.285*	.186
		Sig. (2-tailed)	.599	.	.244	.282	.045	.196
		N	50	50	50	50	50	50
	BUSTRAGY	Correlation Coefficient	-.005	.168	1.000	-.123	.283*	.183
		Sig. (2-tailed)	.972	.244	.	.393	.046	.204
		N	50	50	50	50	50	50
	ITPOLICY	Correlation Coefficient	.229	-.155	-.123	1.000	-.078	-.304*
		Sig. (2-tailed)	.110	.282	.393	.	.590	.032
		N	50	50	50	50	50	50
	ENVFORCE	Correlation Coefficient	.059	.285*	.283*	-.078	1.000	.463**
		Sig. (2-tailed)	.684	.045	.046	.590	.	.001
		N	50	50	50	50	50	50
	PREV.EXP	Correlation Coefficient	-.056	.186	.183	-.304*	.463**	1.000
		Sig. (2-tailed)	.701	.196	.204	.032	.001	.
		N	50	50	50	50	50	50
	SOURCING	Correlation Coefficient	-.166	.128	.045	.121	.030	.039
		Sig. (2-tailed)	.249	.376	.758	.404	.835	.789
		N	50	50	50	50	50	50
	JUSTIFIC	Correlation Coefficient	-.159	.102	-.048	-.048	.047	.384**
		Sig. (2-tailed)	.269	.483	.738	.740	.746	.006
		N	50	50	50	50	50	50
	RISKASSM	Correlation Coefficient	.332*	.014	.122	.227	.344*	.008
		Sig. (2-tailed)	.019	.925	.399	.113	.014	.956
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			INTEGRAT	CONTROL	BUSTRA GY	ITPOLICY	ENVFOR CE	PREV.EX P
Spearman's rho	TECHNOLO	Correlation Coefficient	-.014	.122	-.116	.017	.349*	.186
		Sig. (2-tailed)	.924	.399	.422	.908	.013	.195
		N	50	50	50	50	50	50
	TMCOMPET	Correlation Coefficient	.055	.156	.067	-.061	.202	.276
		Sig. (2-tailed)	.706	.280	.646	.675	.159	.052
		N	50	50	50	50	50	50
	TMSUPPOR	Correlation Coefficient	-.165	.125	.047	-.055	.109	.311*
		Sig. (2-tailed)	.251	.388	.746	.703	.453	.028
		N	50	50	50	50	50	50
	USERINVO	Correlation Coefficient	-.002	.016	.215	-.050	.210	.299*
		Sig. (2-tailed)	.988	.912	.135	.731	.143	.035
		N	50	50	50	50	50	50
	USERATTI	Correlation Coefficient	-.138	.326*	-.012	-.103	.137	.381**
		Sig. (2-tailed)	.341	.021	.931	.477	.341	.006
		N	50	50	50	50	50	50
	STRAIMPT	Correlation Coefficient	-.115	.276	-.286*	-.322*	.031	.267
		Sig. (2-tailed)	.425	.053	.044	.023	.831	.061
		N	50	50	50	50	50	50
	OPERIMPT	Correlation Coefficient	.045	.315*	-.083	.082	.005	.206
		Sig. (2-tailed)	.756	.026	.567	.571	.971	.151
		N	50	50	50	50	50	50
	CHAMPION	Correlation Coefficient	.047	.378**	.072	-.152	.108	.357*
		Sig. (2-tailed)	.748	.007	.619	.291	.457	.011
		N	50	50	50	50	50	50
	EXT.EXPE	Correlation Coefficient	-.091	.372**	.126	-.109	-.138	.224
		Sig. (2-tailed)	.530	.008	.384	.453	.340	.118
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			INTEGRAT	CONTROL	BUSTRAGY	ITPOLICY	ENVFORCE	PREV.EXP
Spearman's rho	CHGSTRUC	Correlation Coefficient	.000	.038	-.173	.142	-.044	-.081
		Sig. (2-tailed)	.998	.794	.230	.327	.763	.574
		N	50	50	50	50	50	50
	CHGWOKPR	Correlation Coefficient	-.188	.101	.077	.039	.002	.049
		Sig. (2-tailed)	.190	.483	.597	.787	.990	.738
		N	50	50	50	50	50	50
	FOCMEASU	Correlation Coefficient	.046	.341*	.180	-.094	.038	.241
		Sig. (2-tailed)	.753	.016	.210	.517	.792	.092
		N	50	50	50	50	50	50
	UNFORESE	Correlation Coefficient	.004	.174	.156	-.109	.563**	.278
		Sig. (2-tailed)	.977	.226	.278	.453	.000	.051
		N	50	50	50	50	50	50
	USERSATI	Correlation Coefficient	-.005	.437**	.084	-.274	.254	.322*
		Sig. (2-tailed)	.975	.002	.562	.054	.075	.022
		N	50	50	50	50	50	50
	EXPEFUNC	Correlation Coefficient	-.105	.262	.153	-.407**	.123	.493**
		Sig. (2-tailed)	.469	.066	.289	.003	.396	.000
		N	50	50	50	50	50	50
	EFFICIEN	Correlation Coefficient	-.020	.478**	.141	-.357*	.230	.489**
		Sig. (2-tailed)	.888	.000	.328	.011	.108	.000
		N	50	50	50	50	50	50
	EFFECTIV	Correlation Coefficient	-.004	.246	.229	-.290*	.129	.322*
		Sig. (2-tailed)	.978	.085	.110	.041	.372	.022
		N	50	50	50	50	50	50
	COMPETIT	Correlation Coefficient	.053	.049	-.110	-.140	-.016	.300*
		Sig. (2-tailed)	.717	.734	.446	.332	.915	.034
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			SOURCING	JUSTIFIC	RISKASSM	TECHNOLO	TMCOMPET	TMSUPPOR	USERINVO
Spearman's rho	INTEGRAT	Correlation Coefficient	-.166	-.159	.332*	-.014	.055	-.165	-.002
		Sig. (2-tailed)	.249	.269	.019	.924	.706	.251	.988
		N	50	50	50	50	50	50	50
	CONTROL	Correlation Coefficient	.128	.102	.014	.122	.156	.125	.016
		Sig. (2-tailed)	.376	.483	.925	.399	.280	.388	.912
		N	50	50	50	50	50	50	50
	BUSTRAGY	Correlation Coefficient	.045	-.048	.122	-.116	.067	.047	.215
		Sig. (2-tailed)	.758	.738	.399	.422	.646	.746	.135
		N	50	50	50	50	50	50	50
	ITPOLICY	Correlation Coefficient	.121	-.048	.227	.017	-.061	-.055	-.050
		Sig. (2-tailed)	.404	.740	.113	.908	.675	.703	.731
		N	50	50	50	50	50	50	50
	ENVFORCE	Correlation Coefficient	.030	.047	.344*	.349*	.202	.109	.210
		Sig. (2-tailed)	.835	.746	.014	.013	.159	.453	.143
		N	50	50	50	50	50	50	50
	PREV.EXP	Correlation Coefficient	.039	.384**	.008	.186	.276	.311*	.299*
		Sig. (2-tailed)	.789	.006	.956	.195	.052	.028	.035
		N	50	50	50	50	50	50	50
	SOURCING	Correlation Coefficient	1.000	.067	-.144	.076	.259	.113	.227
		Sig. (2-tailed)	.	.644	.317	.599	.069	.434	.112
		N	50	50	50	50	50	50	50
	JUSTIFIC	Correlation Coefficient	.067	1.000	-.075	.090	.385**	.259	.238
		Sig. (2-tailed)	.644	.	.603	.535	.006	.070	.097
		N	50	50	50	50	50	50	50
	RISKASSM	Correlation Coefficient	-.144	-.075	1.000	.333*	.256	-.132	-.055
		Sig. (2-tailed)	.317	.603	.	.018	.073	.362	.703
		N	50	50	50	50	50	50	50

