THE HONG KONG POLYTECHNIC UNIVERSITY

DEPARTMENT OF BUILDING AND REAL ESTATE

A CONCEPTUAL MODEL OF SUCCESS FOR DESIGN AND BUILD PROJECTS IN THE PUBLIC SECTOR OF HONG KONG

by

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CERTIFICATE OF ORIGINALITY

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ABSTRACT

The traditional design-bid-build procurement method is considered by many construction clients to be significantly flawed with problems, such as delays in construction work and poor quality standards. To cater for the increasing complexity of projects and the growing emphasis on client's requirements, alternative procurement systems have evolved and Design-Build (D&B) has been increasing in popularity worldwide for better project performance.

Design-Build integrates the design and construction phases to alleviate the problem of fragmentation confronting the construction industry. It has been widely adopted in most western countries and it is increasingly applied to construction projects in Hong Kong. While the benefits of the D&B method have been reported in previous literature, an examination into the drivers for a wider adoption of the D&B method in the public sector can help account for the current practice in Hong Kong. It also aids the decision of construction project stakeholders to select the D&B method based on their project needs. More detailed discussions on the inhibitors of the D&B method are needed, in terms of the problems of running D&B projects and barriers to preclude choice of this method so that project participants can master D&B and promote its use. Comparisons of the perceptions of D&B project participants can also enhance the understanding of the method and communication among project team members.

Success is achievable in construction projects but its concept remains vague among D&B project participants. One approach is the development of a Project

Success Index (PSI-D&B) which can help the project stakeholders compare the relative success level among D&B projects in a scientific manner. The identification of Critical Success Factors (CSFs) is likely to enhance the success level of D&B projects, since more resources can be allocated to the identified predictors of success. Still, there appears to be a lack of comprehensive studies on project success, especially in D&B research in the local context.

This research provides an evaluation of the current practice of the D&B method in the Hong Kong context with a view to developing a conceptual model of success of D&B projects. The main reasons for a wider adoption of the D&B method in the public sector were found to be related to the expertise and responsibilities of the contractor. While major problems concern time pressure, stress by the client and frequent changes by end-users, the choice of the D&B method in Hong Kong is negatively impacted by the additional efforts demanded by the contractor and the client. In addition, a project success equation has been formulated from the principal components analysis so that the success level of a D&B project can be expressed by an index composed of the scores in the performance of time, cost, quality and functionality of the D&B project. Factor Analysis has re-grouped the success variables into twelve factor categories, which are independent variables generating multiple linear equations with the five dependent variables. The strongest predictor of D&B project success is the effectiveness of project management action. Other predictors of success include the client's input in the project, working relationships among project team members, project attractiveness and application of innovative management approaches. A further test of five samples provided evidence that the regression

models are good predictors of D&B project success and D&B project participants have shown agreement on the results.

The research provides an understanding of the D&B method in the Hong Kong context and insights into the procurement studies in construction. It should be useful for project stakeholders to compare the success level with other D&B projects and even forecast the performance of future projects. It should also help in setting up an effective project management system to run high performance D&B projects, as well as enriching academic programmes in construction management. The scope of the study can further be extended to the international arena to aid the understanding of managing D&B projects in different cultures.

PUBLICATIONS ON THE WORK REPORTED IN THE THESIS

ACADEMIC JOURNAL PAPERS

1. Chan, A.P.C., Scott, D., and **Lam, E.W.M.** (2002). Framework of success criteria for design/build projects. *Journal of Management in Engineering*, 18(3), 120-128.
2. **Lam, E.W.M.**, Chan, A.P.C., and Chan, D.W.M. (2003a). Potential problems of running design-build projects in construction. *Transactions, The Hong Kong Institution of Engineers*, 10(3), 8-14.
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1. Chan, A.P.C., Scott, D., and **Lam, E.W.M.** (2001). Study of design/build projects in Hong Kong. *Proceedings - Third International Conference on Construction Project Management*, 29-30 March 2001, Singapore, 366-376.
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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

A construction project is mostly initiated by the needs of the client. In order to satisfy the client's requirements in terms of time, cost and quality, various procurement methods are recommended for selection to increase the chance of success for the complex sequence of activities. The traditional design-bid-build method has been commonly used for delivering construction projects. It has become the dominant method for project delivery in Hong Kong and is still dominant in the U.S. (Rowlinson, 1997; Friedlander, 1998). However, the extensive number of disputes and the growing emphasis on client's requirements have brought to the need for other alternative procurement systems (Ndekugri and Turner, 1994; Moore and Dainty, 2001). Nahapiet and Nahapiet (1985) compared different contractual arrangements for building projects and concluded that the most appropriate contractual arrangement varies according to the particular set of project circumstances. Moreover, Skitmore and Marsden (1988) devised a universal procurement selection technique for the most appropriate procurement arrangement.

The growing emphasis on meeting clients' needs and improving project performance has increased the use of fully integrated D&B project teams (Moore and Dainty, 2001). Design and Build (Design-build, or D&B for short) integrates design and construction to overcome some of the fragmentation in the construction industry

(Yates, 1995; Retherford, 1998). It has been extensively used in western countries for more than a decade but it has only been introduced to the East since the last decade. In Hong Kong, the use of a D&B contract in the private sector is used only occasionally when compared with the use in the public sector (Chan et al., 2001a). Exploring the reasons for the wider adoption of D&B can enable project participants to better understand this alternative procurement method to enhance further applications in building projects.

Success means different things to different people. Although success can be measured quantitatively in terms of time and cost performance, measuring project success is a complex task since the concept is an intangible feeling of perspective that can rarely be agreed upon. The result is in fact determined by a number of factors that independently or interactively affect the final outcome. The study of the inhibitors to the D&B method can also help identify the determinants in achieving project success for D&B projects. A construction project is considered as a complex sequence of activities, which involve a high use of labour (Cheung et. al, 2000). It would be useful if comparisons were made on the responses from the main stakeholders of clients, contractors and consultants so that they can understand each other better for use in effective decision-making. With the extensive use of D&B worldwide and its distinctive features dealing with the problems of the traditional design-bid-build method, an investigation into the project success for D&B can help set a benchmark study to enrich the procurement curriculum.

1.2 IMPORTANCE OF THE DESIGN-BUILD PROCUREMENT SYSTEM

The adoption of the traditional method in the construction industry has become an invariably common practice (Rowlinson and Walker, 1995). Most construction projects are delivered in the conventional way where the architect designs and the contractor constructs (Chan, 1996a). However, clients are becoming dissatisfied with the drawbacks bought about by the separated procurement system and opt for more integrated options (Molenaar and Songer, 1998; Deakin, 1999; Molenaar et al., 1999). As a result, innovative procurement systems emerge and D&B contracts become increasingly popular for building projects (Latham, 1994; Ndekugri and Turner, 1994; Songer and Molenaar, 1996; Palaneeswaran and Kumaraswamy, 2001).

1.2.1 Global Use of Design-Build

Research and surveys reported in the construction press indicate considerable growth in construction procurement by the design-build approach (Ndekugri and Church, 1996). It has been used throughout the world extensively for around 40 years and its popularity has gained substantially over the last 10 years (Turner, 1997; Ernzen and Schexnayder, 2000). More significant moves towards D&B procurement are evident from statistics and examples from the UK, USA and Australia. The construction industry in Singapore is also moving gradually from the traditional to the D&B method, but the practice is still at its relatively evolutionary stage in many client organizations (Palaneeswaran and Kumaraswamy, 2001). In Hong Kong, D&B is adopted to deal with the problems associated with the traditional system (Chan, 2000). It is mostly implemented by the public sector and the government agencies have shown an increasing acceptance of it in recent years (Rizzo, 1998).

1.2.2 Benefits of Design-Build

Design-build is a procurement method where one entity or consortium is contractually responsible for both the design and construction of a project (Songer and Molenaar, 1996). It integrates the design and construction functions into one single source, which then brings about a number of benefits to project participants. By bringing together the construction experience of contractors with the design experience of consultants, the resulting building can be technically more efficient with the overall buildability of the project improved (Akintoye and Fitzgerald, 1995; Turner, 1995). Team work can be improved to reduce the amount of time spent and control information flows due to the direct communication between the client and the contractor (Rowlinson, 1987).

As the contractor is involved early in the design phase, the design and construction phases are shortened because of overlaps in the two processes and the application of fast-track construction techniques (Beard et al., 2001; Abi-Karam, 2002). D&B allows the contractor to have total control over design, scope and budget of the project and so there is less opportunity for cost-significant change orders (Songer and Molenaar, 1996). Greater responsibilities and accountabilities, implicit in the D&B process, serve as a motivator for higher quality of the construction project (Turner, 1995). As a result, D&B is described as a 'design risk aversion' strategy for building clients who can enjoy lower risks associated with the control of project completion and cost overruns (Akintoye and Fitzgerald, 1995).

D&B also introduces fewer amendments to design so that redesign can be eliminated (Beard et al., 2001). It also fosters creative design by inputting the contractors' knowledge early into the design to promote constructability (Songer and Molenaar, 1996). Through comparing the proposals from the tenderers, a solution that offers the 'best value' option in terms of time, cost and design excellence to the client can be selected (Songer and Molenaar, 1996; Beard et al., 2001). D&B even places the designer and builder on equal professional status so that they can provide constructive design solutions to the client (Beard et al., 2001). Fig. 1.1 presents the major benefits of the D&B procurement method.

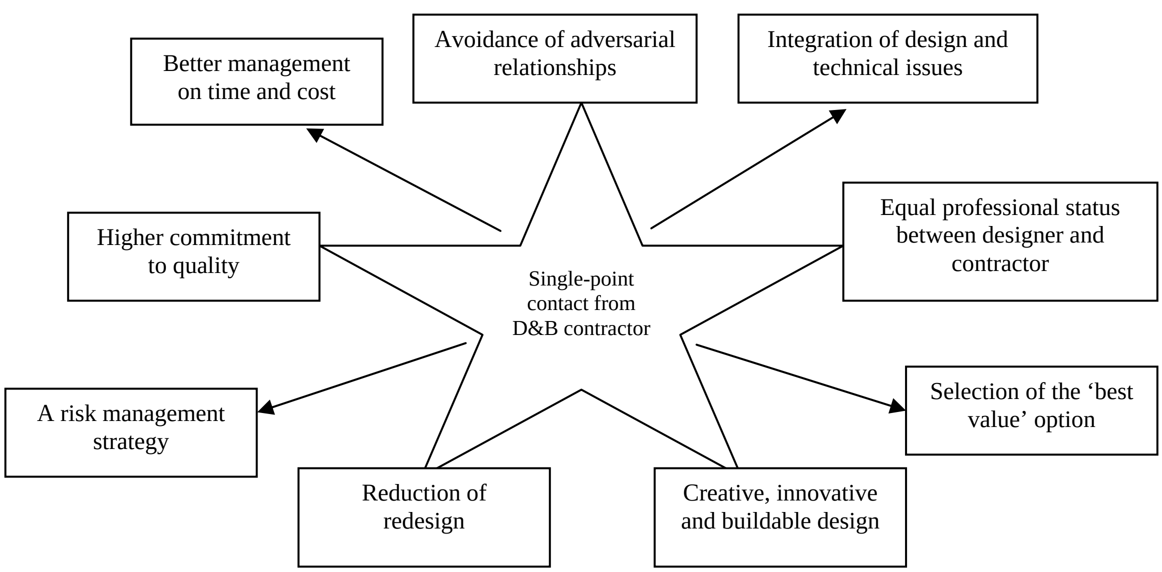


Fig. 1.1 Perceived benefits of D&B from the single-point contact of contractor

1.2.3 Recommendations from the Construction Industry

Various task forces in the construction industry have been formed all over the world to study the existing performances of the industry and suggest recommendations to alleviate any problems. Major reports in the construction industry have indicated several problems with the traditional procurement system in delivering construction projects, with particular emphasis on the problem of fragmentation within the industry.

In the UK, The Latham Report (1994) claimed that the separation of the roles and responsibilities of the project initiator (client), designer and constructor (contractor) slows down the construction process. D&B is able to overcome fragmentation by vertical integration to bring organizations that perform separate roles under a common set of goals and objectives (Ive, 1995). Early involvement of the contractor at the design stage also helps to achieve practical solutions to the problems that arise (Simms, 1995). The Egan Report (1998) revealed that fragmentation of the UK construction industry inhibits performance improvement as the conventional construction process is sequential and separated acting as a barrier to the effective design, planning and construction of projects. As a result, the structure of the industry becomes fragmented, which leads to a contractual and confrontational culture. The report suggested an integrated project process, which was defined as a process utilizing the whole construction team and bringing the skills of all the participants to bear on delivering value to the client so that projects can be designed for ease of construction. In fact, teams of designers, contractors and suppliers are encouraged to work together to develop a fully integrated D&B team.

The Construction Industry Review Committee Report (2001) in Hong Kong described the construction industry as having a high degree of fragmentation with an adversarial culture. Under the conventional approach, the design process often takes place without the input from contractors. It is essential to have an integrated construction industry that is capable of continuous improvements to eliminate inefficiencies during project delivery. Better integration can be facilitated in the delivery of projects through a wider adoption of alternative procurement approaches like D&B, in both the public and the private sectors. As a major client of local construction, the Government should commit itself to becoming a best practice client to adopt an integrated approach in construction procurement.

Considering the global use of design-build, the benefits that it brings about and the recommendations from the construction industry have illustrated that D&B can be the preferred option to the traditional design-bid-build method. While both researchers and practitioners in the industry suggested a more integrated approach to project delivery, the topic of success in D&B projects can further enhance its implementation in the local context and therefore giving a need for the D&B research.

1.3 RESEARCH PROBLEM

Previous research and reports indicated that the traditional design-bid-build procurement system is flawed with problems meeting the clients' requirements. As a result, alternative procurement systems have evolved to tackle potential problems so as to increase the chance of project success. Design-build is one common alternative to the traditional procurement system providing the client with a single point of contact. It shows a leading trend in the construction industry, but its use in Hong Kong is rather limited. If the reasons for the adoption of D&B in Hong Kong are identified, project participants can further understand their needs for such alternative procurement method and they can then justify whether D&B can meet their project objectives.

Success is a demand expected by all project participants. This target is hard to meet, especially for a construction project where the degree of complexity is high and its nature is dynamic. However, the general concept of project success remains ambiguously defined and there is a lack of comprehensive lists of criteria contributing to project success. The factors that are critical to the success of a project are often discussed in a piecemeal one-off manner, which makes it difficult for project participants to identify and evaluate the critical components in a project. Studies of project success on alternative procurement methods, such as D&B, are also lacking, with much previous research considering only the construction project in general. Discussions on the inhibitors of the D&B method often involve a mixture of the problems encountered while running D&B projects, and barriers which affect the choice of the D&B method. Project participants in Hong Kong may find it hard to master the D&B method because of the lack of research concerning clear definitions between problems and barriers of the D&B method, and insufficient documentation on the comparisons of the opinions of the major stakeholders. While some practitioners perceived their D&B projects as a success, others have considered that D&B is no better than the traditional procurement system and there is very much a need to identify what ingredients make D&B projects a success.

To have a thorough understanding of success for D&B projects in the Hong Kong setting, it is essential to fully comprehend what factors lead to the use of D&B and what the inhibitors are in applying the D&B method. How success is measured and the factors involved should be evaluated from the perspectives of the D&B project participants so that the Critical Success Factors (CSFs) for D&B projects can be determined.

1.4 OBJECTIVES OF THE STUDY

In the previous section, gaps in the knowledge were identified and stated in the research problem, and then the research study was set out to serve the following objectives:

a) Evaluate the current practice of the D&B method in the public sector of Hong Kong.

b) Formulate a framework of factors and criteria of success for D&B projects.

c) Compute an index to indicate the success level of a D&B project.

d) Identify those factors that have strong predictive powers for the success of D&B projects.

e) Develop a conceptual model to link the critical success factors to the performance of D&B projects.

1.5 RESEARCH HYPOTHESES

This research aims to study the application of the D&B method to building projects and develop a conceptual model of success for D&B building projects within the Hong Kong setting. Two principal hypotheses were postulated and tested in two stages:

1.5.1 Stage 1: Evaluating the pattern of consistency of the participants' responses on the D&B method

The D&B method brings about a number of benefits to project participants but it is not widely used in the Hong Kong construction industry, except in the public sector. At this stage, the pattern of consistency of the participants' responses on the D&B method will be evaluated on the attributes including: (1) drivers for a wider adoption of the D&B method in the pubic sector, (2) problems of running D&B projects, and (3) barriers to applying the D&B method. Under each specific area, the responses of clients, contractors and consultants of D&B projects are compared by the intra- and inter-group ratings of the reason, problem and barrier attributes to identify the significant disagreement on the ranking exercise. The first principal hypothesis is set out as follows:

H_0: There is no significant disagreement on the ranking of the attributes.

H_1: There is significant disagreement on the ranking of the attributes.

The 'disagreement' means 'difference in perceptions' of the three groups of D&B project participants in the ranking of reasons, problems and barriers of the D&B method.

1.5.2 Stage 2: Developing a Conceptual Model of Success for D&B Projects

This stage forms the core part of the research study, which aims to develop a conceptual model of success for D&B projects within the public sector of Hong Kong. The second principal hypothesis was then postulated as follows:

The success of a D&B project is a function of the project characteristics, project procedures, project management strategies, project-related participants, project work atmosphere and project environment.

Hypotheses for the research were set up and empirical data were collected and analysed to support or reject the principal propositions through several approaches.

1.6 RESEARCH APPROACH

The research was conducted through both qualitative and quantitative approaches. The research process started with a comprehensive literature review, which identified gaps in the knowledge that formulated research problems. The literature review provides the background for the research and also forms the framework on which a questionnaire is based. The qualitative approach included structured interviews and case studies in the pilot study, while the quantitative approach made use of questionnaire surveys. Both structured interviews and questionnaire surveys were further employed in the testing of the research model (Fig. 1.2).

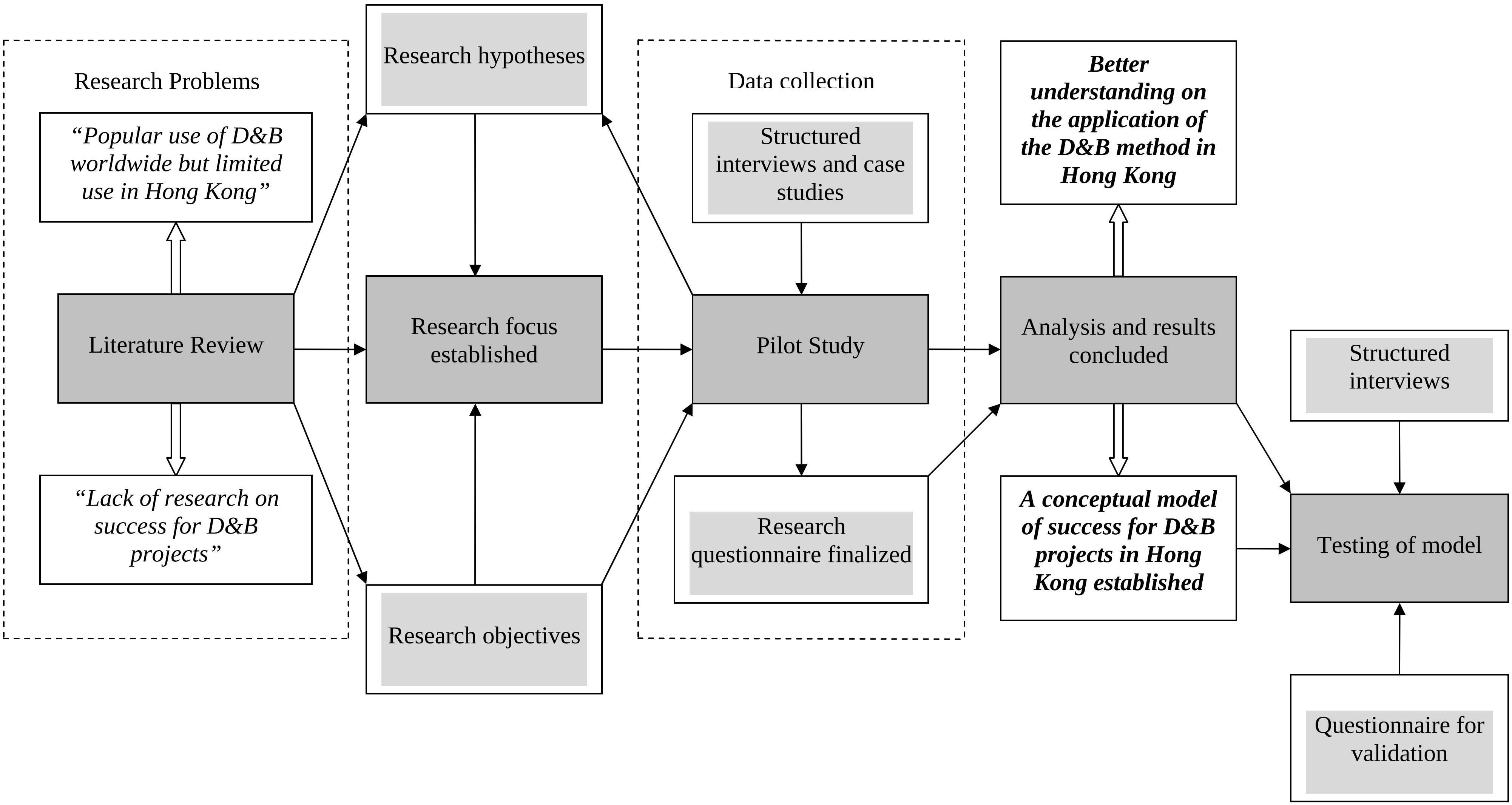


Fig. 1.2 The Research Framework

1.6.1 Pilot Study

The pilot study approach was adopted to develop relevant lines of questions and provide conceptual clarifications for the research (Yin, 1994). It was conducted through structured interviews with D&B project participants in the Hong Kong construction industry. Prior to the pilot study, a draft research questionnaire was prepared based on a comprehensive literature review. Both structured interviews and case studies were employed at this stage.

(1) Structured Interviews

D&B project participants were contacted for face-to-face interviews in order to collect updated information from practitioners within the industry so that any mismatch between theoretical studies and the actual practices could be rectified. Targets of the survey include client representatives, contractors and consultants of public-sector D&B projects. Structured questions on the application of the D&B method and success for D&B projects were set for feedback. The interviewees were also given a set of draft questionnaires for comments. Based on the past experience and expertise of the interviewees, the questionnaires were revised and validated for distribution at a later stage.

(2) Case Studies

Prior to the structured interviews, information on D&B projects in Hong Kong and the project participants involved, was collected to compile a contact list. During the interview, the respondents were asked for details about the D&B project they had worked on and information of other current D&B projects so that differences between background knowledge and the actual real-life context can be identified. Each respondent was also requested to complete the draft questionnaire with reference to an identified D&B project so that realistic data could be collected. Therefore, details on D&B projects could be collected to investigate the situation in Hong Kong.

1.6.2 Questionnaire Surveys

The draft questionnaire was revised and updated based on the comments of the D&B project participants to validate the practicality of the questionnaires in reflecting the actual practice of D&B projects. The final version of the questionnaire was then dispatched to the practitioners in Hong Kong who have experience in running D&B projects. Respondents were asked for the factual information of the D&B project, and their perception of the D&B application in Hong Kong along with the project success issues for their projects. The data were input into statistical software and analyzed in a quantitative manner.

1.7 SIGNIFICANCE OF THE RESEARCH

The problems of the traditional design-bid-build projects have led the clients to find alternative ways to deliver their projects. Design-build is one of the alternative procurement methods but its use is limited in the Hong Kong construction industry. The study of success for D&B projects has brought along with it several benefits. This study is expected to be a positive contribution to encouraging both the adoption and appreciation of the integrated procurement arrangements that will overcome some of the problems of fragmentation currently confronting the construction industry and its clients. The comparison of the responses among the D&B participants enables the team players to better understand the local practices of the D&B method. The development of a conceptual model of success for D&B projects can help to assess whether a D&B project is a success or a failure, and the identification of critical success factors can enhance the chance of success for future projects. Such a study can set a benchmark for D&B research and provide a further research platform for examining alternative procurement methods.

1.8 STRUCTURE OF THE THESIS

This thesis is divided into eleven chapters. This chapter gives the background information of the research study. It shows the importance of the design-build procurement systems in project delivery and expresses the research elements in terms of problem identification, objectives, hypotheses and approaches. The significance of the research is also highlighted and the structure of the thesis is outlined within this chapter.

Chapter 2 reviews the development of the design-build procurement method in most of the developed countries, with particular emphasis on the Hong Kong setting. The drivers used for a wider adoption of the D&B method in the public sector will also be suggested for further evaluation of the D&B adoption in the local context.

Chapter 3 describes the inhibitors of applying the design-build method. It separates the discussion into the problems of running D&B projects and the barriers to the choice of the D&B method in the Hong Kong setting.

Chapter 4 provides a summary of variables affecting the performance of a construction project in the generic sense as well as those of a design-build project. Different models of the factors set up by previous researchers will be described and the variables will be presented which are then regrouped to form a new conceptual model of factors for D&B project success.

Chapter 5 develops a new framework of criteria for measuring the success for design-build projects. The framework generated is based on the various measures of success for a construction project in the generic sense and those of the D&B nature as reported by previous researchers so as to provide a more comprehensive and firmer basis for later analysis. The definitions of criteria and project success will firstly be introduced. Different models of project success, for a construction project, will also be outlined and the criteria explained in the framework.

Chapter 6 describes the methodology for the research. Methods of data collection by literature search, structured interviews and case studies, and questionnaire surveys will be explained. Statistical techniques for data analysis will also be introduced.

Chapter 7 reports the results on the application of the design-build method in the public sector of Hong Kong. It evaluates the reasons for the wider adoption of the D&B method in the public sector, the problems of running D&B projects and the barriers confronted while applying the D&B method within the Hong Kong setting. Results on the comparisons of the responses among the D&B project participants are presented and discussed.

Chapter 8 presents the success criteria and success factors for design-build projects. The project success index for D&B projects is formulated and the variables that affect the level of success of D&B projects are re-grouped by statistical techniques.

Chapter 9 illustrates the conceptual model of success for design-build projects within the public sector of Hong Kong. It presents the results of multiple linear regression analyses of the success criteria and success factors for D&B projects and identifies the critical success factors of D&B projects. The conceptual model will be further developed with analysis on the predictors for D&B project success.

While Chapters 3 – 5 provide a comprehensive desk study on the inhibitors, and the factors and criteria needed for the success of D&B projects, Chapters 7 - 9 report on the empirical studies of evaluating the current practice of the D&B method and the development of the conceptual model for D&B project success. Moreover, Chapter 7 presents the analysis of Stage 1 investigation, while Chapters 8 and 9 document the results of Stage 2 investigations on the development of a conceptual model of success for design-build projects.

Chapter 10 focuses on testing of the model. The samples of the test group are described and the test approaches are introduced. Results of the testing are presented and concluded.

Chapter 11 summarizes the main conclusions of the research study. Contributions of the research are highlighted and recommendations are made for future works.

References and appendices are also attached for information.

1.9 CHAPTER SUMMARY

This introduction has provided the background of the work addressed in the thesis and the justification why this study was carried out. The research approach was described and the hypotheses in this work are presented. A summary of the significance of the research was given together with the structure of the thesis.

CHAPTER 2 DEVELOPMENT OF THE DESIGN-BUILD PROCUREMENT SYSTEM

2.1 INTRODUCTION

The design-build procurement method has been applied by many construction clients to deal with the inadequacies of the traditional procurement method. While there is an extensive use of D&B worldwide, the adoption in Hong Kong is still at a germinating stage. This chapter firstly gives the contemporary definitions of D&B from literature. The global view of the D&B development, with particular emphasis on the Hong Kong setting is then presented. The drivers for a wider use of the D&B method in the public sector of Hong Kong are also examined.

2.2 DEFINITIONS OF DESIGN-BUILD

D&B originated from the ancient "master builder" concept, from which a number of definitions have been advocated by different researchers and Table 2.1 gives further contemporary definitions.

It is a project delivery technique whereby an owner contracts with a single entity (design-builder) to deliver the project (Abi-Karam, 2002). This procurement method integrates the design and construction functions into a single source (Fig. 2.1).

Table 2.1 Definitions of D&B in contemporary research

Researchers	**Definitions**
Merchant and Bajaj (2002)	a general term used to identify a project delivery system with a single point of contact
Kumaraswamy and Dulaimi (2001)	one 'integrated approach to construction'
Molenaar and Gransberg (2001)	an alternative project delivery method that encompasses both project design and construction under one contract
Saucerman (1999)	a contractual relationship for construction where a lone general contractor works directly with the owner from the very beginning of the project and notably in the planning and design phases
Fredrickson (1998)	the combining of the design and construction elements of a project under a single contract
Konchar and Sanvido (1998)	a project delivery system where the owner contracts with a single entity to perform both design and construction under a single D&B contract

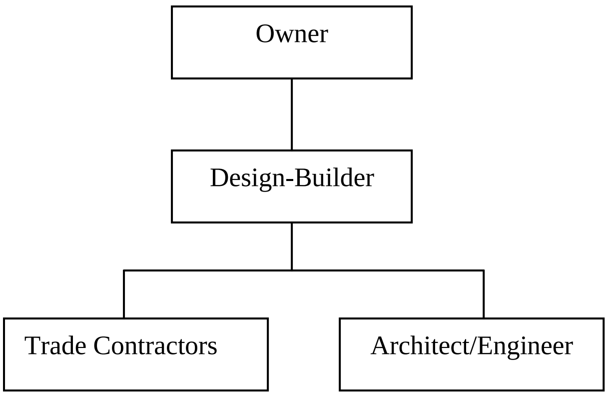


Fig. 2.1 Design-Builder (Adopted from Abi-Karam, 2002)

In Hong Kong, the Architectural Services Department (1997) defined D&B as:

" a method of vesting in the building team the expectations and aspirations of the end users' requirements of the client by integrating the several facets of D&B under a co-operative agreement which permits each party to contribute expertise for the benefits of all and the project."

It is seen from this definition that D&B is a method of procurement in which one organization takes full responsibility and carries sole liability for both design and construction so that the client has a single point of responsibility for both design and construction. It also incorporates client's requirements early in the design stage and fosters the importance of teamwork.

2.3 OVERVIEW OF THE USE OF THE DESIGN-BUILD METHOD

D&B was used early in ancient times where the 'master builders' were commissioned to build palaces, pyramids, cathedrals and temples (Palaneeswaran and Kumaraswamy, 2001). It has become a popular mode of procuring construction work in both western and eastern countries in recent years. Palaneeswaran and Kumaraswamy (2000) claimed that D&B is one of the more popular alternative procurement methods. It has experienced extraordinary growth in recent years and it has been adopted to construct complex buildings in the UK and the US (Deakin, 1999). Previous literature shows that D&B is extensively used throughout the world.

2.3.1 Western Countries

In fact, more significant moves towards D&B procurement are evident from statistics and examples, particularly from the United Kingdom (UK) and the United States (US) (Palaneeswaran and Kumaraswamy, 2001). A review of previous researchers suggests continued growth of D&B in these countries.

(1) UK

The UK construction industry has witnessed a tremendous change in the methods of procuring construction work in recent years (Akintoye, 1994). Clients gradually prefer D&B to other procurement options. Over the last ten years in the UK, the use of D&B has been increased dramatically and there is a growing number of variants of the D&B procurement route (Ndekugri and Turner, 1994). However, the use of D&B contracts on public sector projects is generally low and D&B has been used mainly on housing and health building projects. Most engaged in private sector industrial buildings and commercial office buildings, accounting for up to 60% of all D&B projects (Anumba and Evbuomwan, 1997).

There is ample evidence that an increasing number of clients are adopting the D&B procurement method in preference to others and it has gained a significant foothold in the Northern Ireland Construction market over the past quarter in 1997 (Gunning and McDermott, 1997). It is growing at an average of 15% per annum, and accounts for about 45% of the new contracts won by the largest construction contractors (Egbu et al., 1996). It is estimated that up to 25% of all new-build construction work is based on this method and the figure is expected to rise in the future (Ndekugri and Turner, 1994; Anumba and Evbuomwan, 1997). Moreover, most of the top D&B contractors in the UK have recorded an increase in D&B turnover as a proportion of their turnover. Both clients and contractors expect to see an even greater rise in the proportion of such contracts. Even in the government sector where the UK Department of Transport took the initiative to consider D&B for highways as a serious option to eliminate the increased cost difference between the tendered and out-turn prices of contracts.

Indeed, D&B is now being increasingly used in both private and public sector and it is predicted that it may account for half of all projects in value by the end of the century (Moore and Dainty, 2000).

It seems clear that the use and importance of D&B procurement within the UK construction industry continues to grow in the future and reported investigations suggest similar developments in the US construction industry (Ndekugri and Church, 1996).

(2) US

Design-build is not new to the engineering and construction industry. It has been gaining in importance and more than one-third of the current construction projects in the United States are using the D&B approach (Yates, 1995). It also represents 29% of the top 400 US contractors' revenues (Haviland, 1995). This method even showed a significant growth in 1996 and the top firms generated $39.5 billion in domestic revenues. Current project delivery markets are indeed experiencing a resurgence in the use of the D&B method.

In the last ten years, the market for D&B construction has been increased rapidly in the public sector in the US (Pietroforte and Miller, 2002). Documented D&B success and recent changes in federal procurement laws are indicators of continued large-scale growth (Molenaar, 1999). More recent surveys of Rowings et al. (2000) predicted that D&B will represent over 50% of the commercial market by 2005 and growth in the future will be influenced by use of D&B in areas less familiar with the process.

Some other western countries have also shown interest in the D&B project delivery method. In Australia, fast building is promoted and the novation contract has been used in a number of projects (Chan and Ma, 1999). In Finland, special efforts have been devoted to developing the procurement methods as the means of improving the productivity and there is a willingness to achieve general rules for design-build methods. Anumba and Evbuomwan (1997) also reported that there is an extensive use of D&B in the public sector of Italy for about 20 years. The construction of hospitals, universities and residential buildings has applied D&B which has been one of the most effective procurement methods.

With the emerging economic growth in Asia-Pacific countries, non-traditional procurement approaches are being increasingly used in many sectors of the construction industry in these countries, particularly Japan, Singapore and Hong Kong.

2.3.2 Eastern Countries

(1) <u>Japan</u>

Japan has a long tradition of D&B (Lam, 1990). This procurement method is in fact the traditional method in Japan, for both civil engineering and building works (Walker, 1995). Many Japanese contractors have more than one third of their workload on D&B contracts. They have even expanded their design departments to cope with such increasing workload. Moreover, the construction works based on D&B contracts have long been carried out normally in Japan, with about 10% of the projects related to construction investment adopting this system (Ohkawa, 1995; Anumba and Evbuomwan, 1997). The percentage is as high as 30% - 50% in the case of large construction companies.

In Japan, D&B is widely adopted in nearly all sectors of the construction industry (Lam and Chan, 1995). Despite the large volume of building work being done on a D&B basis, there is no standard form of contract specifically drawn up to cater for the design responsibility of the contractor. In the public sector, the use of D&B is less common as the design is mostly prepared by the ordering entities or their consultants. Indeed, D&B in Japan is mainly practised in the private sector. It is expected that there will be a rise in the trend towards using D&B as a method of procurement.

(2) <u>Singapore</u>

The history of D&B in Singapore is rather short (Lam, 1990). The majority of buildings are contracted out under the traditional arrangement and Kok (1995) claimed that few D&B contracts have been awarded to large commercial projects.

With the strong support provided by the government through the use of the contractual arrangement by public-sector clients, Lip (2001) reported that the D&B approach to the procurement of construction projects is gaining popularity in Singapore. The Public Works Department used D&B contracts for their school construction projects and the Housing Development Board has adopted D&B contract for around 10% of its construction development programme (Kok, 1995; Anumba and Evbuomwan, 1997). Moreover, data from the Building and

Construction Authority showed that in 1999, more than 25% of all building projects (measured by value) were procured through D&B compared to only about 10% in 1995 (Lip, 2001).

In fact, the construction industry in Singapore is moving from the traditional to D&B project procurement. It has been mainly adopted in the public sector and Lip (2001) observed that nearly all the public sector bodies responsible for procuring construction services have tried to award their contracts on a D&B basis. Although the level of utilization of D&B in the private sector is much lower, it is growing. Without a doubt, D&B continues to grow in popularity in Singapore.

(3) <u>Hong Kong</u>

Building projects in Hong Kong are mainly delivered in a traditional contract system (Rowlinson and Walker, 1995). With the potential need for greater cost control and better coordination between the design team and the construction team, clients in Hong Kong are gradually considering other integrated organizational forms such as D&B.

The D&B method is one of the innovative approaches in delivering construction projects. Hampson and Manley (2001) claimed that the public sector is more willing to provide funding on innovation. The government in Hong Kong has established administrative procedures and guidelines for delivering D&B projects since 1999 and most D&B tender documents are based on the D&B Form of

Contract produced by the government. The public policy instruments indeed play a significant role in the British construction industry as a contribution to innovation in construction (Winch, 2001). Belle et al. (2001) opined that government agencies should take the lead in promoting the D&B approach and so research on such an innovative method can be considered to undertake in the public sector. Moreover, civil engineering projects in Hong Kong are less complex than building projects (Miller et al., 1997). Therefore, the focus of the study is confined to the building type projects in the public sector.

2.4 ADOPTION OF THE DESIGN-BUILD PROCUREMENT METHOD IN HONG KONG

In the past, D&B was only carried out on an ad hoc basis in Hong Kong, with an insignificant difference between the public and private sector (Lam, 1990). The development and use of non-traditional forms of contracting is becoming more common and in the last few years, the D&B procurement method has become accepted by the construction industry of Hong Kong (Tam, 1997). The total contract value in the last 20 years is about 3% of the total expenditure, which is about HK$50 billion for D&B main contracts compared with the total expenditure exceeding HK$1,600 billion (Pearson and Skues, 1999).

Indeed, most D&B projects in Hong Kong are used in the public sector. Over 40% of the D&B projects undertaken by construction firms in Hong Kong are public works, while private user-clients tend to use D&B for specific projects only (Chan and Yung, 2000). The government is the single largest client of the construction industry and is responsible for all buildings needed for public services (Rowlinson and Walker, 1995). While the traditional procurement arrangement is still adopted in the majority of projects, the use of D&B is increasing, particularly in the public sector as the government has begun awarding major contracts on this basis. The publication of the General Conditions of Contract for Design and Build Contracts in May 1992 has also assisted the popular use of the D&B method by the government in procuring building projects such as hospitals, slaughterhouses, residential units and minor works.

Of the various government departments, the Architectural Services Department (ASD) accounted for about one-third of the projects in the public sector and its trend in D&B adoption can be used to illustrate the increasing significance of D&B projects in the public sector (Chan and Yung, 2000).

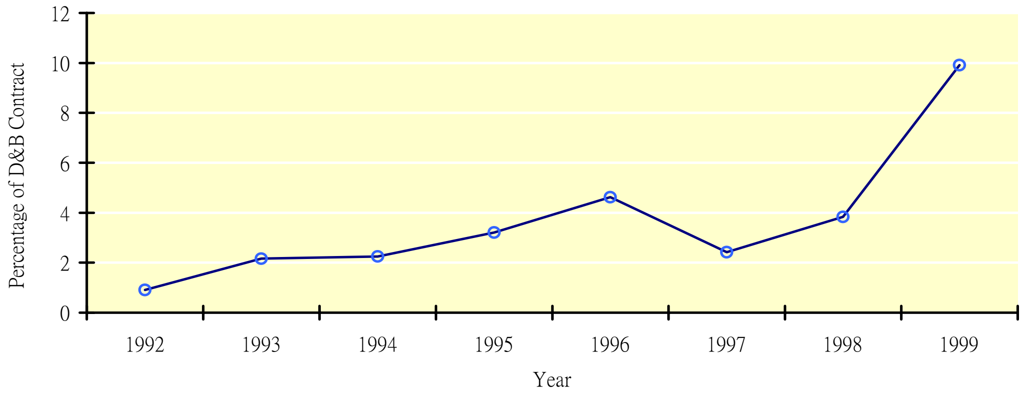


Fig. 2.2 The trend of the use of D&B projects in the ASD between 1992 and 1999 (Chan et al., 2001b)

Fig. 2.2 shows the trend of the use of D&B projects in the ASD over the past 15 years. This figure demonstrates that there is an increasing number of projects adopting the D&B procurement method in the ASD, from 0.91% in 1992 to 9.91% in 1999. The number of contracts in 1999 included those which have been completed between 2000 and 2003 or will be completed by 2004. In addition, four D&B building projects will be completed between 2005 and 2006. Therefore, the D&B method has still been adopted in recent projects, ranging from residential quarters to office headquarters and the projects were scheduled to be completed in 2006. The proportion in total contract value of D&B projects in the ASD over the past 15 years is shown as Fig. 2.3.

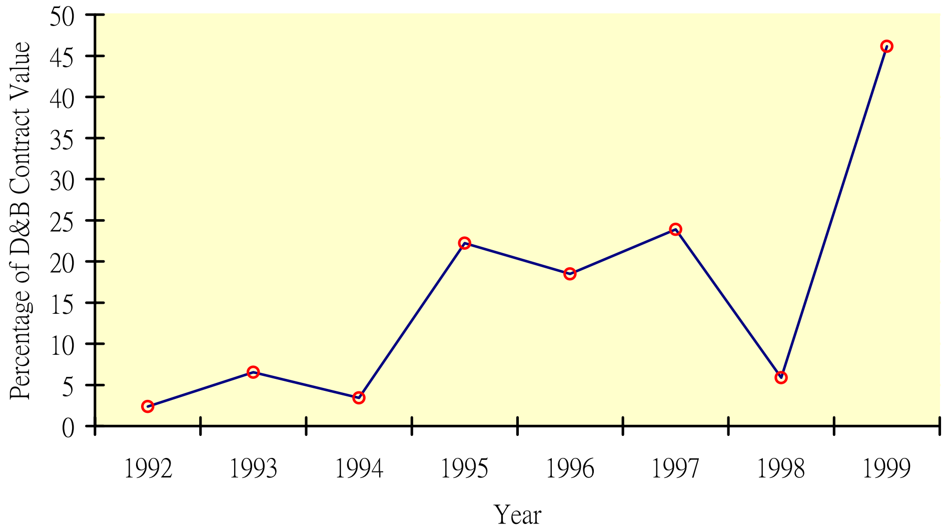


Fig. 2.3 The proportion in total contract value of D&B projects in the ASD between 1992 and 1999 (Chan et al., 2001b)

The contract value of D&B projects increased from HK$68.58 million in 1992 to HK$6025.41 million in 1999, with an increase of nearly a hundred times in the eight-year period. The total D&B contract value over the total construction contract value also increased in the period, from 2.36% in 1992 to 46.14% in 1999, which is almost half of the total construction contract value in the ASD.

There is indeed a large investment in the D&B projects in Hong Kong, indicating a significant influence of the D&B procurement method in the public sector. D&B has been adopted in two major infrastructure projects, namely the Ting Kau Bridge and Approach Viaducts (Leung, 1999). It is also used in procuring some railway projects by the quasi-governmental organizations, which are also classified as the public sector clients (Blake, 1999).

From a review of literature of previous researchers, most D&B projects in, Singapore and Hong Kong are delivered in the public sector, which is quite different from the use in the UK, US and Japan (Table 2.2).

Table 2.2 Summary of the use of the D&B procurement method in different countries

Countries	Public Sector	Private Sector
UK	Less Common	More Common
US	Increasingly Popular	Popular
Japan	Less Common	More Common
Singapore	More Common	Less Common
Hong Kong	More Common	Less Common

2.4.1 Use of Design-Build Variants in Hong Kong

Of the variants of D&B, the traditional type is the most popular because of the relatively longer history, more familiarity with construction professionals, preference of clients and efficient allocation of resources. However, the enhanced type of D&B is an emerging procurement system, which has attracted a lot of enthusiasm in Hong Kong (Chan, 2000). The success of the novation contract of a slaughterhouse project in 1999 has also drawn much attention among project participants. The concepts of the three types of D&B will be introduced in the following sections.