Correlation Tables (Appendix C)

			SOURCING	JUSTIFIC	RISKASSM	TECHNOLO	TMCOMPET	TMSUPPOR	USERINVO
Spearman's rho	TECHNOLO	Correlation Coefficient	.076	.090	.333*	1.000	.127	.061	-.036
		Sig. (2-tailed)	.599	.535	.018	.	.378	.673	.802
		N	50	50	50	50	50	50	50
	TMCOMPET	Correlation Coefficient	.259	.385**	.256	.127	1.000	.286*	.271
		Sig. (2-tailed)	.069	.006	.073	.378	.	.044	.057
		N	50	50	50	50	50	50	50
	TMSUPPOR	Correlation Coefficient	.113	.259	-.132	.061	.286*	1.000	.283*
		Sig. (2-tailed)	.434	.070	.362	.673	.044	.	.047
		N	50	50	50	50	50	50	50
	USERINVO	Correlation Coefficient	.227	.238	-.055	-.036	.271	.283*	1.000
		Sig. (2-tailed)	.112	.097	.703	.802	.057	.047	.
		N	50	50	50	50	50	50	50
	USERATTI	Correlation Coefficient	.286*	.424**	-.112	.058	.190	.367**	.389**
		Sig. (2-tailed)	.044	.002	.437	.688	.186	.009	.005
		N	50	50	50	50	50	50	50
	STRAIMPT	Correlation Coefficient	-.020	.391**	-.136	.106	.195	.007	.168
		Sig. (2-tailed)	.890	.005	.345	.462	.174	.960	.243
		N	50	50	50	50	50	50	50
	OPERIMPT	Correlation Coefficient	.116	.386**	-.061	.022	.108	.152	.169
		Sig. (2-tailed)	.421	.006	.671	.880	.457	.293	.241
		N	50	50	50	50	50	50	50
	CHAMPION	Correlation Coefficient	.264	.372**	-.048	.204	.191	.420**	.166
		Sig. (2-tailed)	.064	.008	.740	.155	.185	.002	.250
		N	50	50	50	50	50	50	50
	EXT.EXPE	Correlation Coefficient	.620**	.105	-.269	.017	.229	.356*	.245
		Sig. (2-tailed)	.000	.468	.059	.905	.109	.011	.086
		N	50	50	50	50	50	50	50

Correlation Tables (Appendix C)

			SOURCING	JUSTIFIC	RISKASSM	TECHNOLO	TMCOMPET	TMSUPPOR	USERINVO
Spearman's rho	CHGSTRUC	Correlation Coefficient	.233	-.129	.061	.008	.092	.188	.307*
		Sig. (2-tailed)	.104	.373	.673	.959	.525	.191	.030
		N	50	50	50	50	50	50	50
	CHGWOKPR	Correlation Coefficient	.099	.042	-.020	-.133	.300*	.165	.216
		Sig. (2-tailed)	.495	.774	.890	.357	.034	.253	.131
		N	50	50	50	50	50	50	50
	FOCMEASU	Correlation Coefficient	.239	.055	.180	.366**	.481**	.069	.119
		Sig. (2-tailed)	.095	.704	.212	.009	.000	.634	.411
		N	50	50	50	50	50	50	50
	UNFORESE	Correlation Coefficient	.089	.023	.165	.171	.351*	.011	.303*
		Sig. (2-tailed)	.539	.873	.252	.236	.012	.938	.033
		N	50	50	50	50	50	50	50
	USERSATI	Correlation Coefficient	.115	.373**	-.144	.191	.098	.096	.179
		Sig. (2-tailed)	.428	.008	.319	.183	.499	.505	.213
		N	50	50	50	50	50	50	50
	EXPEFUNC	Correlation Coefficient	.046	.275	-.110	-.008	.003	.143	.215
		Sig. (2-tailed)	.749	.053	.448	.959	.981	.322	.134
		N	50	50	50	50	50	50	50
	EFFICIEN	Correlation Coefficient	.104	.416**	-.070	.082	.017	.173	.123
		Sig. (2-tailed)	.474	.003	.629	.571	.907	.231	.394
		N	50	50	50	50	50	50	50
	EFFECTIV	Correlation Coefficient	.169	.413**	.053	.003	.104	.124	.237
		Sig. (2-tailed)	.242	.003	.713	.986	.474	.392	.098
		N	50	50	50	50	50	50	50
	COMPETIT	Correlation Coefficient	.067	.570**	-.119	-.052	.208	.201	.140
		Sig. (2-tailed)	.646	.000	.408	.721	.146	.162	.332
		N	50	50	50	50	50	50	50

Correlation Tables (Appendix C)

			USERATTI	STRAIMPT	OPERIMPT	CHAMPION	EXT.EXPE	CHGSTRUC
Spearman's rho	INTEGRAT	Correlation Coefficient	-.138	-.115	.045	.047	-.091	.000
		Sig. (2-tailed)	.341	.425	.756	.748	.530	.998
		N	50	50	50	50	50	50
	CONTROL	Correlation Coefficient	.326*	.276	.315*	.378**	.372**	.038
		Sig. (2-tailed)	.021	.053	.026	.007	.008	.794
		N	50	50	50	50	50	50
	BUSTRAGY	Correlation Coefficient	-.012	-.286*	-.083	.072	.126	-.173
		Sig. (2-tailed)	.931	.044	.567	.619	.384	.230
		N	50	50	50	50	50	50
	ITPOLICY	Correlation Coefficient	-.103	-.322*	.082	-.152	-.109	.142
		Sig. (2-tailed)	.477	.023	.571	.291	.453	.327
		N	50	50	50	50	50	50
	ENVFORCE	Correlation Coefficient	.137	.031	.005	.108	-.138	-.044
		Sig. (2-tailed)	.341	.831	.971	.457	.340	.763
		N	50	50	50	50	50	50
	PREV.EXP	Correlation Coefficient	.381**	.267	.206	.357*	.224	-.081
		Sig. (2-tailed)	.006	.061	.151	.011	.118	.574
		N	50	50	50	50	50	50
	SOURCING	Correlation Coefficient	.286*	-.020	.116	.264	.620**	.233
		Sig. (2-tailed)	.044	.890	.421	.064	.000	.104
		N	50	50	50	50	50	50
	JUSTIFIC	Correlation Coefficient	.424**	.391**	.386**	.372**	.105	-.129
		Sig. (2-tailed)	.002	.005	.006	.008	.468	.373
		N	50	50	50	50	50	50
	RISKASSM	Correlation Coefficient	-.112	-.136	-.061	-.048	-.269	.061
		Sig. (2-tailed)	.437	.345	.671	.740	.059	.673
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			USERATTI	STRAIMPT	OPERIMPT	CHAMPION	EXT.EXPE	CHGSTRUC
Spearman's rho	TECHNOLO	Correlation Coefficient	.058	.106	.022	.204	.017	.008
		Sig. (2-tailed)	.688	.462	.880	.155	.905	.959
		N	50	50	50	50	50	50
	TMCOMPET	Correlation Coefficient	.190	.195	.108	.191	.229	.092
		Sig. (2-tailed)	.186	.174	.457	.185	.109	.525
		N	50	50	50	50	50	50
	TMSUPPOR	Correlation Coefficient	.367**	.007	.152	.420**	.356*	.188
		Sig. (2-tailed)	.009	.960	.293	.002	.011	.191
		N	50	50	50	50	50	50
	USERINVO	Correlation Coefficient	.389**	.168	.169	.166	.245	.307*
		Sig. (2-tailed)	.005	.243	.241	.250	.086	.030
		N	50	50	50	50	50	50
	USERATTI	Correlation Coefficient	1.000	.446**	.333*	.285*	.339*	-.175
		Sig. (2-tailed)	.	.001	.018	.045	.016	.225
		N	50	50	50	50	50	50
	STRAIMPT	Correlation Coefficient	.446**	1.000	.396**	.256	.138	-.010
		Sig. (2-tailed)	.001	.	.004	.073	.339	.946
		N	50	50	50	50	50	50
	OPERIMPT	Correlation Coefficient	.333*	.396**	1.000	.335*	.248	.165
		Sig. (2-tailed)	.018	.004	.	.017	.082	.253
		N	50	50	50	50	50	50
	CHAMPION	Correlation Coefficient	.285*	.256	.335*	1.000	.405**	.118
		Sig. (2-tailed)	.045	.073	.017	.	.004	.415
		N	50	50	50	50	50	50
	EXT.EXPE	Correlation Coefficient	.339*	.138	.248	.405**	1.000	.288*
		Sig. (2-tailed)	.016	.339	.082	.004	.	.042
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			USERATTI	STRAIMPT	OPERIMPT	CHAMPION	EXT.EXPE	CHGSTRUC
Spearman's rho	CHGSTRUC	Correlation Coefficient	-.175	-.010	.165	.118	.288*	1.000
		Sig. (2-tailed)	.225	.946	.253	.415	.042	.
		N	50	50	50	50	50	50
	CHGWOKPR	Correlation Coefficient	.043	.091	.137	-.004	.265	.451**
		Sig. (2-tailed)	.768	.527	.344	.978	.063	.001
		N	50	50	50	50	50	50
	FOCMEASU	Correlation Coefficient	.024	.183	.109	.314*	.434**	.198
		Sig. (2-tailed)	.867	.203	.453	.026	.002	.169
		N	50	50	50	50	50	50
	UNFORESE	Correlation Coefficient	.123	.210	.049	.066	.091	.171
		Sig. (2-tailed)	.394	.144	.737	.651	.529	.236
		N	50	50	50	50	50	50
	USERSATI	Correlation Coefficient	.422**	.476**	.577**	.471**	.207	-.084
		Sig. (2-tailed)	.002	.000	.000	.001	.148	.562
		N	50	50	50	50	50	50
	EXPEFUNC	Correlation Coefficient	.485**	.388**	.488**	.362**	.167	-.149
		Sig. (2-tailed)	.000	.005	.000	.010	.245	.301
		N	50	50	50	50	50	50
	EFFICIEN	Correlation Coefficient	.559**	.427**	.536**	.475**	.219	-.155
		Sig. (2-tailed)	.000	.002	.000	.000	.126	.283
		N	50	50	50	50	50	50
	EFFECTIV	Correlation Coefficient	.429**	.250	.465**	.393**	.069	-.100
		Sig. (2-tailed)	.002	.080	.001	.005	.632	.492
		N	50	50	50	50	50	50
	COMPETIT	Correlation Coefficient	.284*	.457**	.329*	.320*	.195	.038
		Sig. (2-tailed)	.045	.001	.020	.024	.176	.794