(1) <u>Traditional D&B</u>

This form of variant requires the contractor to accept total responsibility for both the design and construction to meet the requirements of the client (Smith and Wilkins, 1996). In Hong Kong, most residential and office buildings are of this type and the D&B contractors normally allocate the professional staff into two groups – the design team and the construction team for better management of the project. External design consultants are employed to manage the design issues for the contractor (Fig. 2.4).

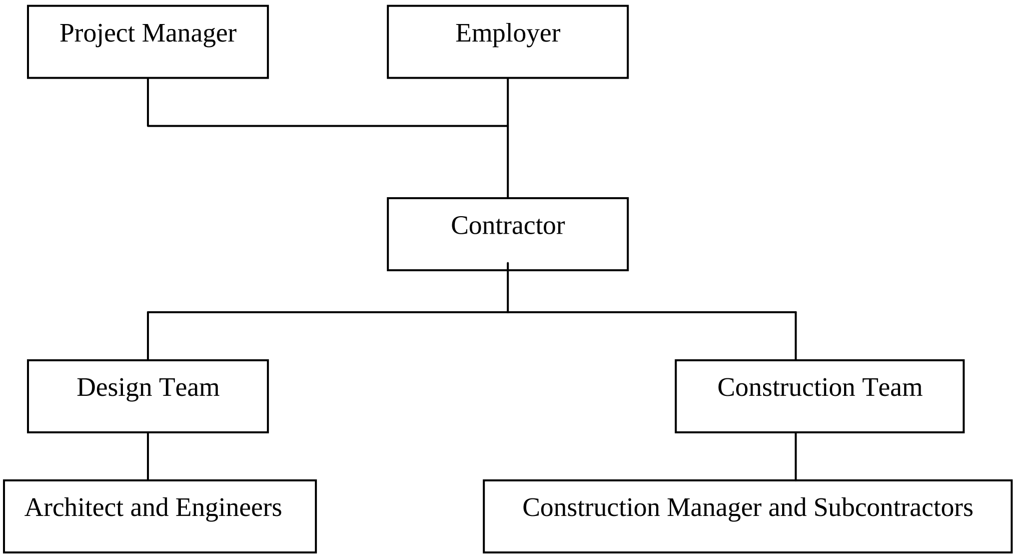


Fig. 2.4 Traditional D&B contract (Lam, 1998)

(2) Enhanced D&B

Enhanced D&B enables the client to ensure the conformance of the basic design to his requirements by retaining control of the initial design (Chan, 2000). The term 'enhanced' signifies that the client would develop the design, using their own team of consultants, to a point where the significant planning issues and inter-departmental relationships were all determined, and would require tenderers to submit a conforming bid based on this design (Deakin, 1999; Chan, 2000). In Hong Kong, enhanced D&B has been employed in hospital projects and Fig. 2.5 illustrates the relationships of key participants in this variant.

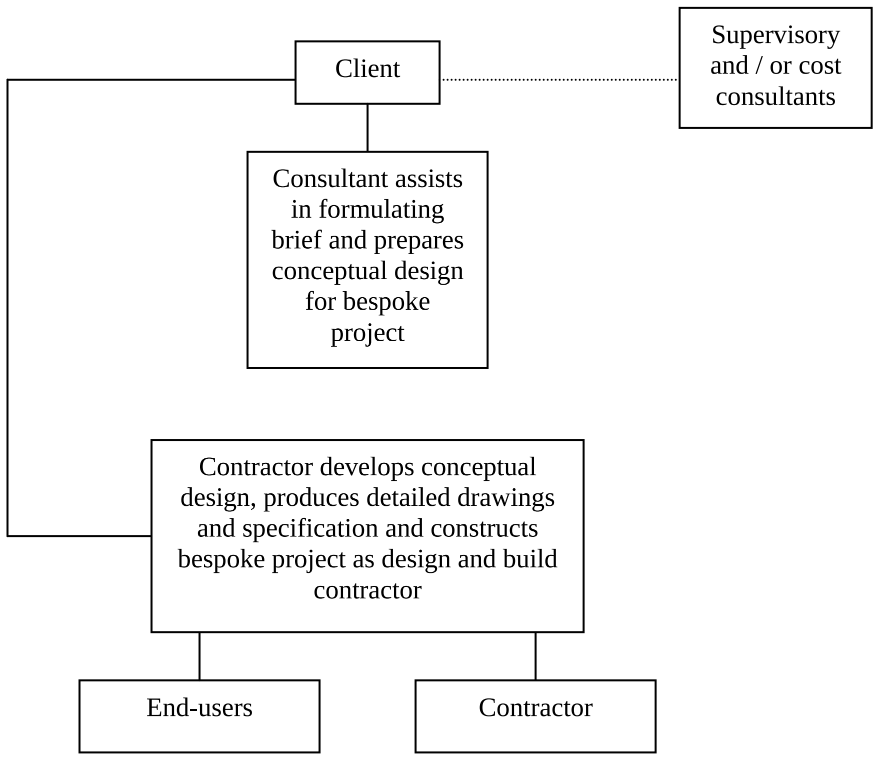


Fig. 2.5 Enhanced D&B contract (Chan and Chan, 2004)

(3) Novation D&B

Novation is a mutual agreement which substitutes an old obligation for a new one (Ng and Skitmore, 2002). Under novation, the client needs to take a more active role in the building process and the contractor is required to employ the same team of consultants after the award of contract. Lam (2000a) pointed out that the novation D&B offers clients more control over the design process and quality since the consultant team would be re-employed by the contractor even after the design development stage. This variant has been applied to a slaughterhouse project in Hong Kong and the relationships of key participants are described as Fig. 2.6.

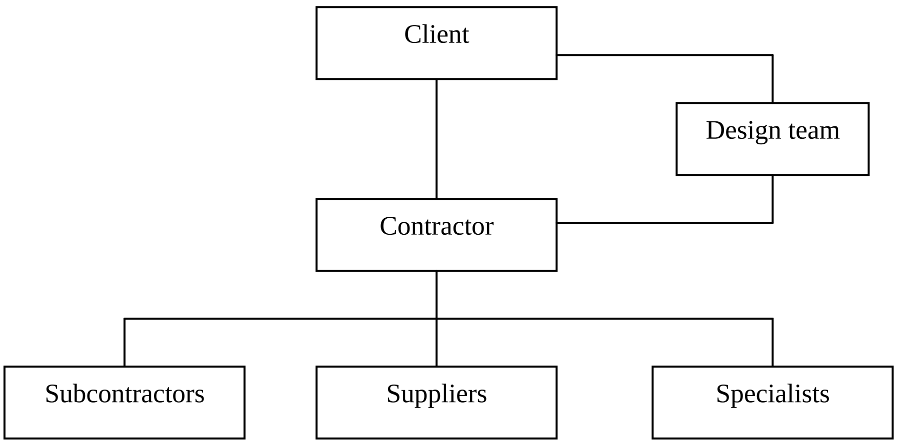


Fig. 2.6 Novation D&B contract (Ng and Skitmore, 2002)

While the traditional procurement arrangement is still adopted in the majority of projects, the use of D&B is increasing since the government started to award major contracts on this basis (Lam and Chan, 1995). In fact, a wider adoption of the D&B method in the public sector of Hong Kong can be explained by the benefits that D&B brings about.

2.5 REASONS FOR APPLYING D&B TO PUBLIC SECTOR PROJECTS

Public sector clients have a high regard for accountability, value for money and certainty of completion. These clients have experimented with D&B with varying degrees of success which may be due to a number of benefits that D&B can offer.

2.5.1 Single Point of Communication

One benefit that D&B offers is the single-point responsibility that has drastically increased productivity at both pre- and post-contractual stages (Franks, 1998). In the public sector, it is recognized that there is usually a lack of communication of end-users' requirements in the brief development and design stages, which is seen as a 'multi-headed client problem'. The enhanced D&B project delivery method consults the end-user's requirements in formulating project brief (Smith and Wilkins, 1996). D&B allows the concerned parties to meet and discuss detailed requirements through direct communication with the contractor who is responsible for the design, construction, planning, organization and control of the project. Such an integrated nature of teams improves communication between designers and builders and encourages a prompt response.

2.5.2 Certainty on Time and Cost

D&B enables public sector clients to have firmer control of time. It offers a faster approach than the traditional procurement method as the fast track concept of overlapping the design and construction is possible (Hong Kong Construction Association, 1990). As construction can commence before the completion of design, the project duration can be shortened. Such characteristics of D&B projects can be better achieved in the public sector as the clients can better follow the application procedures. As a result, the clients can be more certain of when the project is finished which has important cost implications.

In D&B projects, there are certainties in controlling the design of contractors since the client's requirements are well defined and stable at the project inception stage. Therefore, the early cost certainty is possible through D&B (Franks, 1998). This criterion is important, particularly in public sector projects as it is considered essential to have a fixed price determined well in advance. In this context, D&B is chosen because of the definite completion date and the guaranteed cost which are the prime concerns for public sector projects (Chan and Yung, 2000).

2.5.3 Use of Contractor's Expertise

D&B combines both the contractor and design consultants' expertise where the special expertise of the contractor can be utilized (Hong Kong Construction Association, 1990). Moreover, the closer involvement of the design consultants in the building process can lead to designs having a greater appreciation of the construction methods, i.e., buildability (Works Bureau, 1999). It also provides opportunities for innovation and excellence which results in a design with the best value for money (Palaneeswamy and Kumaraswamy, 2000).

2.5.4 Use of Private Sector Resources

Many public sector clients nowadays have sought to privatize social services to minimize financial and managerial effort (La Grange and Prestorius, 1996). In fact, the use of the D&B procurement method in the public sector enables the clients to enjoy some benefits of privatization, including the risk transfer to the private sector, the increase in operating efficiency and the streamlining of the size of the public sector (Lam, 1990). Therefore, the use of the private sector through D&B can reduce the government's resources for design work, reduce claims and help lower risks (Songer and Molenaar, 1996).

2.6 CHAPTER SUMMARY

This chapter provides the definitions of design-build as outlined in recent research. It also gives a global view of the use of the D&B method, with particular emphasis on the Hong Kong setting. It further accounts for the phenomenon by matching the benefits of this alternative procurement system with the established objectives of public sector projects. However, the use of the D&B method is still considered limited in Hong Kong due to a number of inhibitors that are discussed in the following chapter.

CHAPTER 3 INHIBITORS OF APPLYING THE DESIGN-BUILD PROCUREMENT SYSTEM

3.1 INTRODUCTION

Most benefits of the design-build procurement method have been reported in the literature and observed in practice but its use is rather limited in the Hong Kong construction industry. While the D&B project participants may find it difficult to master the D&B projects in practice, some existing factors may also impede the choice of the D&B method in delivering construction projects. The mixture of the inhibitors of the D&B method reported in the literature is therefore separated under two headings, namely the problems of running D&B projects, and the barriers that hinder the development of the D&B method to give a clear evaluation of the D&B method in the local context.

3.2 PROBLEMS OF RUNNING DESIGN-BUILD PROJECTS

It is recognized that among other alternative project delivery systems, D&B appears to be gaining popularity (Mo and Ng, 1997). However, those working within the industry have a limited exposure to and understanding of the D&B method (Konchar et al., 1997). Researchers like Chritamara and Ogunlana (2001) identified that the difficulties of D&B projects are related to technical, financial and environmental risks. Lam et al. (2003) documented a critical literature review, which reveals that managing D&B projects is not without problems. Table 3.1 summarizes the major potential problems when running D&B projects from the literature and the frequency of their citations.

A review of literature indicates that the problems associated with the client can be categorized as those in the pre-construction and construction stages. While the D&B stakeholders face various problems in running their projects, some literature outlines the problems caused by the client and the consultant in project implementation. Fig. 3.1 summarizes the major problems when running D&B projects as identified from the previous studies.

3.2.1 Problems associated with the Client

The major problems of running D&B projects from the viewpoint of a client have been classified by the previous literature as those in the pre-construction and construction stages.

(1) <u>Problems in the pre-construction stage</u>

The problems caused by the client in this stage include lengthy evaluation of tenders and unclear client's requirements while this group may face the problems of little interaction with the tenderers and little choice on market.

Table 3.1 Summary of literature on potential problems of running D&B projects

	Problems of running D&B Projects													
	Problems (Client)							Problems (Contractor)			Problems (Design Consultant)			
	Pre-construction stage				Construction stage									
Researchers	Lengthy evaluation of tenders	Unclear client's requirements	Little interaction with the tenderers	Little choice on market	Frequent and late changes	Delay of design approval	Restricted control over the project	Lack of management expertise	Tendering burden on contractor	Misinterpretation of client's requirements	Loss of professionalism	Ethical problem	Technical problem	Other considerations
Masterman (1992)			✓		✓									
Akintoye (1994)								✓						
Chan (1994)				✓						✓				
Akintoye and Fitzgerald (1995)		✓	✓					✓					✓	✓
Dulaimi et al. (1995)									✓				✓	
Haviland (1995)		✓												
Nkado (1995)								✓						
Ross and Fortune (1995)									✓					
Yeang (1995)						✓								
Ho et al. (1996)	✓							✓						✓
Ndekugri and Church (1996)	✓								✓				✓	
Pain (1996)	✓													
Smith (1996)		✓									✓	✓		✓
Tao (1996)										✓				
Gunning and McDermott (1997)					✓				✓	✓				
Ling (1997)								✓			✓			
Mo and Ng (1997)				✓			✓						✓	
Chan et al. (1999)					✓			✓					✓	✓
Foo et al. (1999)			✓		✓			✓	✓			✓		✓
Hemlin (1999)													✓	✓
Lamont (1999)										✓				
Lewis (1999)					✓									
Saucerman (1999)				✓			✓							
Smith (1999)		✓												
Works Bureau (1999)	✓			✓			✓	✓	✓					
Ernzen and Schexnayder (2000)					✓									
Lam (2000b)	✓	✓		✓	✓		✓							✓
Ling et al. (2000)								✓						✓
Chritamara and Ogunlana (2001)		✓			✓	✓				✓	✓			
Total	5	6	3	5	8	2	4	9	6	5	3	2	6	8

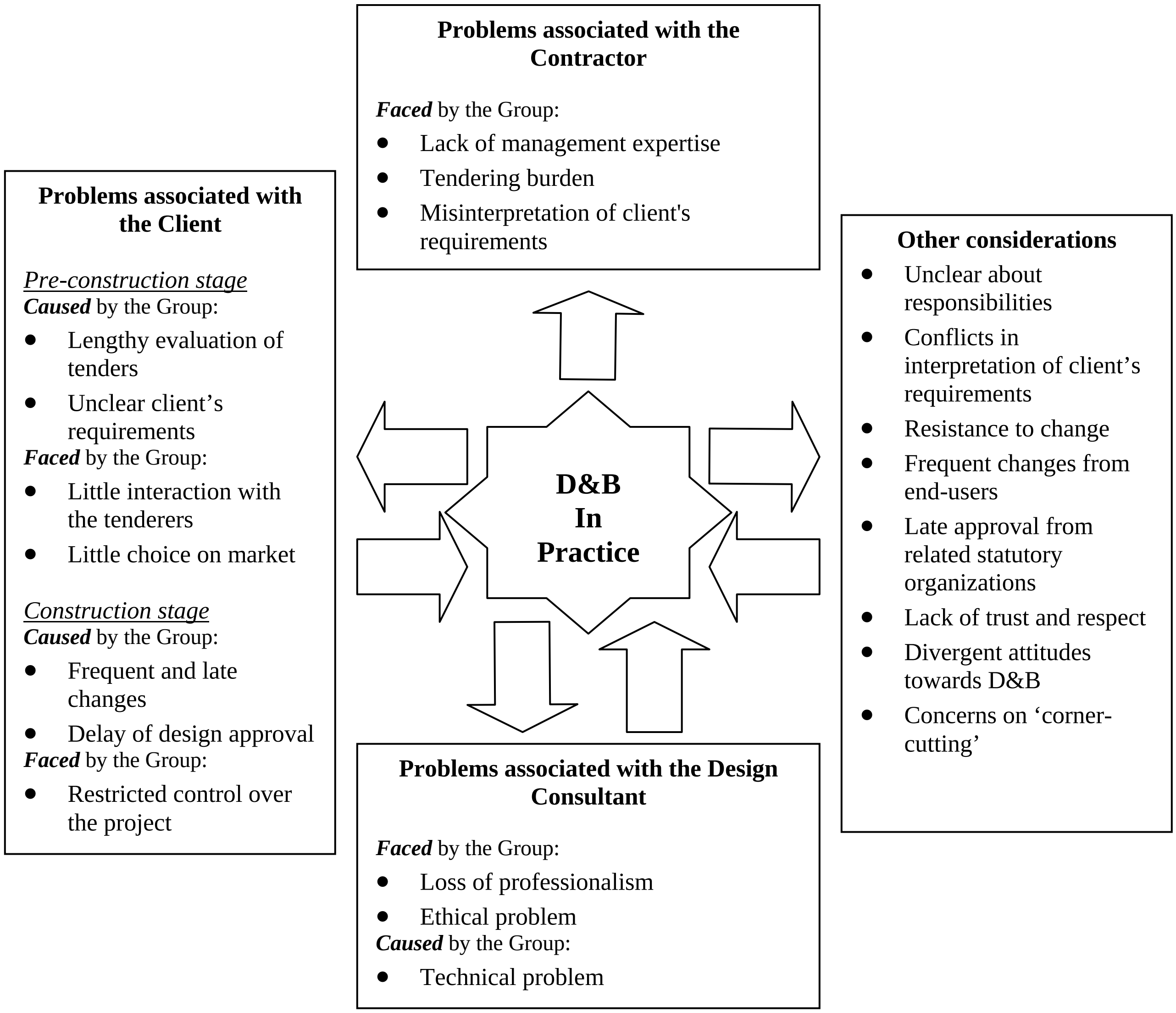


Fig. 3.1 Potential problems of running D&B projects

(a) Lengthy evaluation of tenders

Pain (1996) suggested that to bid for a D&B project, many design routes are possible. Different proposals in terms of design, materials and service equipment may be received and it is difficult for the client to compare the tenders, which involves a large amount of subjective judgment (Ndekugri and Church, 1996; Lam, 2000b). It is also difficult to establish guidelines and adjustments for tender assessment of D&B projects. Ho et al. (1996) claimed that the tendering process is longer and more complex than that of a project under the traditional system because of the lengthy technical and design review process. As the proposals are different, it indeed takes time to compare an 'apple' with an 'orange' so that the client can select the most suitable proposal for the D&B project.

(b) Unclear client's requirements

The client can be considered as the initiator of a building. It has been established by previous researchers that D&B may increase the burden of the client, who will have to define clearly the scope of a project at an early stage (Haviland, 1995). In D&B projects, the client is required to state the project requirements clearly. Otherwise, the opportunity for disputes and variations would be increased due to incomplete documentation, as suggested by Haviland (1995) and Lam (2000b). Such client competency is related to the experience of the client and thus may be limited in some client organizations. The less information that is provided, the more the D&B contractor will have to assume and so the quality of the tender will be affected.

(c) Little interaction with the tenderers

In the traditional D&B projects, the client may have little opportunity to interact with the D&B construction team while the tenders are being called. Foo et al. (1999) claimed that the D&B tenderers may come up with alternatives which do not exactly follow the client's requirements. The problem may be complicated when the client's brief is ambiguous and no communication of the client's precise wishes is conveyed to the contractor (Masterman, 1992). Such poor communication may consequently lead to misunderstanding of requirements and the client may suffer from misinterpretations of the requirements (Akintoye and Fitzgerald, 1995).

(d) Little choice on market

The D&B bidders are normally selected from a registered list through the pre-qualification exercise which restricts the choices for the client. Therefore, the tender price may be inflated due to less competition (Mo and Ng, 1997; Lam, 2000b). The client may not be able to collect sufficient construction bids for comparison nor enjoy the competitive price under the traditional procurement system (Saucerman, 1999; Works Bureau, 1999). Chan (1994) reported that the restriction of nominated subcontractors and other associated disciplines under novation contracts may take away the client's privilege of bargaining for a lower price. Consequently, the tender price will overall be increased to cover the additional risks of accepting the consultants' design by the contractor. Moreover, Lam (2000b) found that D&B requires a contractor to team up with suitable design consultants to submit proposals for a D&B project.

(2) <u>Problems in the construction stage</u>

The problems caused by the client at this stage include frequent and late changes; and delay of design approval while the client may face the problem of restricted control over the project.

(a) Frequent and late changes

In D&B projects, the design stage overlaps with the construction stage but changes may still exist in the construction stage initiated by the client because of an undefined scope at the project initiation (Ernzen and Schexnayder, 2000). Lewis (1999) and Foo et al. (1999) criticized the layered structure of design approval process for government D&B projects, which may also provide rooms for variation even if the initial proposal is accepted. As the design activities proceed with the construction works, any changes in site condition may lead to consequential changes in design and construction – the knock-on effects. As a result, it may take longer for the project to be completed since the sequence of construction of the building has to be re-planned (Gunning and McDermott, 1997; Lam, 2000b).

(b) Delay of design approval

In bidding for a D&B project, tenderers are required to submit a detailed proposal to the client (Chritamara and Ogunlana, 2001). After the tender is accepted, the winning contractor is required to further develop the design into greater detail, such as the specification of the materials. In cases where a hierarchy of approval process is to be undertaken, the chance of delay in design approval may be increased. The problem is particularly critical in government D&B projects where various lengthy approval procedures are claimed to be the culprit of project delay and it takes time for the contractor to obtain approval of materials before the start of the related construction activities. However, Yeang (1995) pointed out that the client may bear risks in design interface with the contractor since any disagreement may lead to a delay in the progress of work.

(c) Restricted control over the project

D&B is known for providing a single point of responsibility by the contractor for the client. Mo and Ng (1997) opined that the control of the client on the project will be reduced as the contractor liaises with the project participants in both design and construction stages. Lam (2000a) even claimed that the client may be at high risk if the contractor does not perform the duty properly. The client may not enjoy the same professional standard from the designer since the design and construction stages become the control of one single entity and thus the overall control of the client over the D&B project is reduced (Friedlander, 1998; Works Bureau, 1999). The control of the client over the design of the project may be restricted as the design consultants are now answerable to the contractor rather than to the client.

3.2.2 Problems associated with the Contractor

The contractor becomes the leader of a D&B project, and is responsible for both the design and construction work. Most literature reported that the most common problems faced by the contractor in running D&B projects were the lack of management expertise, tendering burden and misinterpretation of client's requirements.