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			CHGWOKPR	FOCMEASU	UNFORESE	USERSATI	EXPEFUNC	EFFICIEN
Spearman's rho	INTEGRAT	Correlation Coefficient	-.188	.046	.004	-.005	-.105	-.020
		Sig. (2-tailed)	.190	.753	.977	.975	.469	.888
		N	50	50	50	50	50	50
	CONTROL	Correlation Coefficient	.101	.341*	.174	.437**	.262	.478**
		Sig. (2-tailed)	.483	.016	.226	.002	.066	.000
		N	50	50	50	50	50	50
	BUSTRAGY	Correlation Coefficient	.077	.180	.156	.084	.153	.141
		Sig. (2-tailed)	.597	.210	.278	.562	.289	.328
		N	50	50	50	50	50	50
	ITPOLICY	Correlation Coefficient	.039	-.094	-.109	-.274	-.407**	-.357*
		Sig. (2-tailed)	.787	.517	.453	.054	.003	.011
		N	50	50	50	50	50	50
	ENVFORCE	Correlation Coefficient	.002	.038	.563**	.254	.123	.230
		Sig. (2-tailed)	.990	.792	.000	.075	.396	.108
		N	50	50	50	50	50	50
	PREV.EXP	Correlation Coefficient	.049	.241	.278	.322*	.493**	.489**
		Sig. (2-tailed)	.738	.092	.051	.022	.000	.000
		N	50	50	50	50	50	50
	SOURCING	Correlation Coefficient	.099	.239	.089	.115	.046	.104
		Sig. (2-tailed)	.495	.095	.539	.428	.749	.474
		N	50	50	50	50	50	50
	JUSTIFIC	Correlation Coefficient	.042	.055	.023	.373**	.275	.416**
		Sig. (2-tailed)	.774	.704	.873	.008	.053	.003
		N	50	50	50	50	50	50
	RISKASSM	Correlation Coefficient	-.020	.180	.165	-.144	-.110	-.070
		Sig. (2-tailed)	.890	.212	.252	.319	.448	.629
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			CHGWOKPR	FOCMEASU	UNFORESE	USERSATI	EXPEFUNC	EFFICIEN
Spearman's rho	TECHNOLO	Correlation Coefficient	-.133	.366**	.171	.191	-.008	.082
		Sig. (2-tailed)	.357	.009	.236	.183	.959	.571
		N	50	50	50	50	50	50
	TMCOMPET	Correlation Coefficient	.300*	.481**	.351*	.098	.003	.017
		Sig. (2-tailed)	.034	.000	.012	.499	.981	.907
		N	50	50	50	50	50	50
	TMSUPPOR	Correlation Coefficient	.165	.069	.011	.096	.143	.173
		Sig. (2-tailed)	.253	.634	.938	.505	.322	.231
		N	50	50	50	50	50	50
	USERINVO	Correlation Coefficient	.216	.119	.303*	.179	.215	.123
		Sig. (2-tailed)	.131	.411	.033	.213	.134	.394
		N	50	50	50	50	50	50
	USERATTI	Correlation Coefficient	.043	.024	.123	.422**	.485**	.559**
		Sig. (2-tailed)	.768	.867	.394	.002	.000	.000
		N	50	50	50	50	50	50
	STRAIMPT	Correlation Coefficient	.091	.183	.210	.476**	.388**	.427**
		Sig. (2-tailed)	.527	.203	.144	.000	.005	.002
		N	50	50	50	50	50	50
	OPERIMPT	Correlation Coefficient	.137	.109	.049	.577**	.488**	.536**
		Sig. (2-tailed)	.344	.453	.737	.000	.000	.000
		N	50	50	50	50	50	50
	CHAMPION	Correlation Coefficient	-.004	.314*	.066	.471**	.362**	.475**
		Sig. (2-tailed)	.978	.026	.651	.001	.010	.000
		N	50	50	50	50	50	50
	EXT.EXPE	Correlation Coefficient	.265	.434**	.091	.207	.167	.219
		Sig. (2-tailed)	.063	.002	.529	.148	.245	.126
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			CHGWOKPR	FOCMEASU	UNFORESE	USERSATI	EXPEFUNC	EFFICIEN
Spearman's rho	CHGSTRUC	Correlation Coefficient	.451**	.198	.171	-.084	-.149	-.155
		Sig. (2-tailed)	.001	.169	.236	.562	.301	.283
		N	50	50	50	50	50	50
	CHGWOKPR	Correlation Coefficient	1.000	.243	.293*	-.095	-.183	-.099
		Sig. (2-tailed)	.	.089	.039	.511	.202	.493
		N	50	50	50	50	50	50
	FOCMEASU	Correlation Coefficient	.243	1.000	.248	.172	-.065	.131
		Sig. (2-tailed)	.089	.	.083	.231	.656	.366
		N	50	50	50	50	50	50
	UNFORESE	Correlation Coefficient	.293*	.248	1.000	.183	.147	.048
		Sig. (2-tailed)	.039	.083	.	.204	.307	.743
		N	50	50	50	50	50	50
	USERSATI	Correlation Coefficient	-.095	.172	.183	1.000	.638**	.713**
		Sig. (2-tailed)	.511	.231	.204	.	.000	.000
		N	50	50	50	50	50	50
	EXPEFUNC	Correlation Coefficient	-.183	-.065	.147	.638**	1.000	.780**
		Sig. (2-tailed)	.202	.656	.307	.000	.	.000
		N	50	50	50	50	50	50
	EFFICIEN	Correlation Coefficient	-.099	.131	.048	.713**	.780**	1.000
		Sig. (2-tailed)	.493	.366	.743	.000	.000	.
		N	50	50	50	50	50	50
	EFFECTIV	Correlation Coefficient	-.067	.024	-.009	.614**	.707**	.810**
		Sig. (2-tailed)	.644	.868	.949	.000	.000	.000
		N	50	50	50	50	50	50
	COMPETIT	Correlation Coefficient	.181	.112	.132	.365**	.276	.481**
		Sig. (2-tailed)	.207	.440	.360	.009	.053	.000
		N	50	50	50	50	50	50

Correlation Tables (Appendix C)

			EFFECTIV	COMPETIT
Spearman's rho	INTEGRAT	Correlation Coefficient	-.004	.053
		Sig. (2-tailed)	.978	.717
		N	50	50
	CONTROL	Correlation Coefficient	.246	.049
		Sig. (2-tailed)	.085	.734
		N	50	50
	BUSTRAGY	Correlation Coefficient	.229	-.110
		Sig. (2-tailed)	.110	.446
		N	50	50
	ITPOLICY	Correlation Coefficient	-.290*	-.140
		Sig. (2-tailed)	.041	.332
		N	50	50
	ENVFORCE	Correlation Coefficient	.129	-.016
		Sig. (2-tailed)	.372	.915
		N	50	50
	PREV.EXP	Correlation Coefficient	.322*	.300*
		Sig. (2-tailed)	.022	.034
		N	50	50
	SOURCING	Correlation Coefficient	.169	.067
		Sig. (2-tailed)	.242	.646
		N	50	50
	JUSTIFIC	Correlation Coefficient	.413**	.570**
		Sig. (2-tailed)	.003	.000
		N	50	50
	RISKASSM	Correlation Coefficient	.053	-.119
		Sig. (2-tailed)	.713	.408
		N	50	50

Correlation Tables (Appendix C)

			EFFECTIV	COMPETIT
Spearman's rho	TECHNOLO	Correlation Coefficient	.003	-.052
		Sig. (2-tailed)	.986	.721
		N	50	50
	TMCOMPET	Correlation Coefficient	.104	.208
		Sig. (2-tailed)	.474	.146
		N	50	50
	TMSUPPOR	Correlation Coefficient	.124	.201
		Sig. (2-tailed)	.392	.162
		N	50	50
	USERINVO	Correlation Coefficient	.237	.140
		Sig. (2-tailed)	.098	.332
		N	50	50
	USERATTI	Correlation Coefficient	.429**	.284*
		Sig. (2-tailed)	.002	.045
		N	50	50
	STRAIMPT	Correlation Coefficient	.250	.457**
		Sig. (2-tailed)	.080	.001
		N	50	50
	OPERIMPT	Correlation Coefficient	.465**	.329*
		Sig. (2-tailed)	.001	.020
		N	50	50
	CHAMPION	Correlation Coefficient	.393**	.320*
		Sig. (2-tailed)	.005	.024
		N	50	50
	EXT.EXPE	Correlation Coefficient	.069	.195
		Sig. (2-tailed)	.632	.176
		N	50	50

Correlation Tables (Appendix C)

			EFFECTIV	COMPETIT
Spearman's rho	CHGSTRUC	Correlation Coefficient	-.100	.038
		Sig. (2-tailed)	.492	.794
		N	50	50
	CHGWOKPR	Correlation Coefficient	-.067	.181
		Sig. (2-tailed)	.644	.207
		N	50	50
	FOCMEASU	Correlation Coefficient	.024	.112
		Sig. (2-tailed)	.868	.440
		N	50	50
	UNFORESE	Correlation Coefficient	-.009	.132
		Sig. (2-tailed)	.949	.360
		N	50	50
	USERSATI	Correlation Coefficient	.614**	.365**
		Sig. (2-tailed)	.000	.009
		N	50	50
	EXPEFUNC	Correlation Coefficient	.707**	.276
		Sig. (2-tailed)	.000	.053
		N	50	50
	EFFICIEN	Correlation Coefficient	.810**	.481**
		Sig. (2-tailed)	.000	.000
		N	50	50
	EFFECTIV	Correlation Coefficient	1.000	.490**
		Sig. (2-tailed)	.	.000
		N	50	50
	COMPETIT	Correlation Coefficient	.490**	1.000
		Sig. (2-tailed)	.000	.
		N	50	50

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

ANOVA[d]

Model		Sum of Squares	df	Mean Square
1	Regression	7.543	1	7.543
	Residual	4.501	48	9.377E-02
	Total	12.044	49	
2	Regression	8.399	2	4.200
	Residual	3.645	47	7.756E-02
	Total	12.044	49	
3	Regression	8.971	3	2.990
	Residual	3.073	46	6.681E-02
	Total	12.044	49	

ANOVA[d]

Model		F	Sig.
1	Regression Residual Total	80.448	.000[a]
2	Regression Residual Total	54.149	.000[b]
3	Regression Residual Total	44.754	.000[c]

a. Predictors: (Constant), EXPEFUNC

b. Predictors: (Constant), EXPEFUNC, CONTROL

c. Predictors: (Constant), EXPEFUNC, CONTROL, JUSTIFIC

d. Dependent Variable: EFFICIEN

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients
		B	Std. Error	Beta
1	(Constant)	1.244	.285	
	EXPEFUNC	.683	.076	.791
2	(Constant)	.616	.320	
	EXPEFUNC	.590	.075	.684
	CONTROL	.277	.083	.287
3	(Constant)	.369	.309	
	EXPEFUNC	.574	.069	.666
	CONTROL	.246	.078	.255
	JUSTIFIC	.109	.037	.222

Excluded Variables[d]

Model		Beta In	t	Sig.
1	INTEGRAT	.035[a]	.396	.694
	CONTROL	.287[a]	3.322	.002
	BUSTRAGY	.135[a]	1.545	.129
	ITPOLICY	-.095[a]	-1.009	.318
	ENVFORCE	.177[a]	2.068	.044
	PREV.EXP	.214[a]	2.341	.024
	SOURCING	.096[a]	1.083	.284
	JUSTIFIC	.254[a]	3.099	.003
	RISKASSM	.031[a]	.345	.732
	TECHNOLO	.121[a]	1.378	.175
	TMCOMPET	.012[a]	.132	.896
	TMSUPPOR	.076[a]	.856	.396
	USERINVO	.003[a]	.037	.970
	USERATTI	.232[a]	2.409	.020
	STRAIMPT	.142[a]	1.518	.136
	OPERIMPT	.261[a]	2.805	.007
	CHAMPION	.224[a]	2.412	.020
	EXT.EXPE	.115[a]	1.287	.204
	CHGSTRUC	-.098[a]	-1.109	.273
	CHGWOKPR	.016[a]	.181	.857
	FOCMEASU	.164[a]	1.906	.063
	UNFORESE	-.024[a]	-.263	.794
	USERSATI	.282[a]	2.444	.018
2	INTEGRAT	.031[b]	.387	.700
	BUSTRAGY	.086[b]	1.042	.303
	ITPOLICY	-.083[b]	-.978	.333
	ENVFORCE	.108[b]	1.294	.202
	PREV.EXP	.179[b]	2.109	.040
	SOURCING	.060[b]	.729	.470
	JUSTIFIC	.222[b]	2.925	.005
	RISKASSM	.014[b]	.170	.866
	TECHNOLO	.089[b]	1.101	.277
	TMCOMPET	-.021[b]	-.253	.802
	TMSUPPOR	.053[b]	.643	.523
	USERINVO	.019[b]	.231	.818
	USERATTI	.174[b]	1.894	.065
	STRAIMPT	.088[b]	.999	.323
	OPERIMPT	.204[b]	2.301	.026
	CHAMPION	.140[b]	1.512	.137
	EXT.EXPE	.010[b]	.106	.916
	CHGSTRUC	-.105[b]	-1.310	.197
	CHGWOKPR	-.015[b]	-.186	.853
	FOCMEASU	.066[b]	.742	.462
	UNFORESE	-.059[b]	-.723	.474
	USERSATI	.185[b]	1.623	.111