(a) Lack of management expertise

In D&B projects, the management of design and construction becomes the responsibility of one single organization, usually the contractor. Nkado (1995) believed that the expectations of the contractor's expertise is so high that the D&B contractor is expected to evaluate all performance measures of a project including the cost, quality standards and overall project duration. Ho et al. (1996) also opined that the contractor should coordinate between the design phase and the construction phase effectively. However, the majority of D&B contractors do not have an in-house design team and so they need to assign the design task to external consultants (Akintoye, 1994). There may also be incompatibilities between the contractor and the consultants appointed by the client (Foo, et al., 1999). While in-house designers confer high overheads to the contractor, Ling (1997) believed that employing external consultants may lead to weak communication links and coordination problems, especially for projects involving a high level of coordination and technical expertise. As design consultants are mostly professionals, D&B requires these professionals to work with the less professional contractor organization and it is problematic for the contractor to integrate with the design consultants as well as the independent design checkers (Ling et al., 2000).

(b) Tendering burden

In D&B projects, the contractor bids on a certain number of unknowns at the time of tender since the client may not be certain of the requirements. As the overlapping of design and construction phases is one major advantage of D&B, Ross and Fortune (1995) criticized that it is rather difficult to plan a realistic schedule in such a short period of time and designs tend to be developed with great price uncertainty. If there was inadequate planning of the design, it would be difficult for the contractor to provide a better solution without additional cost to the client to compensate for the uncertainty (Dulaimi et al., 1995; Gunning and McDermott, 1997). The contractor's proposal and resources will also be wasted if the bid is unsuccessful (Ndekugri and Church, 1996; Foo et al., 1999).

(c) Misinterpretation of client's requirements

The client's requirements define the scope of a D&B project and form the basis for the tenderers to prepare the contractors' proposals. Chritamara and Ogunlana (2001) pointed out that if there is ambiguity in the client's requirements, arguments about the client's variation may exist since a misinterpretation of the client's requirements by the contractor may be very costly. There is also a lack of standardized client briefing and code of practice for the D&B tendering process (Gunning and McDermott, 1997). Moreover, Tao (1996) claimed that the inflexible requirements may discourage the contractor from deriving a more effective solution since what he proposes may deviate from the brief. By contrast, Lamont (1999) argued that the inclusion of flexibility within contracts probably introduces a lack of precise definition which in turn leads to diverse interpretation of what is required.

3.2.3 Problems associated with the Design Consultants

The major problems faced by design consultants include the loss of professionalism and ethical issues while the group may cause technical problems in the running of D&B projects.

(a) Loss of professionalism

Under the D&B procurement system, the responsibility for the design quality after tender is no longer in the control of the design consultant nor the client, but falls in the hands of the contractor (Smith, 1996). Ling (1997) concluded that the traditional role of the design professional to ensure the quality of the project is lost and the architectural profession may not be able to enjoy authority and independence under the traditional procurement system. As a result, the design professionals may not be able to exercise the obligation of reasonable skills and care to protect the interests of the client (Chan, 1994). Yates (1995) pointed out that the design consultants may no longer be in the position to look after the best interests of the owner. Job dissatisfaction may occur as a result of an erosion of professional roles and responsibilities in construction procurement.

(b) Ethical problem

Smith (1996) contrasted design professionals with construction experts on different objectives towards the procurement of a project. While the design consultants provide a disinterested service to safeguard the interest of the client at all times, the contractor seeks to maximize their profit. In D&B projects, the single point entity requires the design professionals to work closely with the contractor who becomes the employer of the design teams. Therefore, the design consultants may be involved in a serious conflict of interest situation with the client and the contractor. The design quality of the project may be restricted to the contract sum rather than the design expertise of the consultant.

(c) Technical problem

To achieve the time benefit of D&B, the design consultants have to provide the service with high speed and time for design and organization may not be sufficient (Akintoye and Fitzgerald, 1995). Moreover, Mo and Ng (1997) were concerned that the method of valuing variations is a common problem in all D&B contracts in cases where a breakdown of the contractor's rates and prices are not detailed. Hemlin (1999) pointed out another problem in the poor coordination of design among design consultants, especially when a separate layer of design supervision is introduced. Chan et al. (1999) commented that such discontinuity may create unnecessary duplication efforts, which in turn causes difficulty for the contractor. The lack of sufficient time may also affect the production of good design solutions (Akintoye and Fitzgerald, 1995).

3.2.4 Other Considerations

D&B has existed for decades. Still, some clients, contractors and other consultant parties are not familiar with this procurement method. Chan et al. (1999) pointed out that project team members may be unclear about their responsibilities and conflicts may exist in the interpretation of the client's requirements. Therefore, the participants are accustomed to the traditional system and are resistant to change (Ho et al., 1996). End-users' frequent change of mind may also disturb the progress of the construction work. Foo et al. (1999) concluded that delay may occur as a result of late approval from the related statutory organizations.

Project participants under D&B may not develop trust and respect among themselves. Hemlin (1999) commented that some clients may be conscious of the effects of risks on profit and the use of D&B enables risk avoidance. In fact, some contractors may be driven by the commercial objective to build and they may pay less attention to quality to reduce costs (Akintoye and Fitzgerald, 1995; Lam, 2000a). As a result, the client may not have confidence in the capacity of the contractor who may lack D&B experience. The participants have also expressed concerns about the issue of 'corner-cutting' on behalf of the D&B contractor, which lowers the quality of the project. Akintoye and Fitzgerald (1995) criticized that the contractors fail to appreciate the architect's contribution. There is also resistance from the design consultants as the D&B contractor becomes the team leader of the project (Ling et al., 2000).

Apart from the problems of running D&B projects in practice, the limited use of the D&B method is also attributed to a number of barriers that hinder the choice of such an alternative procurement method.

3.3 BARRIERS TO DESIGN-BUILD DEVELOPMENT

The previous section reported the major problems in running D&B projects from the perspectives of clients, contractors and consultant. To further understand the difference in preference in the choice of D&B, the main barriers inherent in the application of the D&B method are examined from the three main stakeholders.

3.3.1 Barriers to the Client

(a) Demands on client competency

Success in D&B projects largely depends on a clear brief, which requires more effort from the client (Deakin, 1999). Chan et al. (2000) pointed out that much more time and effort are required to develop the client's requirements, especially when the end-users' needs are uncertain or ambiguous since a comprehensive and clear brief is essential for contractors to draft their proposals. Moreover, tendering for D&B projects is more complicated than that for traditional projects and there is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements (Works Bureau, 1999). As a result, Deakin (1999) concluded that the client needs to set out clearly and in detail exactly what he requires at a very early stage and a great deal of effort and professional skills are utilized in the formulation of the client's requirements. However, Lamont (1999) and Harris (1999) criticized that the client may not know exactly what is needed at the preliminary stage of a project, which makes it difficult to ensure good performance at the design and specification stage. Smith (1999) even pointed out that in Hong Kong, few client organizations are able to adequately and comprehensively define what they want unambiguously at the outset of a contract.

(b) Attitudes of the client

Previous researchers, such as Yates (1995) and Chan et al. (2000) reported the benefits of the D&B method. However, Hemlin (1999) claimed that the main motivation of the client in adopting D&B is risk avoidance and it appears that the clients are not aware of any other benefits. In fact, the client tries to pass all risks and responsibilities onto their design and construction experts, especially for the more complex projects where the expertise of the contractor can be utilized (Smith, 1996; Chan et al., 2000). Ho (1995) pointed out that most clients prefer the traditional practice to the D&B method since most local firms are familiar with and accustomed to the traditional system. Yates (1995) and Ho et al. (1996) also commented that the client enjoys the architect being a caretaker to look after their best interests and there is resistance to change. On the one hand, the client may not have confidence in the new procurement method which is still in the learning and testing stage; on the other hand, the client lacks control over quality of design since the design professionals are no longer close to the client and risks may be imposed on the client related to design quality (Hong Kong Institute of Architects, 1998; Harris, 1999; Smith, 1999).

3.3.2 Barriers to the Contractor

(a) Costs of unsuccessful tender

Tao (1996) emphasized that the contractor tendering for the D&B project will suffer greatly if the contract is not awarded because of the cost of preparing tenders. In fact, the overall cost of tendering is immense since a design must be completed by the contractor and the associated team of designers as part of the tender document without any form of subsidies from the client (Smith, 1999). However, as Ndekugri and Church (1996) and Foo et al. (1999) noted, only one proposal is awarded the contract and other contractor proposals and resources will be wasted.

(b) Extra risks on contractor with less incentive on the use of D&B

D&B contractors carry a high degree of risks and liability since they bid on certain unknowns at the time of the tender (Harris, 1999). Ross and Fortune (1995) pointed out that it is also difficult to plan a realistic schedule in such a short period of time due to the lack of relevant information. The contractor may end up with the potential cost and time implications of variations with the risk of delays in obtaining necessary statutory approvals (Deakin, 1999). Hemlin (1999) and Chan et al. (2000) further concluded that a higher tender price for covering the risks of accepting incomplete design may result and the risks undertaken by the contractor need to be shared by different subcontractors. Project participants may not develop mutual trust and understanding with each other and they may pass all responsibilities onto their contractors (Smith, 1996; Lewis, 1999). Tao (1996) and Harris (1999) claimed that all aspects of the design present risks to the contractor, coupled with the inflexible requirements which may discourage the contractor from deriving a more effective design solution. Even if the contractors consider that D&B works well in practice, they may not have sufficient incentive to promote the advantages of D&B method to the clients and they may adopt a rather passive role (Hong Kong Institute of Architects, 1998; Deakin, 1999).

(c) Inexperience of contractors

D&B requires the contractor to be responsible for both design and construction. However, Deakin (1999) and Hemlin (1999) reported that there is a lack of capable and experienced D&B contractors, leading to a poor coordination of design among design consultants, which poses a new challenge to the contractor to manage consultants. Some D&B contractors do not have sufficient design management experience and the lack of knowledge in the design process may give rise to poor quality and stereotype design (Akintoye and Fitzgerald, 1995). Moreover, most D&B contractors do not have in-house architects and engineers and so they need to assign the design task to external consultants (Akintoye, 1994; Mo and Ng, 1997). Some D&B contractors may not appreciate their management role in quality control, supervision and certification and so delays in obtaining statutory approvals may result (Akintoye and Fitzgerald, 1995; Deakin, 1999). Chan et al. (2000) also pointed out that the D&B contractors do not fully understand their role in this alternative procurement method.

3.3.3 Barriers to the Consultant

Ling et al. (2000) claimed that there may be a negative impact on the image of the design team in the D&B method as the D&B contractor becomes the team leader of the project. As a result, the independence and prestige of the design professionals will be undermined, and even destroyed (Smith, 1996). Job dissatisfaction may occur as a result of an erosion of professional roles to ensure the quality of the project (Ling, 1997). The designers may even feel resistant to the D&B method and may find it difficult to achieve a true professional activity (Akintoye and Fitzgerald, 1995; Chong, 1996).

3.3.4 Other Noted Barriers

Hemlin (1999) claimed that project participants may not have confidence in managing D&B projects successfully. Even if D&B has existed for decades, some project participants may not be familiar with the method and so there is a lack of promotion of D&B within the industry, which may hinder further adoption (Pearson and Skues, 1999). Legislative restrictions have also inhibited the applicability of the D&B concept to specific project types and Konchar et al. (1997) reported that there is an inadequate number of local legal precedents regarding D&B projects to follow in case of disputes. Therefore, if there is work left by a defaulting D&B contractor, legal problems of responsibility for the unfinished work may arise (Works Bureau, 1999). In Hong Kong, there is a lack of D&B knowledge and experience which may impede the more widespread use of D&B (Pearson and Skues, 1999). Fig. 3.2 illustrates the main barriers to the D&B development as described in the chapter.

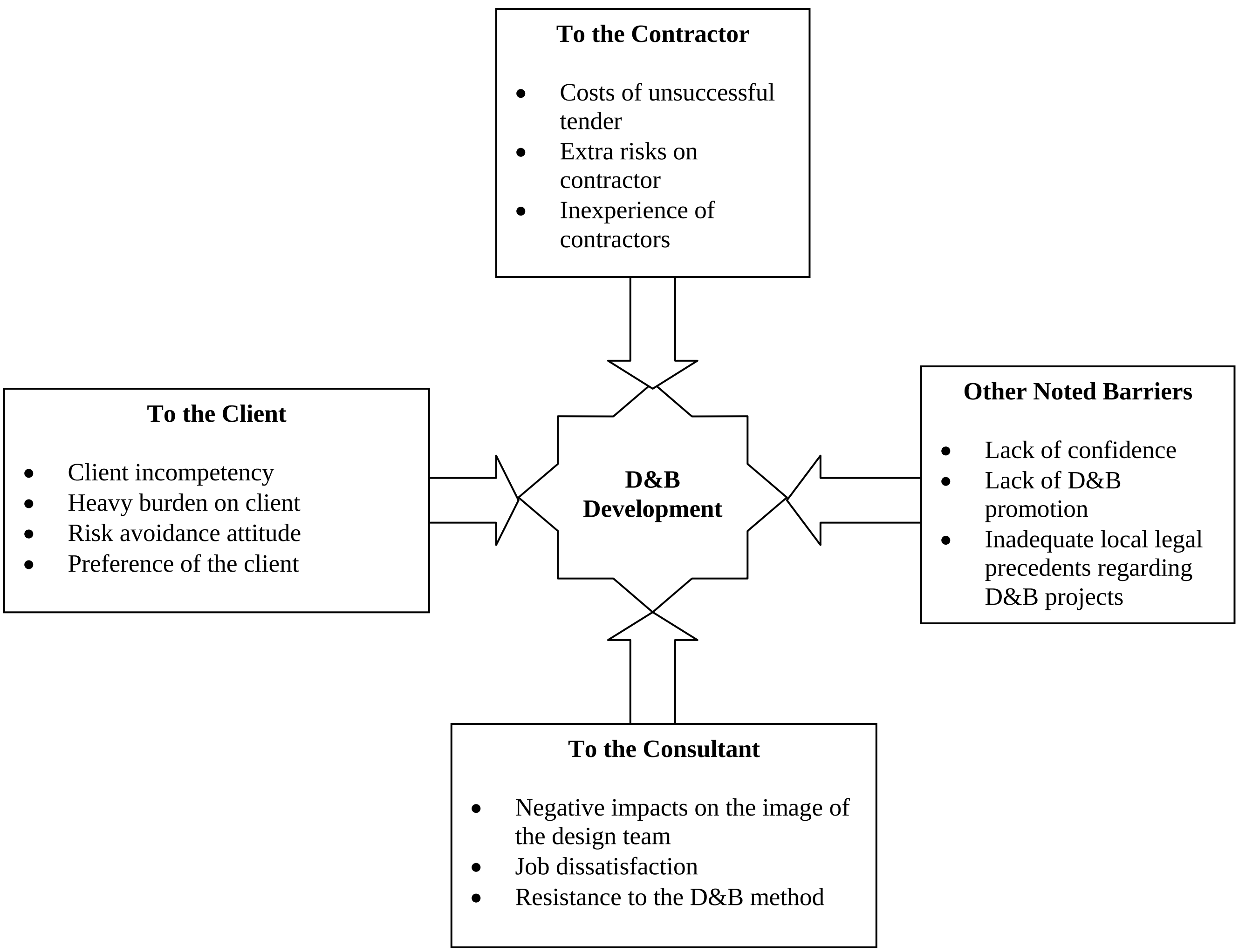


Fig. 3.2 Barriers to D&B development

3.4 CHAPTER SUMMARY

D&B has been widely adopted globally in an attempt to tackle the problems of the traditional design-bid-build method. However, its use is comparatively limited in the East due to a number of inhibitors. This chapter described the problems of running D&B projects in practice and the barriers to the choice of the D&B method, from the perspectives of the key D&B project participants. While there is a growing emphasis on the increasing use of the integrated D&B method, project participants should be able to identify the success factors for D&B project so that improvement can be made in the future.

CHAPTER 4 FACTORS AFFECTING DESIGN-BUILD PROJECT SUCCESS

4.1 INTRODUCTION

The identification of critical success factors enables project team leaders to make improvements in project management areas. Most studies discussed the topic for construction projects in a generic sense and it seems that limited models of the success factors for D&B projects have been developed. This chapter aims to establish a conceptual framework of critical success factors (CSFs) for D&B projects. It first defines the meaning of CSFs in construction. Then a review of different CSF models will be presented. A comprehensive framework of CSFs for D&B projects and the related factor variables will be established.

4.2 DEFINING PROJECT SUCCESS AND CRITICAL SUCCESS FACTORS

Belout (1998) defined success as the effectiveness and the efficiency of a product. To manage a construction project efficiently, Clarke (1999) believed that by separating out the "important few from the trivial many", this would focus attention on some key critical success factors so that lessons learnt can be well applied to future cases.

Sanvido et al. (1992) considered CSFs as extremely important and Tiong et al. (1992) believed that the likelihood of a successful outcome would be increased if the CSFs were sustained. The definitions of CSFs by previous researchers are shown in Table 4.1.

Table 4.1 Definitions of critical success factors (CSFs)

Year	Authors	Definitions
1992	Sanvido et al.	Factors predicting success on projects
1992	Tiong et al.	Those things that must be given special and continued attention
1995	Etmanczyk	Elements that must be present for an organization to attain its vision
1999	Lim and Mohamed	The set of circumstances, facts, or influences which contribute to the result

Critical success factors (CSFs) are the statements of how improved business practice must be achieved if an organization is to be able to attain its mission (McCabe, 2001). Indeed, criteria and factors resemble the cause-and-effect relationship, and Lim and Mohamed (1999) discussed the essential difference between criteria and factors as shown in Fig. 4.1. The factors contribute to the success or failure of a project, but do not form the basis of the judgement, which is essentially the function of the criteria.

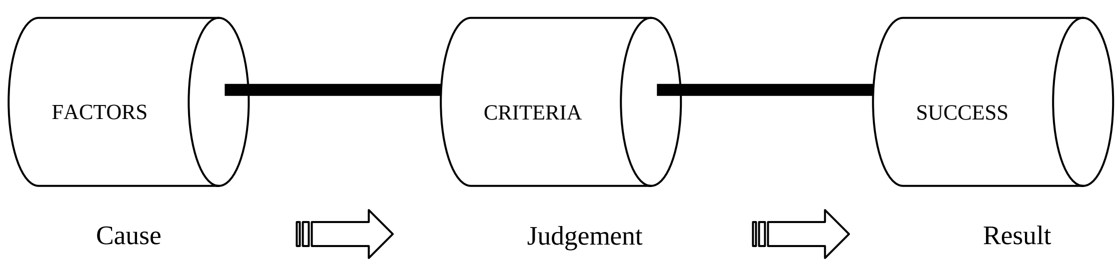


Fig. 4.1 Relationship between Factors and Success (Lim and Mohamed, 1999)

4.3 REVIEW OF MODELS OF CRITICAL SUCCESS FACTORS FOR A CONSTRUCTION PROJECT

Chua et al. (1999) opined that the search of critical success factors for a given type of project can be implemented by a review of the literature and based on expert opinions. Table 4.2 shows the relevant categories of CSFs by previous researchers and four major models of CSFs were identified, namely Pinto (1990), Beale and Freeman (1991), Belassi and Tukel (1996), and Chua et al. (1999).

Table 4.2 Summary of CSFs for construction projects

Critical Success Factors / **Previous Studies**	Project procedures	Project characteristics	Project-related participants	Project work atmosphere	Project environment	Project management strategies
Chua et al. (1999)	✓	✓	✓	✓		
Clarke (1999)	✓	✓	✓	✓		
Dissanayaka and Kumaraswamy (1999)	✓	✓	✓	✓	✓	
Liu and Walker (1998)		✓	✓	✓		
Eldin (1997)			✓	✓		
Belassi and Tukel (1996)		✓	✓		✓	
Chan (1996b)	✓	✓	✓	✓	✓	✓
Smith and Wilkins (1996)	✓			✓		✓
Willoughby (1995)		✓	✓	✓		✓
Yeo (1995)		✓	✓		✓	
Barnes and Wearne (1993)	✓	✓	✓	✓	✓	✓
Mohsini and Davidson (1992)			✓	✓		
Sanvido et al. (1992)	✓	✓	✓			✓
Tayler (1992)	✓			✓		✓
Beale and Freeman (1991)	✓	✓	✓	✓	✓	✓
Ibbs (1991)	✓	✓	✓		✓	
Pinto (1990)		✓	✓	✓		✓
Sidwell (1990)		✓		✓	✓	✓
Total	10	14	15	14	8	9

4.3.1 Pinto – The Ten-Factor Model

Project success is influenced by a number of factors that are in turn interrelated with each other. Pinto (1990) developed the ten-factor model, in which ten identified CSFs are strongly correlated with project success (Fig. 4.2).

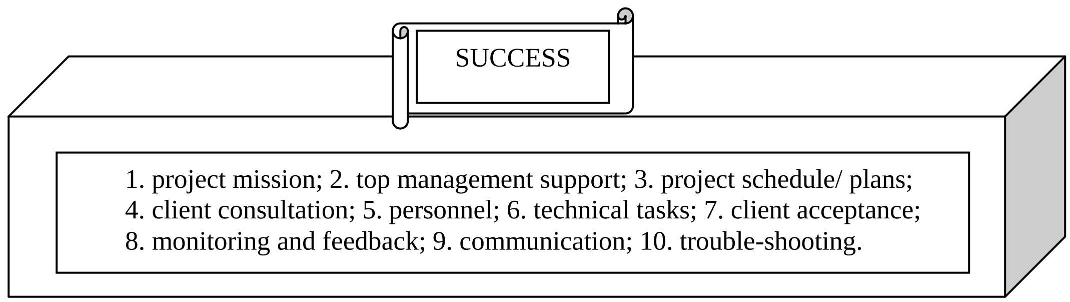


Fig. 4.2 The Ten-Factor Model (Pinto, 1990)

4.3.2 Beale and Freeman - Model of Project Execution Phase

More important issues were found to significantly increase the likelihood of project success. Beale and Freeman (1991) developed a general project management model of a construction project to explain the factors that will affect the successful execution of a project (Fig. 4.3). The variables are divided into endogenous and exogenous to project and project team.