Excluded Variables[d]

Model		Beta In	t	Sig.
3	INTEGRAT	.056[c]	.746	.459
	BUSTRAGY	.073[c]	.961	.341
	ITPOLICY	-.084[c]	-1.057	.296
	ENVFORCE	.101[c]	1.304	.199
	PREV.EXP	.107[c]	1.228	.226
	SOURCING	.059[c]	.781	.439
	RISKASSM	.020[c]	.266	.791
	TECHNOLO	.064[c]	.843	.404
	TMCOMPET	-.119[c]	-1.487	.144
	TMSUPPOR	-.005[c]	-.062	.951
	USERINVO	-.024[c]	-.314	.755
	USERATTI	.095[c]	1.015	.316
	STRAIMPT	.019[c]	.224	.824
	OPERIMPT	.127[c]	1.378	.175
	CHAMPION	.073[c]	.798	.429
	EXT.EXPE	.001[c]	.011	.991
	CHGSTRUC	-.060[c]	-.785	.437
	CHGWOKPR	-.029[c]	-.379	.706
	FOCMEASU	.053[c]	.644	.523
	UNFORESE	-.051[c]	-.670	.507
	USERSATI	.094[c]	.826	.413

Excluded Variables[d]

Model		Partial Correlation	Collinearity Statistics Tolerance
1	INTEGRAT	.058	1.000
	CONTROL	.436	.861
	BUSTRAGY	.220	.993
	ITPOLICY	-.146	.886
	ENVFORCE	.289	.992
	PREV.EXP	.323	.852
	SOURCING	.156	.994
	JUSTIFIC	.412	.981
	RISKASSM	.050	.997
	TECHNOLO	.197	.998
	TMCOMPET	.019	.998
	TMSUPPOR	.124	.982
	USERINVO	.005	.981
	USERATTI	.332	.760
	STRAIMPT	.216	.865
	OPERIMPT	.379	.790
	CHAMPION	.332	.820
	EXT.EXPE	.184	.960
	CHGSTRUC	-.160	.995
	CHGWOKPR	.026	.980
	FOCMEASU	.268	.998
	UNFORESE	-.038	.981
	USERSATI	.336	.530
2	INTEGRAT	.057	.999
	BUSTRAGY	.152	.954
	ITPOLICY	-.143	.885
	ENVFORCE	.187	.907
	PREV.EXP	.297	.837
	SOURCING	.107	.975
	JUSTIFIC	.396	.963
	RISKASSM	.025	.993
	TECHNOLO	.160	.983
	TMCOMPET	-.037	.983
	TMSUPPOR	.094	.974
	USERINVO	.034	.978
	USERATTI	.269	.724
	STRAIMPT	.146	.830
	OPERIMPT	.321	.751
	CHAMPION	.218	.726
	EXT.EXPE	.016	.811
	CHGSTRUC	-.190	.994
	CHGWOKPR	-.027	.967
	FOCMEASU	.109	.831
	UNFORESE	-.106	.964
	USERSATI	.233	.477

Excluded Variables[d]

Model		Partial Correlation	Collinearity Statistics Tolerance
3	INTEGRAT	.111	.987
	BUSTRAGY	.142	.951
	ITPOLICY	-.156	.885
	ENVFORCE	.191	.907
	PREV.EXP	.180	.728
	SOURCING	.116	.975
	RISKASSM	.040	.993
	TECHNOLO	.125	.969
	TMCOMPET	-.216	.848
	TMSUPPOR	-.009	.908
	USERINVO	-.047	.942
	USERATTI	.150	.633
	STRAIMPT	.033	.758
	OPERIMPT	.201	.643
	CHAMPION	.118	.666
	EXT.EXPE	.002	.810
	CHGSTRUC	-.116	.948
	CHGWOKPR	-.056	.963
	FOCMEASU	.096	.829
	UNFORESE	-.099	.963
	USERSATI	.122	.429

a. Predictors in the Model: (Constant), EXPEFUNC

b. Predictors in the Model: (Constant), EXPEFUNC, CONTROL

c. Predictors in the Model: (Constant), EXPEFUNC, CONTROL, JUSTIFIC

d. Dependent Variable: EFFICIEN

EFFECTIVENESS **APPENDIX (D)**

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	EXPEFUNC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	JUSTIFIC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	ITPOLICY	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: EFFECTIV

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.743[a]	.552	.543	.3911
2	.789[b]	.622	.606	.3628
3	.811[c]	.657	.635	.3494

a. Predictors: (Constant), EXPEFUNC

b. Predictors: (Constant), EXPEFUNC, JUSTIFIC

c. Predictors: (Constant), EXPEFUNC, JUSTIFIC, ITPOLICY

ANOVA[d]

Model		Sum of Squares	df	Mean Square
1	Regression	9.046	1	9.046
	Residual	7.342	48	.153
	Total	16.387	49	
2	Regression	10.199	2	5.100
	Residual	6.188	47	.132
	Total	16.387	49	
3	Regression	10.771	3	3.590
	Residual	5.616	46	.122
	Total	16.387	49	

ANOVA[d]

Model		F	Sig.
1	Regression Residual Total	59.141	.000[a]
2	Regression Residual Total	38.733	.000[b]
3	Regression Residual Total	29.408	.000[c]

a. Predictors: (Constant), EXPEFUNC

b. Predictors: (Constant), EXPEFUNC, JUSTIFIC

c. Predictors: (Constant), EXPEFUNC, JUSTIFIC, ITPOLICY

d. Dependent Variable: EFFECTIV

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients
Model		B	Std. Error	Beta
1	(Constant)	.979	.364	
	EXPEFUNC	.747	.097	.743
2	(Constant)	.533	.370	
	EXPEFUNC	.711	.091	.706
	JUSTIFIC	.153	.052	.268
3	(Constant)	.991	.414	
	EXPEFUNC	.643	.093	.640
	JUSTIFIC	.153	.050	.267
	ITPOLICY	-.103	.048	-.198

Coefficients[a]

Model		t	Sig.
1	(Constant)	2.692	.010
	EXPEFUNC	7.690	.000
2	(Constant)	1.441	.156
	EXPEFUNC	7.806	.000
	JUSTIFIC	2.960	.005
3	(Constant)	2.393	.021
	EXPEFUNC	6.920	.000
	JUSTIFIC	3.063	.004
	ITPOLICY	-2.164	.036

a. Dependent Variable: EFFECTIV

Excluded Variables[d]

Model		Beta In	t	Sig.
1	INTEGRAT	.027[a]	.274	.786
	CONTROL	.058[a]	.556	.581
	BUSTRAGY	.152[a]	1.587	.119
	ITPOLICY	-.200[a]	-2.008	.050
	ENVFORCE	.034[a]	.344	.732
	PREV.EXP	.047[a]	.447	.657
	SOURCING	.141[a]	1.472	.148
	JUSTIFIC	.268[a]	2.960	.005
	RISKASSM	.088[a]	.913	.366
	TECHNOLO	.058[a]	.597	.554
	TMCOMPET	.090[a]	.927	.359
	TMSUPPOR	.024[a]	.242	.810
	USERINVO	.064[a]	.654	.516
	USERATTI	.127[a]	1.149	.256
	STRAIMPT	-.013[a]	-.121	.904
	OPERIMPT	.142[a]	1.315	.195
	CHAMPION	.089[a]	.833	.409
	EXT.EXPE	-.014[a]	-.145	.885
	CHGSTRUC	-.145[a]	-1.518	.136
	CHGWOKPR	.011[a]	.115	.909
	FOCMEASU	.062[a]	.634	.529
	UNFORESE	-.114[a]	-1.178	.245
	USERSATI	.105[a]	.789	.434
2	INTEGRAT	.056[b]	.617	.541
	CONTROL	.020[b]	.204	.839
	BUSTRAGY	.131[b]	1.470	.148
	ITPOLICY	-.198[b]	-2.164	.036
	ENVFORCE	.015[b]	.169	.867
	PREV.EXP	-.069[b]	-.660	.513
	SOURCING	.136[b]	1.530	.133
	RISKASSM	.094[b]	1.045	.301
	TECHNOLO	.023[b]	.255	.800
	TMCOMPET	-.014[b]	-.139	.890
	TMSUPPOR	-.052[b]	-.546	.588
	USERINVO	.016[b]	.170	.866
	USERATTI	.016[b]	.140	.889
	STRAIMPT	-.113[b]	-1.115	.271
	OPERIMPT	.028[b]	.251	.803
	CHAMPION	-.003[b]	-.028	.978
	EXT.EXPE	-.038[b]	-.410	.684
	CHGSTRUC	-.093[b]	-1.015	.316
	CHGWOKPR	-.009[b]	-.100	.921
	FOCMEASU	.035[b]	.380	.706
	UNFORESE	-.109[b]	-1.213	.231
	USERSATI	-.022[b]	-.168	.867

Excluded Variables[d]

Model		Beta In	t	Sig.
3	INTEGRAT	.099[c]	1.118	.270
	CONTROL	.012[c]	.128	.898
	BUSTRAGY	.089[c]	.989	.328
	ENVFORCE	-.009[c]	-.101	.920
	PREV.EXP	-.105[c]	-1.027	.310
	SOURCING	.162[c]	1.912	.062
	RISKASSM	.119[c]	1.374	.176
	TECHNOLO	.049[c]	.551	.585
	TMCOMPET	-.027[c]	-.288	.775
	TMSUPPOR	-.050[c]	-.550	.585
	USERINVO	.015[c]	.165	.870
	USERATTI	.041[c]	.378	.707
	STRAIMPT	-.138[c]	-1.420	.163
	OPERIMPT	.128[c]	1.130	.264
	CHAMPION	-.004[c]	-.040	.968
	EXT.EXPE	-.025[c]	-.274	.786
	CHGSTRUC	-.076[c]	-.850	.400
	CHGWOKPR	-.017[c]	-.191	.849
	FOCMEASU	.033[c]	.379	.706
	UNFORESE	-.117[c]	-1.355	.182
	USERSATI	-.015[c]	-.121	.904

Excluded Variables[d]

Model		Partial Correlation	Collinearity Statistics Tolerance
1	INTEGRAT	.040	1.000
	CONTROL	.081	.861
	BUSTRAGY	.226	.993
	ITPOLICY	-.281	.886
	ENVFORCE	.050	.992
	PREV.EXP	.065	.852
	SOURCING	.210	.994
	JUSTIFIC	.396	.981
	RISKASSM	.132	.997
	TECHNOLO	.087	.998
	TMCOMPET	.134	.998
	TMSUPPOR	.035	.982
	USERINVO	.095	.981
	USERATTI	.165	.760
	STRAIMPT	-.018	.865
	OPERIMPT	.188	.790
	CHAMPION	.121	.820
	EXT.EXPE	-.021	.960
	CHGSTRUC	-.216	.995
	CHGWOKPR	.017	.980
	FOCMEASU	.092	.998
	UNFORESE	-.169	.981
	USERSATI	.114	.530
2	INTEGRAT	.091	.988
	CONTROL	.030	.845
	BUSTRAGY	.212	.986
	ITPOLICY	-.304	.886
	ENVFORCE	.025	.988
	PREV.EXP	-.097	.734
	SOURCING	.220	.994
	RISKASSM	.152	.997
	TECHNOLO	.038	.981
	TMCOMPET	-.020	.852
	TMSUPPOR	-.080	.911
	USERINVO	.025	.949
	USERATTI	.021	.655
	STRAIMPT	-.162	.781
	OPERIMPT	.037	.665
	CHAMPION	-.004	.740
	EXT.EXPE	-.060	.953
	CHGSTRUC	-.148	.951
	CHGWOKPR	-.015	.975
	FOCMEASU	.056	.988
	UNFORESE	-.176	.980
	USERSATI	-.025	.467

Excluded Variables[d]