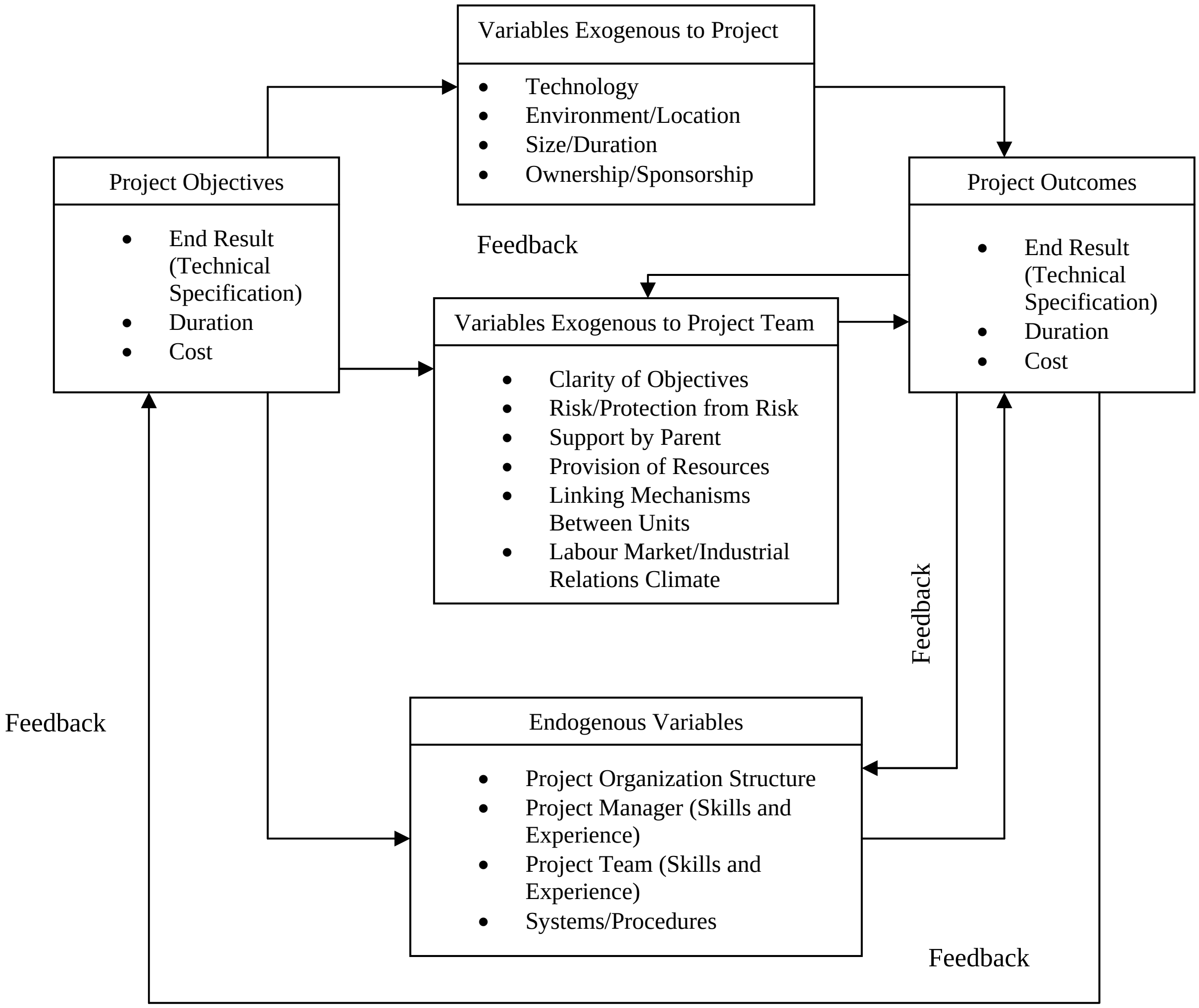


Fig. 4.3 Model of Project Execution Phase (Beale and Freeman, 1991)

Unlike Pinto (1990), this model highlighted two project-related factors: project characteristics and project team, which were also considered as crucial factors by other researchers, like Ibbs (1991) and Jaselskis (1991). In addition, another factor of project procedures was further cited by Tayler (1992) and Naoum (1994) as influential in affecting project success in terms of effectiveness of control mechanisms and planning.

4.3.3 Belassi and Tukel - Model of Success/ Failure Factors in Projects

As project-related factors are found to be critical in affecting project success, Chan (1996b) and Walker (1996) devoted deeper effort to research the field of project management actions related to project success, such as the roles and influences of the construction team leader. The significance of human-related factors was also highlighted by other researchers. Tener (1993) believed that high performers do consistently superior work. This idea was echoed by Walker and Kalinowski (1994), and Albanese (1994) who regarded members with a commitment as an ingredient to success. The model of Belassi and Tukel (1996) was found to be a more complete picture depicting the various critical success factors to a construction project (Fig. 4.4).

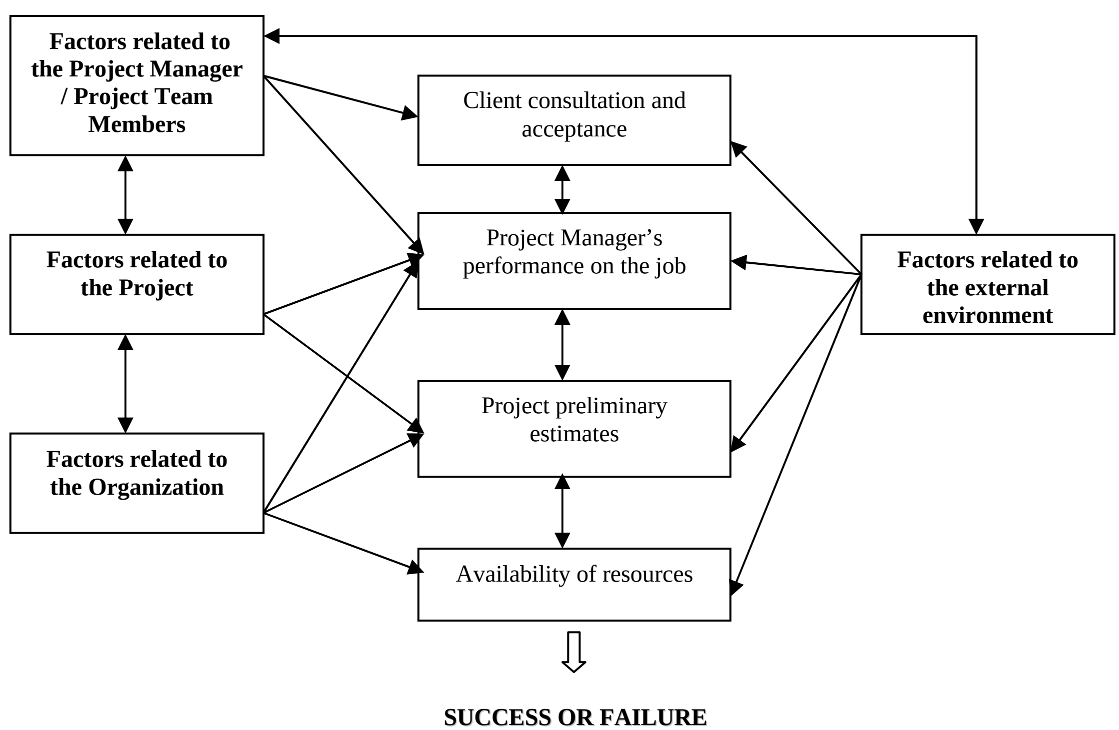


Fig.4.4 Model of Success/ Failure Factors in Projects (Belassi and Tukel, 1996)

4.3.4 Chua et al. - The Hierarchical Model for Construction Project Success

A more formal, systematic and sequential grouping of critical success factors was found in later studies. While Liu and Walker (1998) opined that adequate guidelines and communication channels through various contractual arrangements were important to control the process, Clarke (1999) and Liu (1999) believed that project characteristics in terms of clear goals should be known and understood by the project team to achieve project success. Subject to the dynamic environment, a construction project should be well managed by considering the external factors involved (Dissanayaka and Kumaraswamy, 1999; Lim and Mohamed, 1999). These factors are re-grouped by Chua et al. (1999) as a hierarchical model for project success as shown in Fig. 4.5.

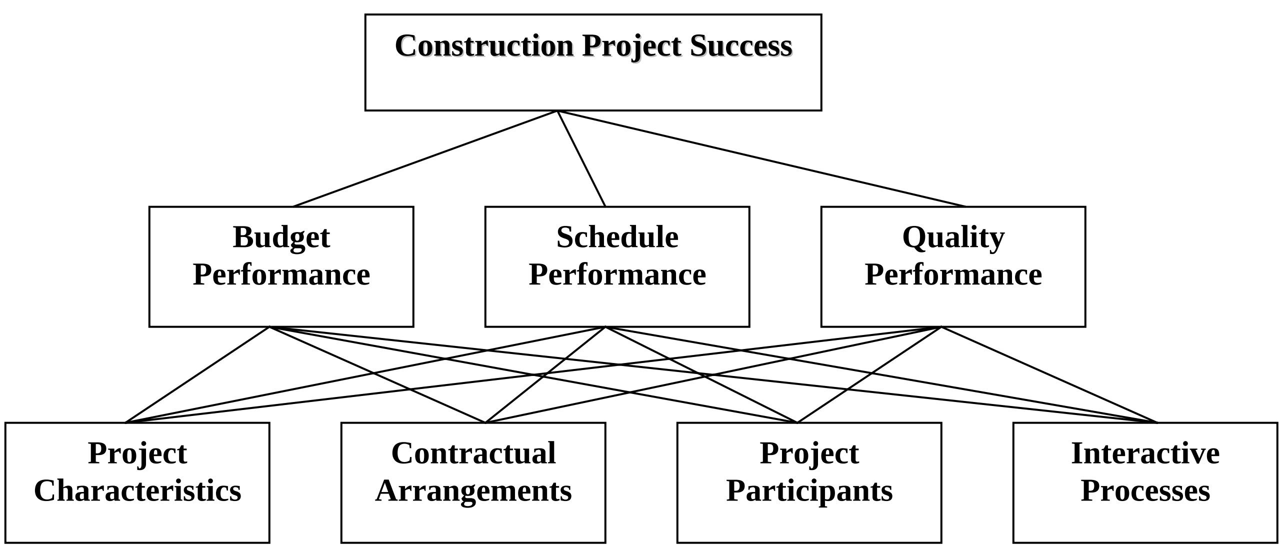


Fig.4.5 A Hierarchical Model for Construction Project Success (Chua et al., 1999)

With the insufficiency of the separated procurement system in meeting the demands of building clients, alternative procurement routes, like design-build, are being increasingly adopted (Palaneeswaran and Kumaraswamy, 2000). However, the performance of D&B projects sometimes varies and the lack of knowledge in managing D&B, especially in the context of critical success factors, may inhibit the growth of such an innovative system. Lam et al. (2004) provided a review of the literature, which consolidates the knowledge basis to study CSFs of D&B projects so that the opportunities to attain project success can be increased.

4.4 FACTORS DETERMINING THE SUCCESS OF A DESIGN-BUILD PROJECT

Design-build offers a variety of advantages to better the implementation of projects (Akintoye, 1994; Rowlinson, 1997; Leung, 1999; Molenaar et al., 1999). As D&B projects require a greater level of managerial expertise from the contractor for the integration of design and construction, the selection of contractors and sub-contractors has been considered by Shoesmith (1996), Deakin (1999), Hemlin (1999), Molenaar et al. (1999), and Palaneeswaran and Kumaraswamy (2000) as one important success factor prior to the management of the D&B project. Lamont (1999) added that attention should also be paid to the selection system and that it should be comprehensive and visible.

Akintoye (1994), Deakin (1999), Leung (1999), and Pearson and Skues (1999) agreed that the factor of project characteristics in terms of a clearly defined scope is vital for the success of a D&B project. Songer and Molenaar (1997) matched the CSFs of D&B projects with project characteristics. The definition and understanding of project scope was concluded as the most important element for D&B project success. Rowlinson (1997) and Deakin (1999) further opined that the way for the project scope to be clearly defined is fundamentally dependent on a clear brief which is believed to be another important prerequisite for success.

Potter and Sanvido (1994), and Leung (1999) suggested the factor of project participants as one CSF for D&B projects. The relationship among project participants has also drawn the attention of Smith and Wilkins (1996), and Rowlinson (1997) as one of the CSFs since a well-organized and cohesive facility team enables better management by the contractor. The characteristics of the contractor, in terms of D&B knowledge, experience and confidence, and the ability to maintain proper documentation are also highlighted (Songer and Molenaar, 1996; Hemlin, 1999; Leung, 1999). End-users' input is also considered necessary to enhance the degree of success for D&B projects (Retherford, 1998; Pearson and Skues, 1999). As a result, the various CSFs identified from both researchers and practitioners in the industry can be consolidated into six headings, namely Project characteristics, Project procedures, Project management strategies, Project-related participants, Project work atmosphere and Project environment (Table 4.3)

Table 4.3 Summary of CSFs for D&B projects

Authors	Critical Success Factors					
	Project characteristics	Project procedures	Project management strategies	Project-related participants	Project working atmosphere	Project environment
Akintoye (1994)	√		√	√	√	√
Potter and Sanvido (1994)		√		√	√	
Kok (1995)	√			√	√	
Yates (1995)	√	√	√	√		
Smith and Wilkins (1996)	√	√	√	√	√	
Songer and Molenaar (1996)				√		
Rowlinson (1997)	√		√	√	√	
Songer and Molenaar (1997)	√					
Molenaar and Songer (1998)	√			√	√	√
Retherford (1998)			√	√	√	√
Deakin (1999)	√	√	√		√	
Harris (1999)	√	√		√		
Hemlin (1999)		√		√	√	
Lamont (1999)		√				
Leung (1999)	√	√		√		√
Molenaar et al. (1999)		√		√		
Pearson and Skues (1999)	√	√	√	√	√	√
Smith (1999)	√	√				
Palaneeswaran and Kumaraswamy (2000)		√				
Total	12	12	7	14	10	5

and the following diagram illustrates a new conceptual framework of critical success factors for D&B projects (Fig. 4.6).

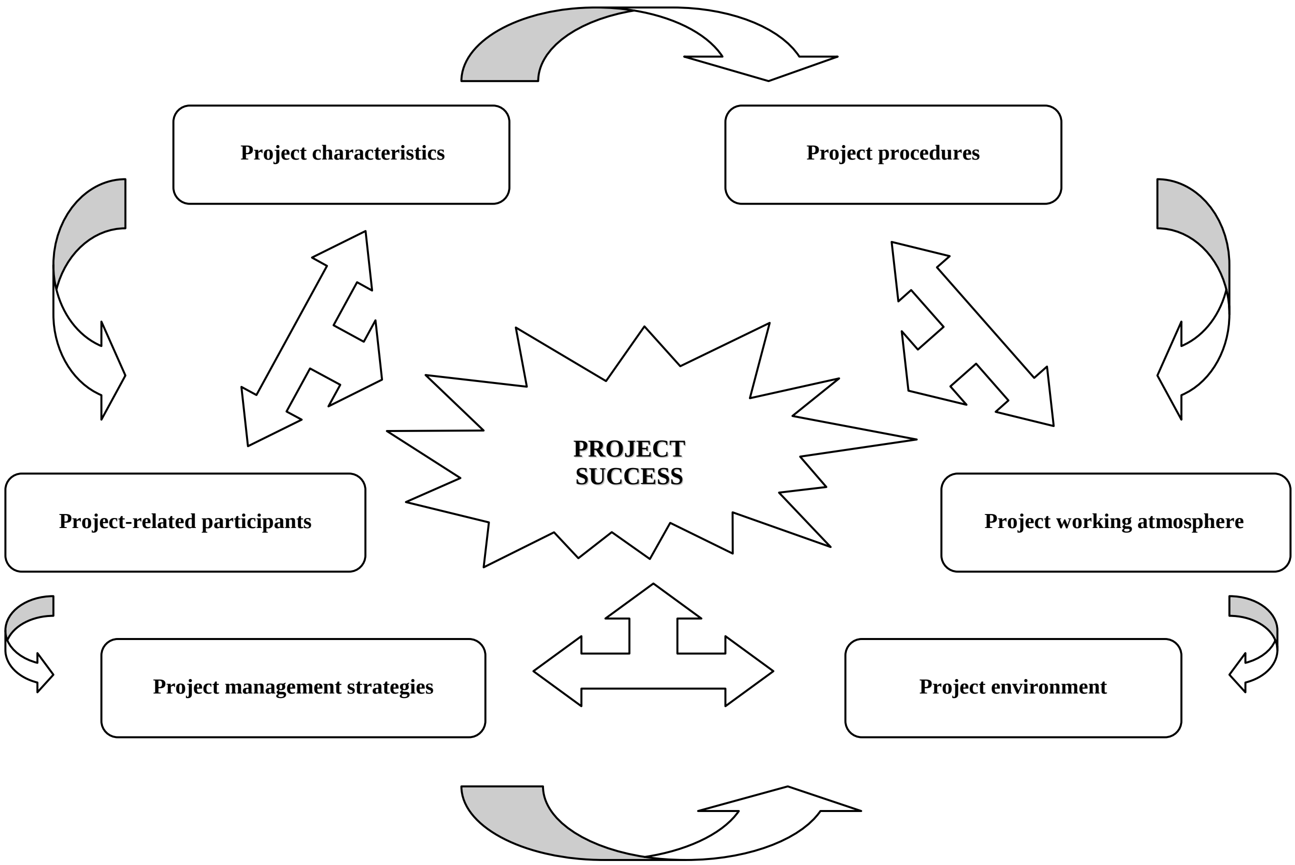


Fig. 4.6 A new conceptual framework of factors affecting success for D&B projects

As shown in Fig. 4.6, the success of a D&B project can be considered to be conceptually influenced by the six factor categories. Parfitt and Sanvido (1993) pointed out that each of the factor categories contains many factor variables that are the critical elements of the success factors.

4.4.1 Project Characteristics

Project characteristics concern the nature of a D&B project, including the project size, level of complexity and project location. Yates (1995), and Songer and Molenaar (1997) determined the size of a project by the building cost, gross floor area, number or workers, duration of project and the value of contract. Moreover, Belassi and Tukel (1996), and Songer and Molenaar (1997) measured project complexity by the types of physical services involved, the number of sub-contractors, resources in terms of labour, plant and materials, the level of technology and the uniqueness of project activities.

One important variable under this factor for D&B projects, as cited by Yates (1995), Leung (1999), and Pearson and Skues (1999), is the scope and definition of the objectives. Leung (1999) further added that whether the project is appealing to the contractor and whether the project provides scope for innovation by the contractor and the design teams can also affect the success level of a D&B project since the contractor is involved in the preparation of the design. If the project is innovative enough for the contractor to provide a better alternative option in the tender stage, the chance of success can be higher.

Hence, the factor variables of Project Characteristics include: project size, level of complexity, project location, project scope, project objectives, appeal of the project and project scope for innovation.

4.4.2 Project Procedures

Chan (1996b) analyzed project procedures under two factor variables, namely procurement method and tendering method. In the search of critical success factors for D&B projects, the procurement form is focused on the integrated procurement system and some researchers considered the contractual issues important to the success of D&B projects (Akintoye, 1994; Yates, 1995; Dissanayaka and Kumaraswamy, 1999; Harris, 1999).

Yates (1995) and Sadeh et al. (2000) opined that the use of the proper type of contract can increase the chance of success. Modifications should be made in D&B projects to strengthen the contract in design responsibilities (Chan, 2000). Project procedure manuals should also be prepared to define the procedures to be adopted and define the means of ensuring adequate control so that the standard procedures, practices and systems can be observed throughout the life of the project (Pearson and Skues, 1999). Moreover, Chua et al. (1999) believed that the focus of a contract should not be just on the choice of procurement, but the identification of risk and its equitable allocation.

The selection of contractors deserves consideration prior to the start of the D&B project. Other related issues, like the procedures and the system for tender evaluation have also been investigated by Lamont (1999), Leung (1999) and Smith (1999).

Hence, the factor variables of Project Procedures include: contractual arrangement and the tendering system.

4.4.3 Project Management Strategies

Modern projects have become increasingly complex and multifaceted and Hubbard (1990), Thamhain (1991) and Deakin (1999) opined that the factor of project management strategies is critical in achieving project success.

Atkinson (1999) advocated that project success occurs through the proper utilization of the right project management practices. Specifying project objectives is regarded as one important project management action by focusing on both the short-term and long-term benefits of the project. To draw the attention of project participants on both the project-related and company-related issues, Thomas et al. (1998), and Pearson and Skues (1999) suggested setting up proper communication and feedback channels in order to coordinate the large number of people. Hidenori (1995) pointed out that progress and coordination meetings should be regularly organized to maintain the close cooperation of the D&B contractor with the client and the design team. Variation control should also be applied to filter out unnecessary changes which can prolong the project completion date. Moreover, Smith and Wilkins (1996) believed that the project management structure should be established in order to clearly define the appropriate organizational structures, roles and levels of authority. As a result, the performance and progress can be recorded and passed up quickly among the professionals (Pearson and Skues, 1999). An effective implementation of project management actions also requires adequate systems for quality, risk, safety and more human-related conflict management at the planning stage so that project participants can have standard procedures to follow (Yates, 1995; Jaselskis et al., 1996; Al-Meshekeh and Langford, 1999). Innovative management approaches like partnering should be employed to avoid the escalation of potential problems (Deakin, 1999; Chan et al., 2003). Chan (1996b) and Beard et al. (2001) also stressed that controls on the front-line workers, like the sub-contractors, are also required to avoid misunderstandings so that success can be ensured.

To sum up the studies in this area, the factor variables of Project Management Strategies include: communication and feedback systems, quality, safety, risk and conflict management systems, organizational structures, control mechanisms of sub-contractors' works, and the overall managerial actions in planning, organizing, leading and controlling.

4.4.4 Project-Related Participants

The completion of a project requires input from a variety of human-related groups (Munns and Bjeirmi, 1996) and project-related participants comprise the major parties to a D&B project, namely the Client, the Project team leaders – Contractor and Design consultant, and the End-users who all contribute significantly to the success of a D&B project.

(1) The Client

Kamara et al. (2000) defined a client as the person or firm responsible for commissioning and paying for the design and construction of a facility. They can be classified either as primary and secondary, or experienced and inexperienced and play a vital role in the successful outcome of the project. In D&B projects, the contractor develops the design according to the client's brief. Rowlinson (1997) and Kamara et al. (2000) believed that the client should be able to brief and be prepared to take an active role in the construction process to avoid a gap between the requirements of the client and other project team members. Saarinen and Hobel (1990), and Chan (1996b) also pointed out that the traditional goals of a construction project in terms of time, cost and quality should be stressed by the client to show its concerns and create pressure to the project team members.

(2) The Client's Representative, The Contractor and The Design Consultants

The client's project team, the contractor and the design consultants are the key project participants in a D&B project, and their respective team leaders form the main focus of this factor. Slevin and Pinto (1991), Goodwin (1993), Tener (1993), Yates (1995), and Smith and Wilkins (1996) outlined the necessary skills required by a project manager as leading, planning, organizing and coordinating skills. Moreover, Leung (1999) and Deakin (1999) added that the project team players should have a clear understanding of the client's brief and be mindful to the business and cultural aspects of the company. As D&B projects require design inputs from the contractor, Leung (1999) suggested such team leaders be able to develop client's requirements by clearly formulating the intention of the client. All project team leaders should also be devoted to the integration of specialized knowledge for a common purpose towards project success and should have sufficient knowledge on D&B documentation and dissemination (Songer and Molenaar, 1996; Hemlin, 1999).

Apart from working within the constraints of the project itself, researchers such as Smith and Wilkins (1996), Edum-Fotwe and McCaffer (2000), and El-Sabaa (2001) opined that project team leaders should also possess certain human skills in coping with stress, establishing good relationships among team members and developing a harmonious working atmosphere. Such team-building skills, as cited by Tippett and Peters (1995), and Hemlin (1999), are increasingly required by the project team leaders to increase the project team's effectiveness. Moreover, Yates (1995) and Hemlin (1999) focused on the adaptability to changes necessary in order to cope with constant and rapid developments in technology, markets, regulations and socioeconomic factors. Todryk (1990), and Munns and Bjeirmi (1996) also agreed that the support from the parent company is a vital requirement for project success. The authority delegated to the client and the project team leaders can also significantly affect the success of a construction project (Pitagorsky, 1998).

(3) <u>The End-users</u>

Retherford (1998) and Deakin (1999) supported that the understanding of the needs of the end-users is important for the success of a D&B project. Therefore, the project team leaders should coordinate end-users' input for the successful implementation of a D&B project (Deakin, 1999; Pearson and Skues, 1999).

For the purpose of the present studies, the factor variables on Project-related Participants are composed of client's experience, client's ability, client's emphasis on time, cost and quality, client's contribution to the project, project team leader's experience, project team leader's knowledge and skills, project team leader's commitment to time, cost and quality, project team leader's responsiveness to changes and external environment, project team leader's effectiveness to coordinate end-users, support from the parent company and end-user's ability to input.

4.4.5 Project Working Atmosphere

A pleasant and encouraging working atmosphere is conducive to the success of a D&B project. The attitudes of the project participants can also significantly affect their performance. For instance, Kok (1995), and Smith and Wilkins (1996) cited that the contractor should be confident of the design and construction of a D&B project. Other team members should establish satisfaction, expectations and values from the project. Retherford (1998) further elaborated that an adequate delegation of the project team decision-making authority can indeed raise their morale.

Potter and Sanvido (1994), and Rowlinson (1997) believed that when the project team members hold positive and cooperative attitudes towards the implementation of the D&B project, the chance of forming a cohesive and well-integrated team can be increased which is essential for D&B project success. Kok (1995) and Deakin (1999) described that such a team is effective in eliminating communication problems, and it encourages respect and mutual trust. As a result, the formation of team spirits strengthens the willingness of all parties to work as a team and enhances cooperation to link interdependent functions together towards project success.

Hence, the factor variables of Project Working Atmosphere include: project team members' attitudes to the job, project team members' interaction with each other and project team members' working relationship with each other.

4.4.6 Project Environment

Projects do not occur in a vacuum but within a particular context. As a result, Belassi and Tukel (1996), and Munns and Bjeirmi (1996) suggested that some external factors can also affect the success or failure of a project.

Most D&B projects are undertaken in open space. Beale and Freeman (1991), and Belassi and Tukel (1996) considered that some physical factors, like the weather conditions, may have an impact on project success. If the weather is continuously fine, the opportunity to complete the project by the contractual completion date can be more secured.

Governmental powers and influences, along with the politics can affect the success level of a D&B project. Depending on controversy and public sector or government involvement, Okpala (1991) opined that the project may be subject to public hearings, environmental impact studies and supreme court appeals. Moreover, Leung (1999), Pearson and Skues (1999) suggested that the levels of bureaucracies, and the support and commitment from the government in terms of funding and availability of land can be significant in determining the success of a D&B project. Akinsola et al. (1997) pointed out that the relationships with the industry also show effects on the D&B project success, though to a lesser extent.

Eschenbach and Eschenbach (1996), and Liu and Walker (1998) added another factor, i.e., social entities which incorporate opinions in the design of a construction project. Moreover, market imperfections, disequilibrium prices, inflation and the prevailing marketplace have also been identified as factor variables by Okpala (1991), Walker and Kalinowski (1994), and Eschenbach and Eschenbach (1996) under the economic factor.

Hence, the factor variables of Project Environment include: physical environment, political environment, industrial relations environment, social environment and the economic environment.

4.5 CONCEPTUAL MODEL OF CRITICAL SUCCESS FACTORS FOR DESIGN-BUILD PROJECTS

The success of a D&B project can be enhanced by a number of factors. To begin with, project characteristics should be clearly defined and understood by all project-related participants. The project should be implemented under certain project procedures and be monitored and controlled through various sorts of project management strategies. The key project players should also show the knowledge and skills to manage the D&B project effectively, and should coordinate themselves and work towards a common goal. Attention should also be paid to project environment factors where the project key players should adapt to any necessary changes.

In fact, the factors affecting the success of a D&B project are all interrelated. The size of a D&B project (Project characteristics) can be affected by the economic conditions (Project environment). A favorable marketplace will increase the willingness to invest in a construction project. If the D&B project is complex, the organization of the project team may be rearranged to suit the need (Project-related participants). Tailor-made forms of contracts may also be used (Project procedures) to handle the more complex requirements.

Project management strategies are closely related to the experience of the project-related participants (Project-related participants) and the constraints imposed on by the external agents (Project environment). They are also determined by the nature of the project (Project characteristics) and project procedures (Project procedures). If the D&B project is under control, the commitment of the project participants to the project goals can be ensured (Project-related participants) in order to create a harmonious working atmosphere (Project working atmosphere). Therefore, it can be hypothesized that the success of a D&B project is a function of project characteristics, project procedures, project management strategies, project-related participants, project working atmosphere and project environment. Such interrelationship can be visualized in Fig. 4.7.

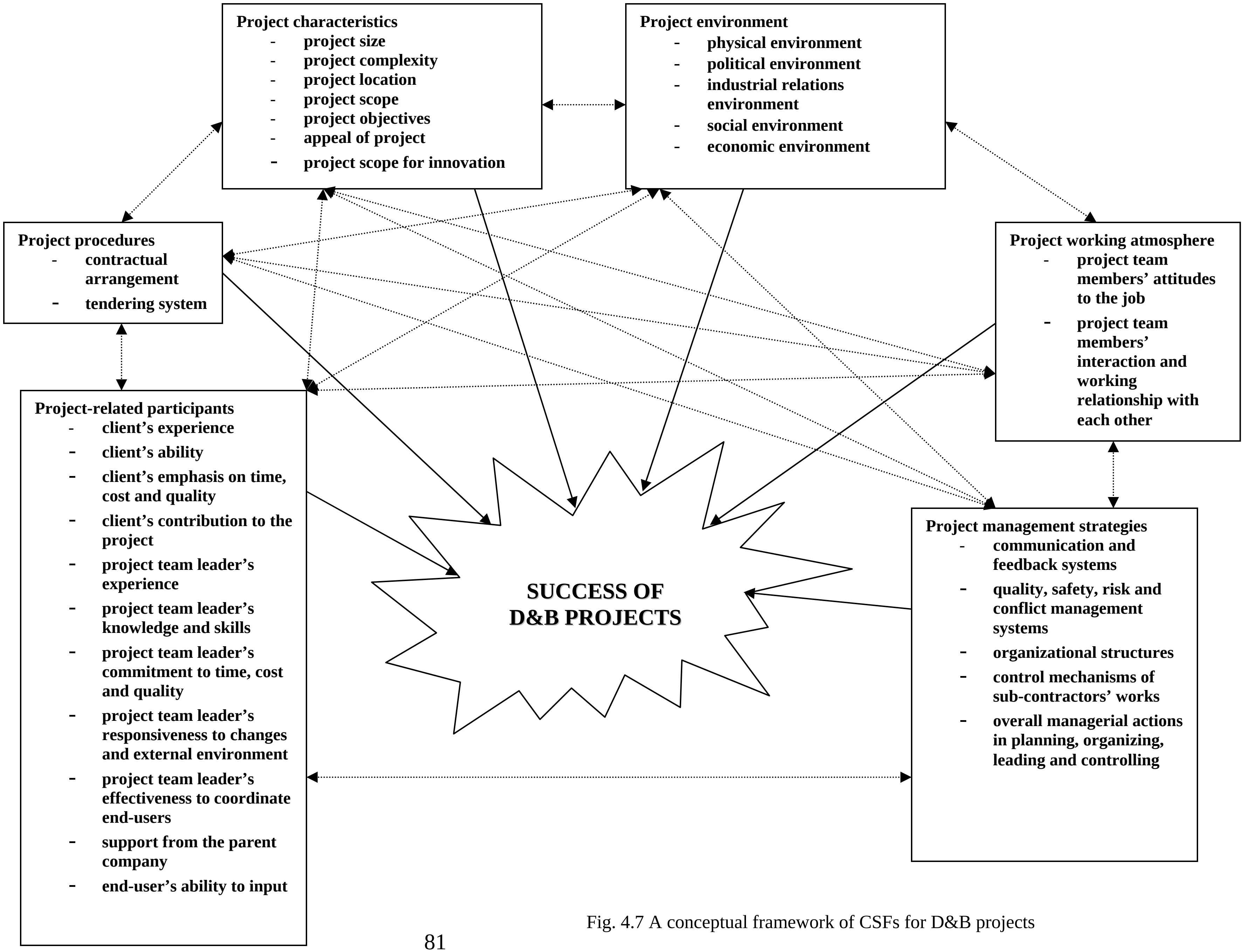


Fig. 4.7 A conceptual framework of CSFs for D&B projects

4.6 CHAPTER SUMMARY

Design-build is considered as one of the alternative procurement methods to cater for the increasing complexity of buildings and the fragmentation in design and construction phases. The identification of success factors can further enhance the performance of D&B projects. The review of literature suggests that project characteristics, project procedures, project management strategies, project-related participants, project working atmosphere and project environment can affect the success level of D&B projects, which are regarded as the independent variables for the research. The framework encompasses past studies on success factors and develops a research focus setting up criteria on which the success of D&B projects should be based.

CHAPTER 5 CRITERIA FOR SUCCESSFUL DESIGN-BUILD PROJECTS

5.1 INTRODUCTION

Project participants have different perceptions towards the ambiguous concept of project success. As a result, the lack of consensus makes it difficult to tell whether a project is successful. This chapter provides a comprehensive list of criteria for measuring success of design-build projects. The definitions for the criteria of project success will firstly be presented. Then relevant measures of success for a construction project and the major models in the last fifteen years are reviewed, with particular emphasis on D&B projects. The success criteria will further be modified to establish an assessment framework for D&B projects.

5.2 DEFINING CRITERIA AND PROJECT SUCCESS

The definition of success often changes from project to project but Parfitt and Sanvido (1993) claimed that the criteria for success can commonly be developed to assess the performance of a project. Traditionally, success is defined as the degree to which project goals and expectations are met. It should be viewed from different perspectives of individuals and the goals related to a variety of elements, including technical, financial, educational, social and professional issues (Parfitt and Sanvido, 1993; Lim and Mohamed, 1999). The criteria are the set of principles or standards by which judgement is made (Lim and Mohamed, 1999).

Project success seems to be the goal, which can be achieved through the objectives of budget, schedule and quality. Each project has a set of goals to accomplish, which serve as a standard to measure performance. Indeed, criteria are needed to compare the goal level against the performance level, and project success aims to attain project goals and participant satisfaction. Fig. 5.1 shows the relationship among goals, performance measures and project success.

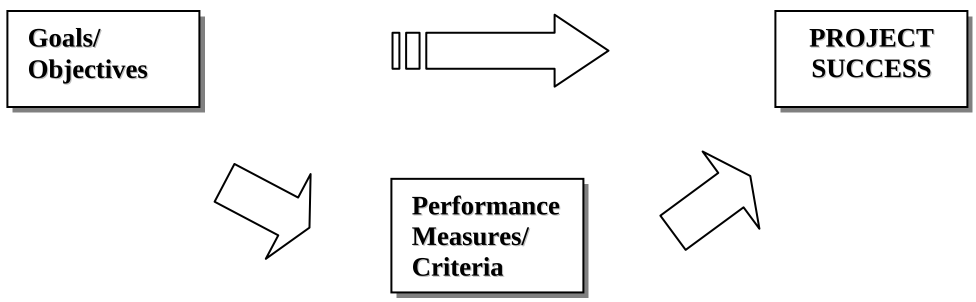


Fig. 5.1 Relationship among goals, performance measures and project success

While success can be measured in terms of goal attainment, there is ambiguity in determining whether a project is a success or failure. A gradual change in the assessment criteria of project success was observed over the last fifteen years.

5.3 CHANGING MEASURES OF PROJECT PERFORMANCE

A review of previous studies suggests that research measuring project success has progressed through a number of stages. Chan et al. (2002) described different views of previous researchers on project performance by focusing on meeting objectives. This was followed by taking a global approach of the topic, and more recently, the focus has been considerations beyond the project.

5.3.1 Trend 1: Project Success - Meeting Objectives

Most projects stem from the needs or objectives of a client. It would seem obvious that if these objectives are achieved, the project is claimed to be successful. Thomas et al. (1998) classified some agreed-upon objectives as technical measures. Maloney (1990) believed that whether the objectives are met can be evaluated through the project performance in terms of cost, schedule and quality. The performance should be evaluated over relatively long periods of time in terms of its contribution to the organization’s objectives. However, project success should be something much more important than simply meeting cost, schedule and performance specifications. Other researchers suggested that the less tangible project success criteria should also be considered in terms of psycho-social outcomes and the respective viewpoints of different project participants, such as Pinto and Pinto (1991), Freeman and Beale (1992), and Riggs et al. (1992). While time, cost and quality are the main goals in most projects, the perspectives of owners, designers and contractors should not be ignored.

5.3.2 Trend 2: Project Success – A Global Approach

In spite of the tangible nature of project performance, Turner and Cochrane (1993) suggested projects be judged against two parameters: how well defined are the goals and how well defined are the methods of achieving them. Anderson and Tucker (1994) suggested that a greater variety of criteria related to success should be taken into account, including profit, indicating the varied nature of project success. Attempts were gradually found to generate a more systematic categorization of performance criteria of project success to achieve a global approach. Chan (1996b) established a conceptual framework for measuring construction project success that considered the project success criteria from both objective and subjective points of view. Another classification from Stevens (1996) considered the ‘hard’ and ‘soft’ sides of project success criteria, with time and cost being ‘hard’ and satisfaction being ‘soft’.

5.3.3 Trend 3: Project Success – Benefits beyond the Project

Brown and Adams (2000) viewed that time, cost and quality are still the prime project objectives. They are considered by Newcombe (2000) as the ‘eternal triangle’ and Atkinson (1999) as ‘iron triangle’. However, it is unlikely that the client will give equal weight to this triangle. Apart from considering the goal attainment of project success, more emphasis is also placed on the assessment of the positive effects brought about by the project to judge what success means. Such a new approach can be recognized by the later development of some major models of project success, namely Shenhar et al. (1997), Atkinson (1999), Lim and Mohamed (1999) and Sadeh et al. (2000).

(1) <u>Shenhar et al. - Four Dimensions of Project Success</u>

Shenhar et al. (1997) assessed the success of a project along four distinct dimensions: project efficiency, impact on the customer, business success and preparing for the future (Fig. 5.2). The emphasis on criteria of project success changes along the project life. The project itself is also more explicitly considered as a business that shows benefits to the organization. Therefore, the measure of project success moves from the project to the organization.

Fig. 5.2 The Four Dimensions of Project Success (Shenhar et al., 1997)

(2) Atkinson - Framework of Project Success Criteria

While Shenhar et al. (1997) perceived that project success criteria changed with time, Atkinson (1999) proposed a new way to consider success criteria, which was assessed in both the delivery and post-delivery stages (Fig. 5.3). The iron triangle of cost, time and quality was still the necessary criteria in the delivery stage while benefits to stakeholders were considered at the other stage. He considered the iron triangle, the information system, benefits to organization and benefits to stakeholder community as "The Square Route" which is a loop enclosing the success criteria of a project.

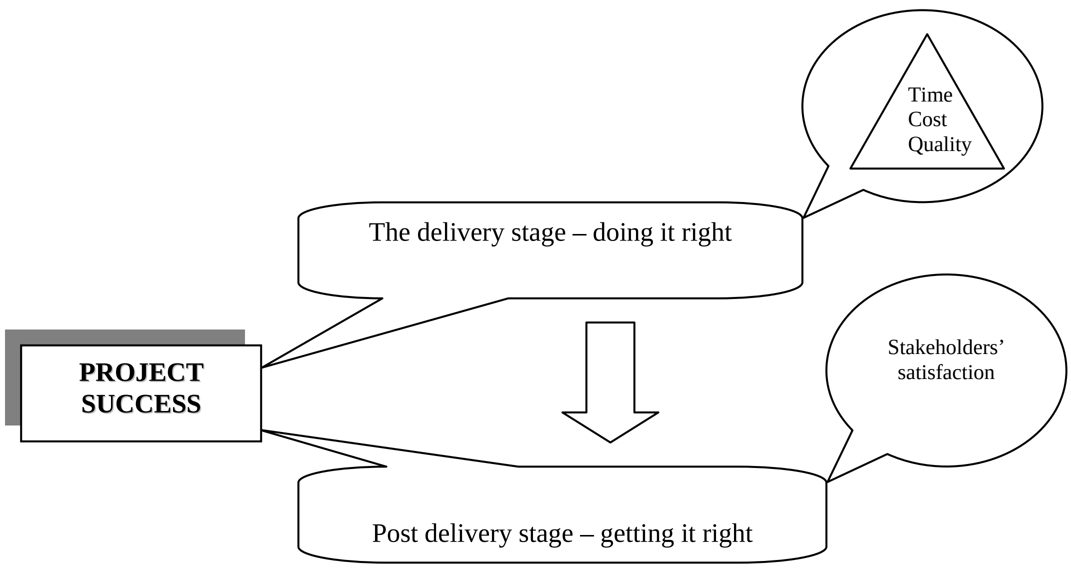


Fig. 5.3 The Framework of Project Success Criteria (Atkinson, 1999)

(3) Lim and Mohamed - Macro and Micro Viewpoints of Project Success

Instead of concentrating on the success criteria of a project in future time, Lim and Mohamed (1999) classified project success into two categories: the macro and micro viewpoints (Fig. 5.4).

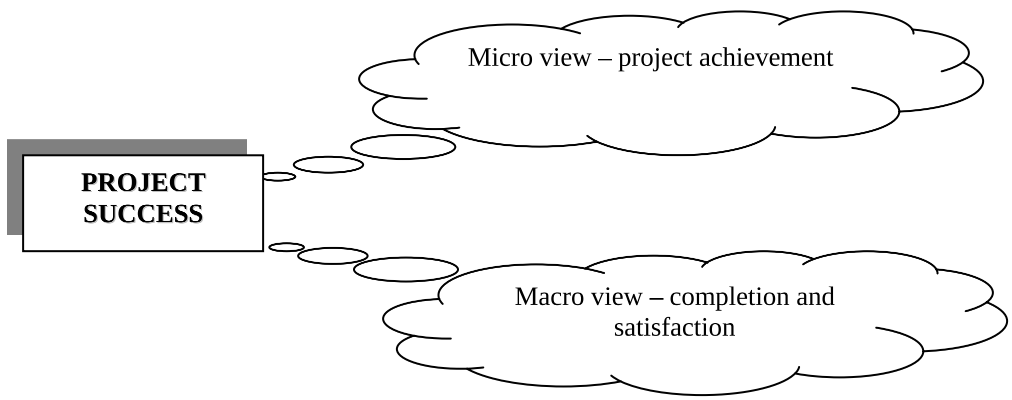


Fig. 5.4 Macro and Micro Viewpoints of Project Success (Lim and Mohamed, 1999)

The micro viewpoint of project success deals with project achievements assessed in the completion of a project. Beyond completion, the psychological effects of the project on project participants, the level of satisfaction, are taken into account in the macro view.

(4) <u>Sadeh et al. - Four Dimensions of Success Measures</u>

Sadeh et al. (2000) divided the success measures into four separate dimensions, namely meeting design goals, benefit to the end user, benefit to the developing organization and benefit to the defense and national infrastructure (Fig. 5.5). The scale of project success measures extends far away from the project, but to the people and other projects as well.