Model		Partial Correlation	Collinearity Statistics Tolerance
3	INTEGRAT	.164	.946
	CONTROL	.019	.844
	BUSTRAGY	.146	.922
	ENVFORCE	-.015	.971
	PREV.EXP	-.151	.718
	SOURCING	.274	.977
	RISKASSM	.201	.982
	TECHNOLO	.082	.964
	TMCOMPET	-.043	.849
	TMSUPPOR	-.082	.911
	USERINVO	.025	.949
	USERATTI	.056	.647
	STRAIMPT	-.207	.771
	OPERIMPT	.166	.578
	CHAMPION	-.006	.740
	EXT.EXPE	-.041	.948
	CHGSTRUC	-.126	.942
	CHGWOKPR	-.028	.973
	FOCMEASU	.056	.988
	UNFORESE	-.198	.979
	USERSATI	-.018	.467

a. Predictors in the Model: (Constant), EXPEFUNC

b. Predictors in the Model: (Constant), EXPEFUNC, JUSTIFIC

c. Predictors in the Model: (Constant), EXPEFUNC, JUSTIFIC, ITPOLICY

d. Dependent Variable: EFFECTIV

COMPETITIVE ADVANTAGE APPENDIX (D)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	JUSTIFIC	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	STRAIMPT	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: COMPETIT

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.505[a]	.255	.240	.5392
2	.578[b]	.335	.306	.5150

a. Predictors: (Constant), JUSTIFIC

b. Predictors: (Constant), JUSTIFIC, STRAIMPT

ANOVA[c]

Model		Sum of Squares	df	Mean Square
1	Regression	4.784	1	4.784
	Residual	13.954	48	.291
	Total	18.738	49	
2	Regression	6.271	2	3.135
	Residual	12.467	47	.265
	Total	18.738	49	

ANOVA[c]

Model		F	Sig.
1	Regression Residual Total	16.456	.000[a]
2	Regression Residual Total	11.820	.000[b]

a. Predictors: (Constant), JUSTIFIC

b. Predictors: (Constant), JUSTIFIC, STRAIMPT

c. Dependent Variable: COMPETIT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.123	.300		7.086	.000
	JUSTIFIC	.309	.076	.505	4.057	.000
2	(Constant)	1.533	.379		4.040	.000
	JUSTIFIC	.247	.077	.404	3.196	.002
	STRAIMPT	.242	.102	.299	2.367	.022

a. Dependent Variable: COMPETIT

Excluded Variables[c]

Model		Beta In	t	Sig.
1	INTEGRAT	.041[a]	.328	.745
	CONTROL	-.092[a]	-.720	.475
	BUSTRAGY	-.103[a]	-.821	.416
	ITPOLICY	-.128[a]	-1.026	.310
	ENVFORCE	-.062[a]	-.491	.625
	PREV.EXP	.119[a]	.877	.385
	SOURCING	.022[a]	.178	.860
	RISKASSM	-.012[a]	-.096	.924
	TECHNOLO	-.052[a]	-.412	.682
	TMCOMPET	.026[a]	.188	.851
	TMSUPPOR	-.008[a]	-.058	.954
	USERINVO	-.017[a]	-.133	.895
	USERATTI	.134[a]	.993	.326
	STRAIMPT	.299[a]	2.367	.022
	OPERIMPT	.084[a]	.609	.546
	CHAMPION	.140[a]	1.061	.294
	EXT.EXPE	.097[a]	.774	.443
	CHGSTRUC	.076[a]	.595	.555
	CHGWOKPR	.143[a]	1.152	.255
	FOCMEASU	.070[a]	.558	.580
	UNFORESE	.138[a]	1.114	.271
	USERSATI	.147[a]	1.109	.273
	EXPEFUNC	.261[a]	2.152	.037
2	INTEGRAT	.067[b]	.552	.584
	CONTROL	-.183[b]	-1.472	.148
	BUSTRAGY	-.010[b]	-.080	.936
	ITPOLICY	-.071[b]	-.578	.566
	ENVFORCE	-.063[b]	-.523	.604
	PREV.EXP	.057[b]	.428	.670
	SOURCING	.038[b]	.319	.751
	RISKASSM	.000[b]	.001	.999
	TECHNOLO	-.082[b]	-.677	.502
	TMCOMPET	.002[b]	.013	.990
	TMSUPPOR	.029[b]	.232	.818
	USERINVO	-.048[b]	-.387	.700
	USERATTI	.025[b]	.180	.858
	OPERIMPT	.006[b]	.041	.967
	CHAMPION	.106[b]	.832	.410
	EXT.EXPE	.071[b]	.585	.561
	CHGSTRUC	.063[b]	.510	.613
	CHGWOKPR	.132[b]	1.111	.272
	FOCMEASU	.007[b]	.054	.957
	UNFORESE	.078[b]	.635	.528
	USERSATI	.038[b]	.277	.783
	EXPEFUNC	.185[b]	1.462	.150

Excluded Variables[c]

Model		Partial Correlation	Collinearity Statistics
			Tolerance
1	INTEGRAT	.048	.988
	CONTROL	-.104	.969
	BUSTRAGY	-.119	.992
	ITPOLICY	-.148	.997
	ENVFORCE	-.071	.994
	PREV.EXP	.127	.846
	SOURCING	.026	.999
	RISKASSM	-.014	.999
	TECHNOLO	-.060	.984
	TMCOMPET	.027	.852
	TMSUPPOR	-.008	.921
	USERINVO	-.019	.961
	USERATTI	.143	.849
	STRAIMPT	.326	.886
	OPERIMPT	.088	.830
	CHAMPION	.153	.885
	EXT.EXPE	.112	.988
	CHGSTRUC	.086	.953
	CHGWOKPR	.166	.997
	FOCMEASU	.081	.988
	UNFORESE	.160	1.000
	USERSATI	.160	.884
	EXPEFUNC	.299	.981
2	INTEGRAT	.081	.980
	CONTROL	-.212	.898
	BUSTRAGY	-.012	.883
	ITPOLICY	-.085	.952
	ENVFORCE	-.077	.994
	PREV.EXP	.063	.808
	SOURCING	.047	.996
	RISKASSM	.000	.997
	TECHNOLO	-.099	.974
	TMCOMPET	.002	.847
	TMSUPPOR	.034	.907
	USERINVO	-.057	.950
	USERATTI	.026	.734
	OPERIMPT	.006	.777
	CHAMPION	.122	.873
	EXT.EXPE	.086	.979
	CHGSTRUC	.075	.950
	CHGWOKPR	.162	.995
	FOCMEASU	.008	.938
	UNFORESE	.093	.948
	USERSATI	.041	.756
	EXPEFUNC	.211	.865

a. Predictors in the Model: (Constant), JUSTIFIC

b. Predictors in the Model: (Constant), JUSTIFIC, STRAIMPT

c. Dependent Variable: COMPETIT