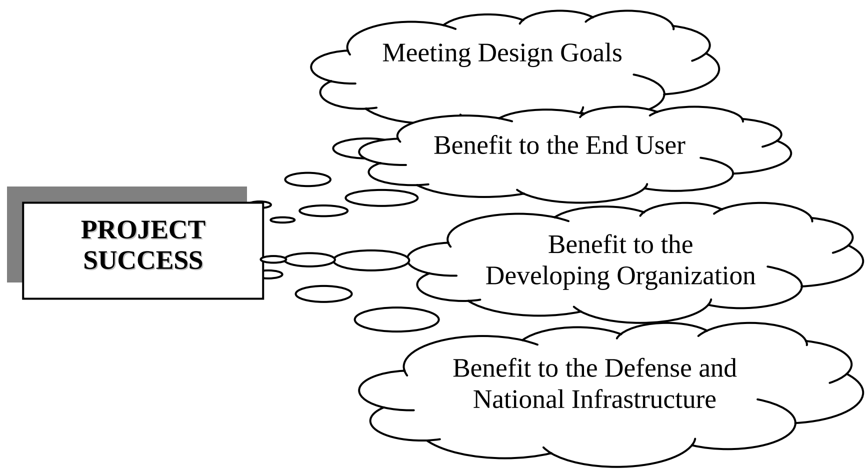


Fig. 5.5 The Four Dimensions of Success Measures (Sadeh et al., 2000)

5.3.4 Summary of Measures of Success for a Construction Project

The success level of a project can be assessed whether the objectives are met. Indeed, the criteria of a construction project in general can be classified under two main categories, one being hard, objective, tangible, and measurable and the other soft, subjective, intangible, and less measurable. As for the former, the criteria of time and cost were widely recognized. While Wuellner (1990), Pocock et al. (1996) and Shenhar et al. (1997) suggested profitability as one other objective criterion, Tayler (1992), Kumaraswamy and Thorpe (1995), and Liu and Walker (1998) considered health and safety as an important aspect for evaluation. For the latter, the attainment of goals in terms of quality, technical performance (Freeman and Beale, 1992; Belassi and Tukel, 1996), functionality (Parfitt and Sanvido, 1993; Chan, 1996b), productivity (Freeman and Beale, 1992), satisfaction (Freeman and Beale, 1992; Chan, 1996b; Lim and Mohamed, 1999), absence of conflicts (Parfitt and Sanvido, 1993; Pocock, et al., 1996), aesthetics (Kumaraswamy and Thorpe 1995), educational, social and professional aspects (Parfitt and Sanvido, 1993), and environmental sustainability (Kumaraswamy and Thorpe 1995; Liu and Walker, 1998) are considered as major project success criteria by previous researchers. The integration of criteria of project success by previous researchers can be pictorially represented as Fig. 5.6 and summarized in Table 5.1.

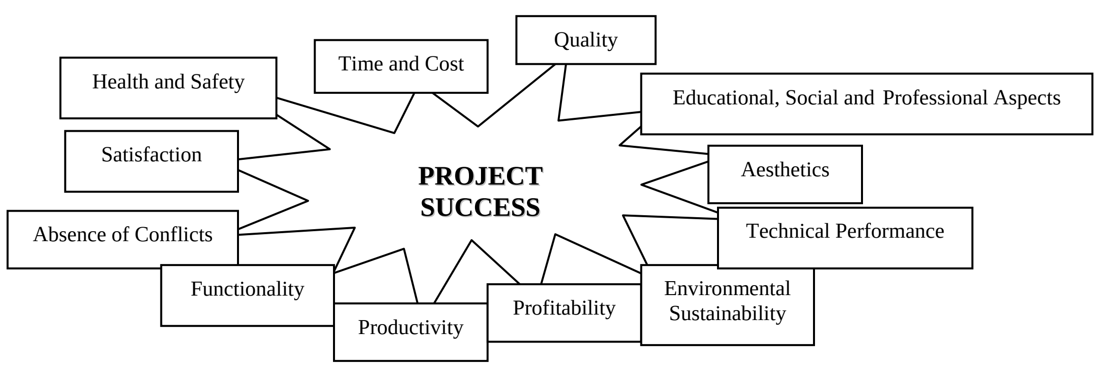


Fig. 5.6 Criteria for project success

Table 5.1 Summary of literature on project success criteria

	Objective Measures			**Subjective Measures**								
Previous Studies	**Time and Cost**	**Profitability**	**Health and Safety**	**Quality**	**Technical performance**	**Functionality**	**Productivity**	**Satisfaction and expectation of project participants**	**Environmental sustainability**	**Absence of claims and disputes**	**Aesthetics**	**Educational, social and professional aspects**
Maloney (1990)	✓			✓			✓					
Norris (1990)		✓										
Freeman and Beale (1992)	✓	✓		✓	✓		✓	✓				
Riggs et al. (1992)	✓			✓	✓							
Tayler (1992)	✓	✓	✓	✓			✓					
Parfitt and Sanvido (1993)	✓	✓	✓	✓	✓	✓		✓		✓		✓
Bubshait and Almohawis (1994)	✓		✓	✓								
Naoum (1994)	✓			✓				✓				
Kumaraswamy and Thorpe (1995)	✓		✓	✓				✓	✓		✓	
Larson (1995)								✓		✓		
Chan (1996b)	✓			✓		✓		✓				
Shenhar et al. (1997)	✓	✓		✓								
Liu and Walker (1998)			✓					✓	✓			
Al-Meshekeh and Langford (1999)										✓		
Chua et al. (1999)	✓			✓								
Atkinson (1999)	✓			✓								
Lim and Mohamed (1999)	✓		✓	✓				✓				
Brown and Adams (2000)	✓			✓								
Cheung et al. (2000)	✓			✓						✓		
Total	15	5	6	15	3	2	3	8	2	4	1	1

Adopting a new procurement approach implies a change to the conventional method. While previous research discussed the success criteria for a construction project in general, more emphasis should be placed on the success criteria of a particular procurement method that is not traditional in order to break the old way of doing things. Design-build has been used extensively worldwide (Kwong, 1996). Walker (1996) claimed that such a non-traditional procurement method is likely to lead to better construction performance than traditional ones and its success criteria should be evaluated for better project performance.

5.4 ASSESSING SUCCESS FOR A DESIGN-BUILD PROJECT

Molenaar and Gransberg (2001) defined design-build (D&B) as an alternative project delivery method that encompasses both project design and construction under one contract. This procurement method has become a popular mode of procuring construction work, especially in the public sector (Songer and Molenaar, 1997). A review of the literature in the last fifteen years indicates that researchers have gradually started to investigate the topic of success criteria for D&B projects (Table 5.2).

Table 5.2 Cited papers of D&B project success

Year	Author(s)	Title	Review on Project Success
1994	Ndekugri and Turner	Building procurement by design and build approach	Establish criteria for D&B project success
1996	Songer and Molenaar	Selection factors and success criteria for design-build in the US and UK	Define success criteria for D&B projects
1997	Songer and Molenaar	Project characteristics for successful public-sector design-build	Address public sector criteria of success for D&B projects
2000	Chan	Evaluation of enhanced design and build system – a case study of a hospital project	Assess project success criteria of a hospital project

Previous studies use D&B project success criteria to explain the reasons for selecting the D&B procurement method. Ndekugri and Turner (1994) stated that if the client's criteria are met, then the performance of the D&B project can be considered a success. Results from Songer and Molenaar (1996) indicated that the primary success criteria for D&B projects are on budget, on schedule and conforms to user's expectations, which are all consistent with the success criteria of a construction project in general. Moreover, Chan (2000) judged the performance of an enhanced D&B project based on the criteria of time, cost, quality, functionality and safety requirements. A summary of the criteria for project success of a D&B project is presented in Table 5.3.

Table 5.3 Literature on success criteria for D&B projects

Types	**D&B project success criteria**	**Previous Studies**		
		Chan (2000)	Ndekugri and Turner (1994)	Songer and Molenaar (1996, 1997)
Objective	time, cost, quality	✓	✓	✓
	safety	✓		
Subjective	meeting specifications/ employer's requirements (ER)			✓
	conformance to expectation of project team members			✓
	satisfaction of project team members		✓	✓
	functionality	✓		
	aesthetics		✓	
	reduction in dispute		✓	✓

Although D&B has distinctive features over other procurement methods, Songer and Molenaar (1996) opined that the criteria for judging its success are similar to those for a construction project in generic sense. Therefore, review of past research on project success for a construction project in a generic sense and that of D&B nature generates a more comprehensive list of criteria for this research (Fig. 5.7). Such a

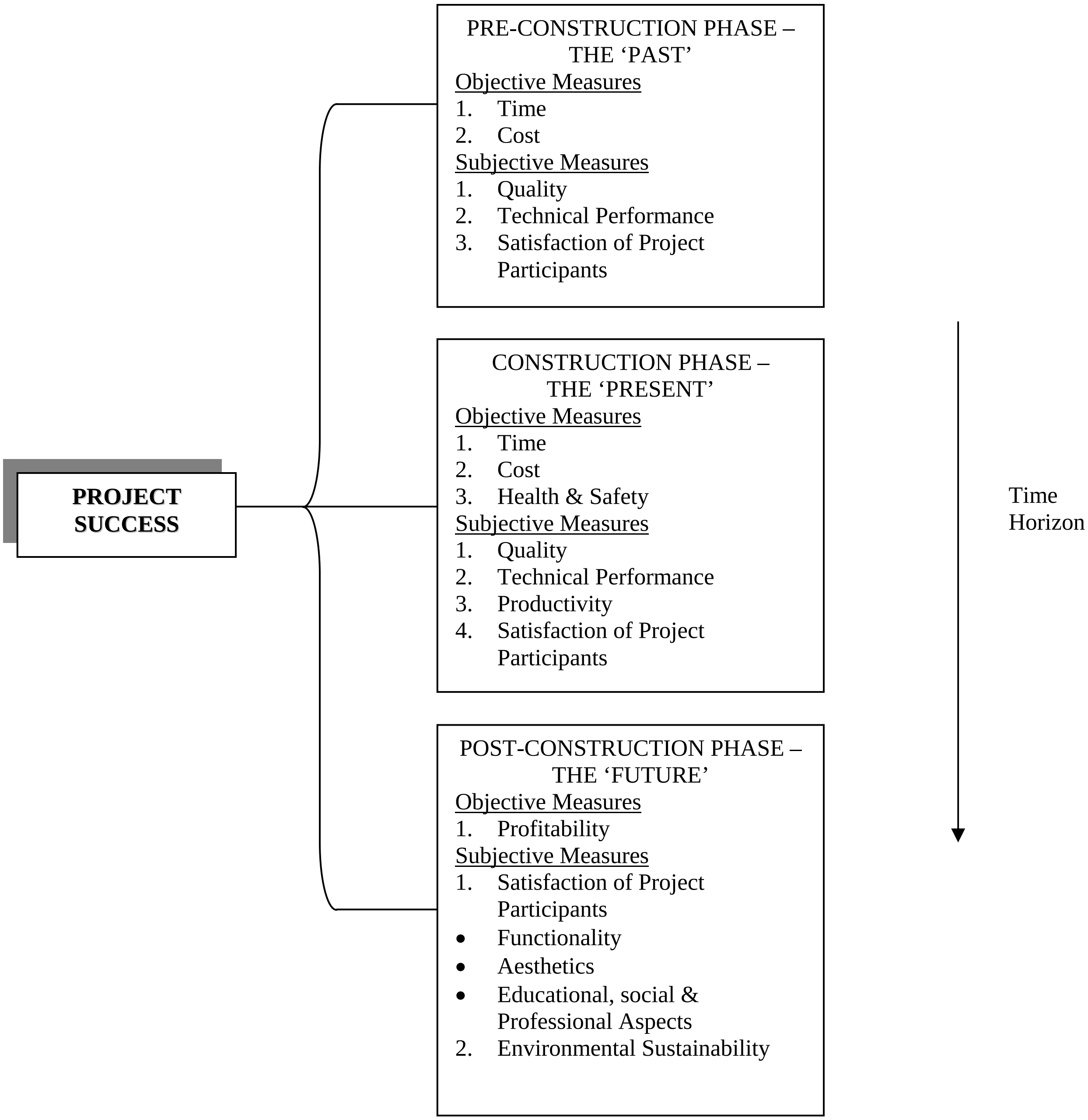


Fig. 5.7 Framework of success criteria for D&B projects

comprehensive list introduces a new way of presenting collective research into the measurements of success for D&B projects.

This framework (Fig. 5.7) adopts the view of Shenhar et al. (1997) that project success criteria change with time. While Atkinson (1999) considers project success criteria in the delivery and post delivery stages, this framework analyzes project success from the three conceptual phases of a construction project, namely the pre-construction, the construction, and the post-construction phases. Moreover, the list of success criteria for D&B projects in previous studies is incorporated and categorized as objective and subjective measures, which are the basic components of the framework for the research.

5.5 CRITERIA FOR MEASURING PERFORMANCES OF DESIGN-BUILD PROJECTS

Measures to reflect the objectives determined by the project team members are always needed, which were classified by Chan (1996b) into objective and subjective measures. While the new framework itself takes all success criteria into consideration, different perspectives may have different success priorities.

5.5.1 Objective Measures

Previous research described objective measures as hard and tangible, which include time, cost, health and safety, and profitability in project success measurement.

(1) Time

Time is defined as the degree to which the general conditions promote the completion of a project within the allocated duration (Bubshait and Almohawis, 1994). Naoum (1994), Chan (1996b), and Al-Meshekeh and Langford (1999) measured this criterion by time overrun, construction time and speed of construction respectively. Songer and Molenaar (1997) also considered 'on schedule' as one success criterion for D&B projects. Table 5.4 illustrates the definitions of each measurement of time.

Table 5.4 Types of time measurement

Year	Author(s)	Measurement	Definition
1994	Naoum	Time overrun	Increase or decrease in percentage in estimated program (in days/ weeks)
1996b	Chan	Construction time	Number of days from start on site to practical completion of project
1999	Al-Meshekeh and Langford	Speed of construction	Gross floor area (in square meters) divided by the construction time (in days)

(2) Cost

Cost is defined as the degree to which the general conditions promote the completion of a project within the estimated budget (Bubshait and Almohawis, 1994). It can be measured by cost overrun (Naoum, 1994) and unit cost (Chan, 1996b) as Table 5.5 shows. Songer and Molenaar (1997) also considered 'on budget' as one success criterion for D&B projects.

Table 5.5 Types of cost measurement

Year	Author(s)	Measurement	Definition
1994	Naoum	Cost overrun	Increase or decrease in budget (in dollars)
1996b	Chan	Unit cost	Cost of building (in dollars) divided by gross floor area (in square meters)

(3) Profitability

Profitability measures the financial success of a project (Parfitt and Sanvido, 1993). Most clients value a construction project as a business entity and this criterion is always measured in order to know how much profit the firm makes from the project. Freeman and Beale (1992) identified some common discounted cash flow (DCF) techniques, like the net present value, internal rate of return and the present value index. One simpler way of measuring this criterion was suggested by Norris (1990) who measured profit as the increment by which revenues exceed costs.

(4) Health and Safety

Health and Safety is defined as the degree to which the general conditions promote the completion of a project without major accidents of injuries (Bubshait and Almohawis, 1994). In fact, accidents are caused by a combination of unsafe acts and unsafe conditions, and the measure of safety can be represented by the injury/ accident rate per 1000 workers (Labour Department, 2000).

5.5.2 Subjective Measures

These are also termed as soft, intangible and less measurable measures, and quality, technical performance, satisfaction, productivity and environmental sustainability are to be assessed. As subjective measures involve different perceptions of participants, a Likert scale is normally adopted to show the level of significance.

(1) <u>Quality</u>

Bubshait and Almohawis (1994) defined quality as the degree to which the general conditions promote meeting of the project's established requirements of materials and workmanship. It is also expressed in terms of technical specification, function and appearance, and is defined as the totality features required by a product or service to satisfy a given need (Hatush and Skitmore, 1997). Table 5.6 shows some of the measures of quality by previous researchers.

Table 5.6 Measures of quality

Year	Author(s)	Measurement
1990	Saarinen and Hobel	Integration of three elements: defects, on-time delivery and budget compliance – budget and schedule included in designing requirements for quality performance
1992	Sanvido et al.	Degree of conformance to predetermined standard of performance
1996	Stevens	Performance of cost, schedule and safety

While Chan (2000) considered 'quality' as one success criterion for D&B projects, Songer and Molenaar (1997) considered 'high quality of workmanship' as one success measure, which is consistent with the overall quality measurement.

Molenaar et al. (1999) considered three criteria for measuring quality in D&B projects: conformity with expectations, administrative burden and the overall owner satisfaction, which are essentially the composite measures of quality for a construction project in general.

(2) <u>Technical Performance</u>

The requirements of technical performance are normally established in specifications and its performance is best measured by the degree of variations from those listed in specifications. In D&B projects, a clear brief is the most important prerequisite for success (Ndekugri and Turner, 1994), and Molenaar and Songer (1998) believed that the project scope should be clearly defined so that success can be achieved. Indeed, clear specifications and a consistent understanding of the intent of the specifications by all parties greatly improve the quality of a project.

(3) <u>Functionality</u>

This criterion correlates with expectations of project participants and can best be measured by the degree of conformance to all technical performance specifications. Both financial and technical aspects implemented to technical specifications should be considered, achieving the 'fitness for purpose' objective. While Songer and Molenaar (1997) considered 'meeting specifications' as one success criterion for D&B projects, Chan (2000) considered 'functionality' as one success measure.

To summarize, the three measures outlined above, i.e., quality, technical performance and functionality are closely related and are considered important to the client, contractor and consultant to justify the objectives of a D&B project. Chan et al. (2000) pointed out that the quality issue is of particular interest to both the designer and the client since the contractor takes up the task whose expertise in terms of design and workmanship is critical to the success of the D&B project. As the design team no longer has the clear authority to supervise the quality aspect of the project, the client may be uncertain whether the contractor team can achieve the required standard (Lam, 2000a).

(4) <u>Productivity</u>

Tayler (1992) opined that productivity is universally accepted as one success criterion, which is the main key to the cost effectiveness of projects. It refers to the amount of resource input to complete a given task and it is usually assessed on a ranked basis (Chan, 1996b).

(5) <u>Satisfaction</u>

Satisfaction describes the level of 'happiness' of people affected by a project. Such people include key project participants, namely the client, architect, contractor, various subcontractors, surveyors and engineers, and end users.

Liu and Walker (1998) considered satisfaction an attribute of success. Moreover, Torbica and Stroh (2001) believed that if end users are satisfied, the project can be considered successfully completed in the long run. Other criteria, such as aesthetics, professional image, and educational and social aspects may also be considered to evaluate project success. Ndekugri and Turner (1994), and Songer and Molenaar (1996; 1997) also considered satisfaction of project team members, aesthetics and reduction in disputes as success criteria for D&B projects.

Satisfaction should be established from the three perspectives of clients, contractors and designers to consider the D&B project successful. While it is essential for the designer to develop a meaningful collaboration with the contractor to meet the client's requirements to achieve client's satisfaction, they themselves need to be satisfied in order to maintain the cohesiveness and teamwork for the project (Akintoye, 1994). Testi et al. (1996) further stated that the end-users would be satisfied if the principle of customer focus is applied.

(6) <u>Environmental Sustainability</u>

Impacts of a construction project on the environment are notoriously negative. One common example is the generation of construction waste, which can be measured by the difference between the amount of the total delivery of materials to the site and the amount of work completed (Skoyles, 1987). Therefore, the measure of impacts of a construction project to the environment is objective. However, measuring the effects of a project to the environment in terms of sound and air may exert a subjective image upon participants who will make 'good', 'acceptable' or 'unacceptable' comments that should be measured by a rating scale.

5.6 PERFORMANCE MEASURES FOR THE RESEARCH

The lack of research in D&B projects required more investigation on a global approach to measuring success. The objective measures of time, cost, and health and safety, and the subjective measures of quality, functionality (technical performance), reduction in claims and disputes, satisfaction (expectation) of project participants, environmental sustainability, aesthetics, and educational, social and professional aspects form the basic components of the framework of success criteria for the research, all of which measure the success of a D&B project along its project life. In fact, productivity measures the performance or effectiveness of an individual, such as the contractor's ability to allocate the available resources efficiently. Moreover, Chan et al. (2000) claimed that public sector clients are less sensitive to profitability and Culp and Smith (2001) suggested that the main concerns of public sector clients should be public accountability and certainty of cost. Therefore, the two criteria are excluded from further analysis.

5.7 CHAPTER SUMMARY

The topic of project success has attracted the interests of both researchers and practitioners. The chapter has established the framework of success criteria for D&B projects, which are considered as the dependent variables for the research. To enhance project success, previous research on the criteria and factors of success for

D&B projects were reviewed and the framework of success for D&B projects was established from literature. To further develop the conceptual model for the study, empirical research has been conducted in Hong Kong. The setting, context and the methodology applied in the present study will be outlined in the following chapter.

CHAPTER 6 RESEARCH METHODOLOGY

6.1 INTRODUCTION

This chapter introduces the methodology for the research. It starts with outlining the research process for the study. Then the selection of previous research for a literature review will be presented. The approaches to empirical data collection and the methods of data analysis will also be described, followed by the formulation of the research model for the study.

6.2 THE RESEARCH PROCESS

The research has passed through a number of processes in order to achieve the objectives as stated in Chapter 1. This research is mainly based on the model of research processes as advocated by Sekaran (2000), who converts vague idea, through the formulation of working hypothesis, into testable hypotheses that are designed specifically for the research questions (Fig. 6.1). Data will be collected, analyzed and interpreted, and research conclusions will be drawn up for further research work. This process has been documented by Chan et al. (2001b) and followed by Chan (2004).

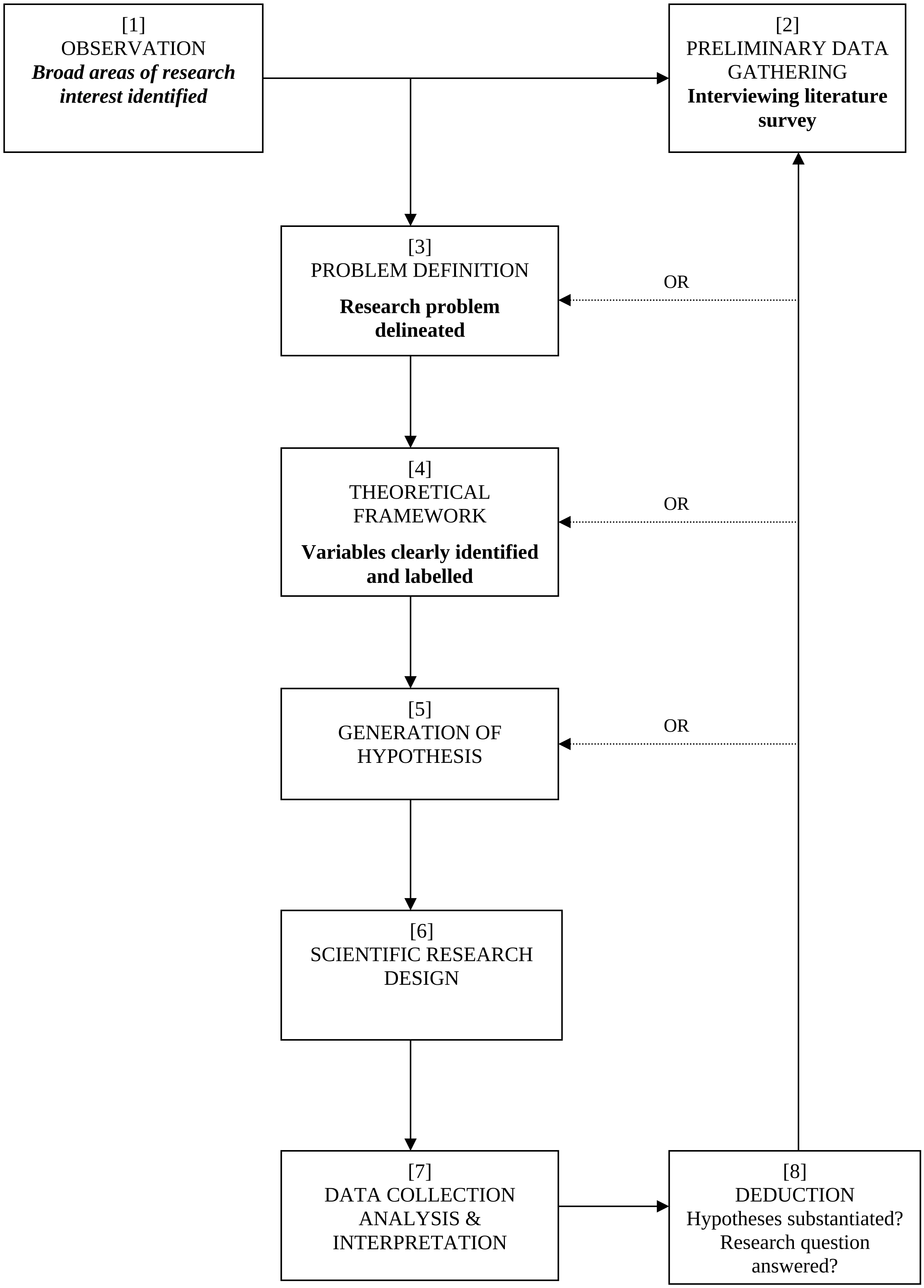


Fig. 6.1 Sekaran's research process (2000)

The research starts with a review of literature for the background information of the research and identifying research problems. The framework of the success criteria and factors for D&B projects is also developed, followed by an empirical study with D&B project participants in the Hong Kong construction industry (Fig. 6.2).

6.2.1 Literature Review

A comprehensive literature search was conducted over the past fifteen years to establish the framework of criteria and factors of success for D&B projects. The selection of literature was mainly based on the research findings of Chau (1997), both UK and US based, including

- Construction Management and Economics
- Journal of Construction Engineering and Management
- Engineering, Construction and Architectural Management
- Journal of Management in Engineering
- International Journal of Project Management
- Journal of Construction Procurement

One other journal, the Project Management Journal, was also selected as it was found out that some previous researchers made a regular reference to the papers in that journal, indicating that the journal should also be included for project success research. Relevant books, conference proceedings and construction reports were also

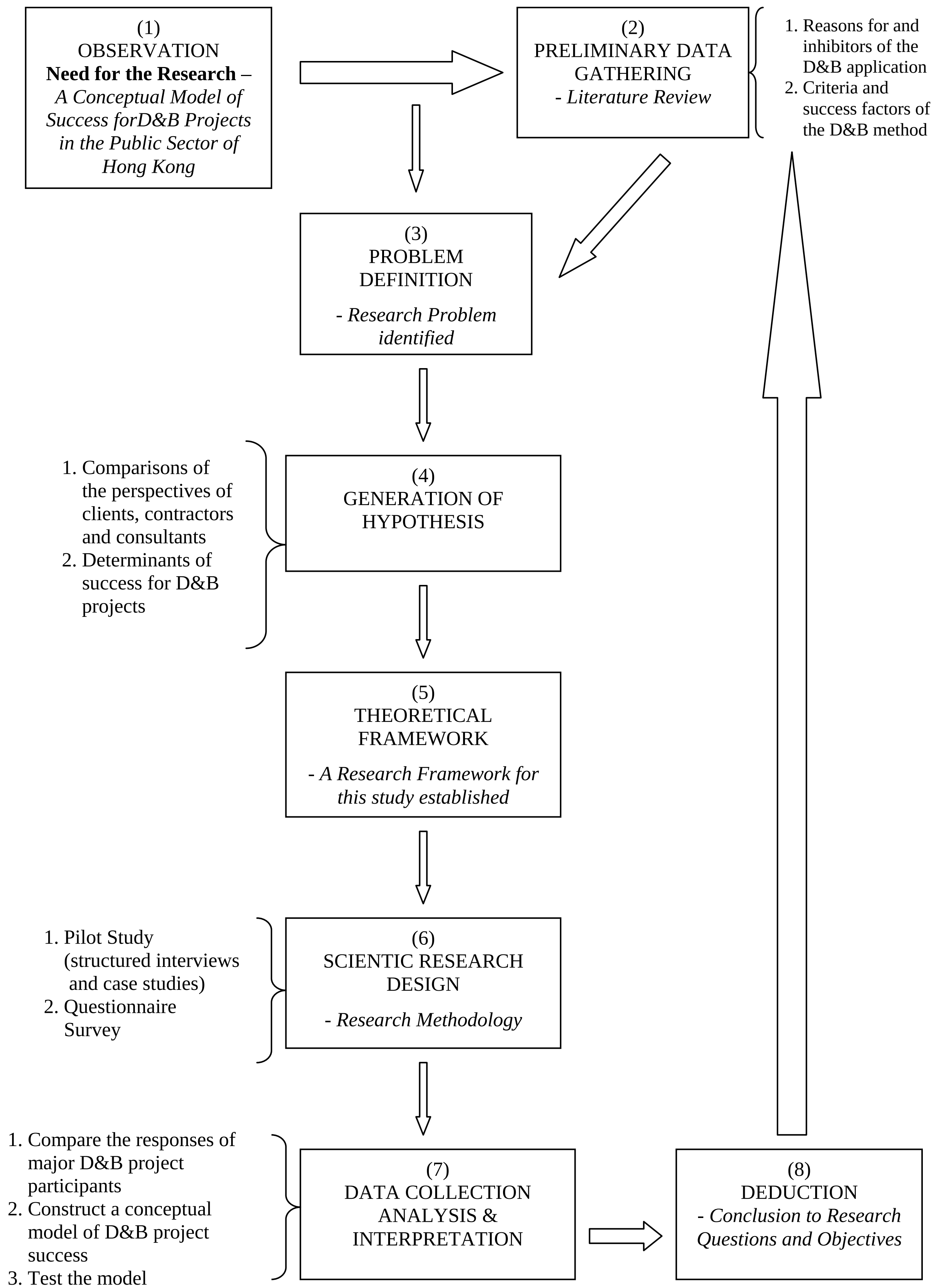


Fig. 6.2 Research process for this study

reviewed to enrich the literature database. To maintain the efficiency and effectiveness of the literature searching process, an on-line search was also undertaken and the search engines identified are CatchWord, Ebsco and Science Direct. Some papers may not be retrieved on line and so manual search was done to catch any missing articles. The literature search focused on:

a) The reasons for the adoption of the D&B method;
b) The problems of running D&B projects;
c) The barriers to applying the D&B method;
d) The factors that are essential for running a successful D&B project;
e) The criteria of measuring success for D&B projects.

The process was repeated so as to keep updated with the latest knowledge in the field. As a result, a comprehensive database on D&B in the specific area of project success can be established for the development of the draft questionnaire.

6.2.2 Methods of Empirical Data Collection

Upon the preparation of the draft questionnaire, the process of a pilot study took place, which was conducted by structured interviews and case study analysis.

(1) Pilot Study

Walker (1997) was of the opinion that a pilot study is essential in providing a focus mechanism to establish the research direction more clearly. This stage is important in understanding the actual practice of D&B in the Hong Kong construction industry, and identifying what the critical success factors are and how they can be measured from the perspectives of the client, contractor and consultant.

(A) Structured interviews and case studies

The approach of structured interviews is one of the main data collection tools in qualitative research, where interview questions are planned and standardized in advance (Punch, 1998). It is employed to study the perspectives of participants at a preliminary stage and it is best used when it is known, at the outset, what information is needed (Sekaran, 2000; Travers, 2001). Structured interviews were conducted face-to-face with twenty-three D&B participants in Hong Kong to collect empirical data for the research. To facilitate the interview process, a list of 'open' questions were attached to the letter of invitation and asked the D&B participants for their opinions on the application of the D&B method in the territory, and the success criteria and critical success factors for D&B projects. Moreover, information sheets were prepared for the respondents to collect hard data of the D&B project. Each interview lasted for about one hour and mostly took place at the respondent's office. Almost all respondents held senior positions in their respective organizations, among which eight came from the contractor group, ten from the client group and five from the consultant group (Table 6.1).

Table 6.1 Demographic data of interviewees

Ref. No.	Group	Designation	Project Type
Ctr1	Contractor	Contracts Director	Residential
Clt2	Client	Senior Quantity Surveyor	Residential
Cot3	Consultant	Associate Director	Residential
Cot4	Consultant	Associate Director	Residential
Cot5	Consultant	Associate Director	Slaughterhouse
Clt6	Client	Chief Architect	Office
Ctr7	Contractor	Contracts Manager	Residential
Clt8	Client	Architect	Residential
Clt9	Client	Architect	Residential
Clt10	Client	Architect	Residential
Ctr11	Contractor	Procurement Manager	Residential
Ctr12	Contractor	Project Manager	Residential
Clt13	Client	Architect	Hospital
Ctr14	Contractor	Contracts Manager	Maintenance Depot
Clt15	Client	Project Manager	Slaughterhouse
Ctr16	Contractor	Chief Engineer	Slaughterhouse
Clt17	Client	Architect	Office
Cot18	Consultant	Senior Engineer	Office
Clt19	Client	Senior Manager	Fit-out works
Cot20	Consultant	Senior Manager	Hospital
Clt21	Client	Architect	Residential
Ctr22	Contractor	Site Agent	Hospital
Ctr23	Contractor	Project Manager	Residential

Purposive sampling strategies were adopted in which only participants having satisfied certain pre-determined criteria are included as the target respondents (Ng et al., 2002). In this research, the selected respondents should have experience in running at least one D&B building project in the public sector of Hong Kong. The following strategies were used to identify the experienced participants in the industry:

1) By references from local journals and web-pages of the client, contractor and consultant companies;
2) By references from theses at undergraduate and postgraduate levels;

3) By the “top level” management of relevant identified organizations;

4) By directly contacting the relevant organizations for referring suitable persons.

Some of the strategies were employed by Palaneeswaran and Kumaraswamy (2003) in the knowledge mining of their procurement studies. Conventional means of contacts with project participants like e-mailings and telecommunications were adopted to make sure that the information was updated. To make the respondents understand the objectives of the research, an invitation letter stating the aims of the research was delivered to the respondents by fax or ordinary postal mail (Appendix A). The list of interview questions and the project information sheet for the D&B project concerned were also attached so that the respondents could prepare and gather the required project information prior to the interview (Appendices B.1 and B.2). As a result, twenty-three participants agreed to take part in the face-to-face interviews. For tracing purposes, the data on these contacts were stored in Microsoft Excel spreadsheets and were regularly updated during the research process for later compiling the mailing list of the questionnaire.

The interviews were structured which focused on the application of the D&B method in the Hong Kong construction industry and the project success issues on such specific key areas as project characteristics, contract procedures, project management action, project performance and project success factors. The respondents were requested to give their opinions with reference to the D&B project they have been involved in and instructed to complete the project information sheet during the interview.

Another major aim of conducting the interviews in the pilot study is to test the validity of the questionnaire. The interviewees were requested to read the draft questionnaire to look for unclear presentations in achieving the research objectives of investigating the reasons, problems, barriers, and enhancing success for D&B projects. Therefore, the draft questionnaire was presented to the respondent and asked for comments, including the way the questions were set, the clarity of the questions and the suitability of the options available, in order to better assure the validity and fine-tuning of the final questionnaire. The interviewees were also requested to complete the draft questionnaires to check for any difficulties and misunderstandings. Research Supervisors were also consulted and amendments were made to develop the final questionnaire (Appendix C). For example, the instructions for completing the questionnaire had been modified to stress the fact that each set of the questionnaire should be completed for one D&B project only. The research should also be based on the building types of D&B projects in the public sector, which is considered to be the largest client with commitment to the best practice, so that the specific project data sets obtained would be more comparable (Kumaraswamy and Dissanayaka, 1998). In the questionnaire, the respondents were asked to evaluate the factors affecting the performance of their D&B projects and at the same time they were requested to rate their level of satisfaction on such projects. These variables would be analyzed correspondingly. As a result, factors leading to a good or a bad D&B project would be identified accordingly. While some attributes were amended to avoid having two directions in one question, others were extended to incorporate the work of previous research and maintain the consistency of the research. The sequence of the questions to be asked was also adjusted and the language was changed to improve the communication with the respondents. Acknowledgement letters were dispatched to thank the participants for their valuable time taken up during the interview survey and at the same time they were invited to participate in the questionnaire survey at a later stage (Appendix D). It is noted that the pilot study respondents may have bias in influencing the finalization of the questionnaire. However, as the population of the research was limited to those participants having experience in running at least one D&B building project in the Hong Kong construction industry, the exclusion of the pilot study respondents from the questionnaire survey may reduce the sample size and the representative nature of the population. Moreover, each pilot study respondent will be given the finalized questionnaire with modifications from other respondents in an attempt to minimize the effects of bias. A diagrammatical presentation, which starts from the literature search, and carries on through the process of the pilot study to the finalization of the research questionnaire, can be summarized in Fig. 6.3.

(2) <u>Questionnaire Survey</u>

Sekaran (2000) described a questionnaire as a pre-formulated written set of questions to which respondents record their answers, usually within rather closely defined alternatives. The research questionnaire was designed to obtain data required

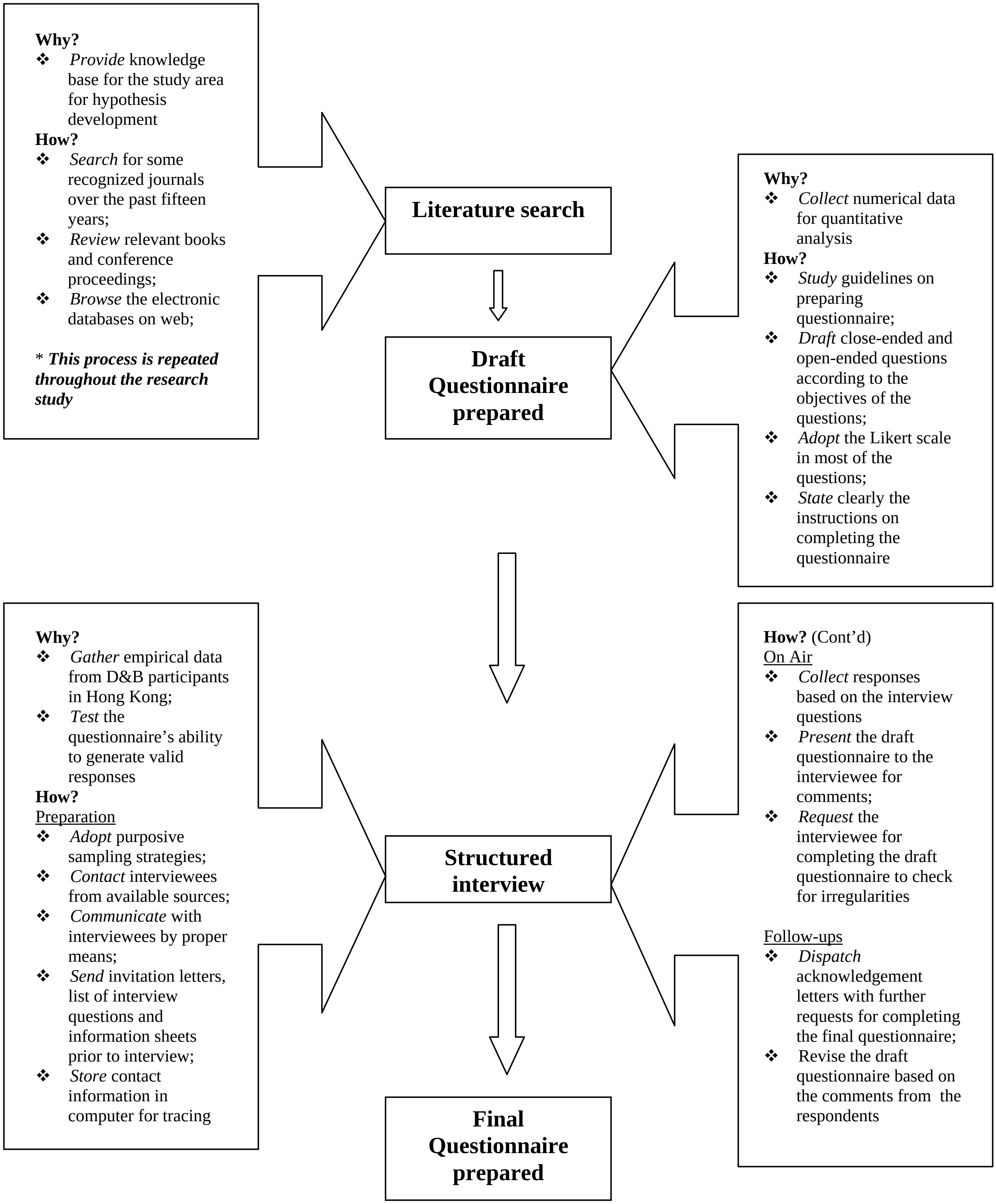


Fig. 6.3 Preparation of research questionnaire

to test the hypotheses postulated for the study. To prepare a valid set of questions, guidelines on preparing questionnaires were studied, such as the content, purpose and wording of the questions. Most questions are of the close-ended type to provide a uniform format to facilitate comparisons among respondents. Some questions are open-ended to allow the respondent to express their personal ideas (Labaw, 1980). The Likert scale is used in this study, which entails a five- and seven-point rating scale to collect the perceptions of the respondent measured on a continuum, from one extreme value to the other with an equal number of positive and negative response possibilities and one neutral category (Rea and Parker, 1997). Instructions are also clearly stated in the questionnaire to prevent void responses and the final questionnaire comprised fourteen sections, namely

1. About The Respondent;
2. About The Problems in Running D&B Projects;
3. About The Barriers to D&B Development in Hong Kong;
4. About The Project;
5. About The Project Procedures;
6. About The Project Environments;
7. About The Project-related Participants;
8. About The Project Management Strategies;
9. About The Project Work Atmosphere;
10. About The Personal Views on Success Factors for D&B Projects;
11. About The Personal Views on Success Criteria for D&B Projects;

12. About The Level of Satisfaction (Project Level);
13. About The Project Performance;
14. About The Reasons for the Increasing Use of D&B in the Public Sector of Hong Kong.

Sections 1 and 4 ask for background information of the respondent and the D&B project respectively and Section 4 is further sub-divided into two parts: project scope details and project features. Section 4.1 describes the project scope details which may be confidential to some respondents. This section is made optional to enable respondents who are reluctant to disclose this confidential information to answer the remaining parts of the questionnaire. While Sections 2, 3, and 14 focus on the application of the D&B method in the Hong Kong setting, Sections 4, 5, 6, 7, 8, 9 and 14 question the critical success factors for D&B projects, and Sections 11, 12 and 13 request data on the success criteria and performance of the D&B project. For the close-ended questions, the responses were recorded on a Likert scale for quantitative analysis. In order to develop the conceptual model, the research adopted a response-based approach which makes use of the data from the D&B project participants in the construction industry of Hong Kong.

A covering letter was prepared to state the instructions for completion and the ways to return the completed questionnaires (Appendix E). Other preparation work included the self-addressed return envelopes, the printing of labels and the photocopying of the whole set of material. Before distributing the questionnaire, a reference number has been allocated to each set of questionnaires to match with that of the sending list complied for subsequent checking and follow-up purposes. All the hard copy questionnaires were dispatched through ordinary postal mail and fax upon requests from respondents. The letter of reminder (Appendix F) was also distributed to collect further responses and the process of quantitative data collection is depicted as Fig. 6.4.

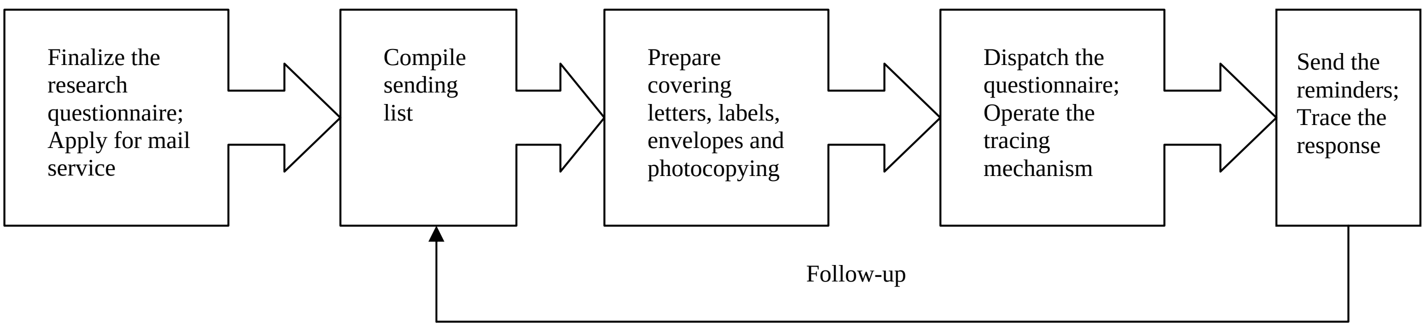


Fig. 6.4 Process of quantitative data collection

The literature review provides fruitful information which forms the contents of the draft questionnaire. A pilot study was carried out in which structured interviews were held with the D&B project participants in the Hong Kong construction industry, and comments were received to develop the research questionnaire. Upon collection of quantitative data from the questionnaire survey, an analysis of data follows, which requires a number of statistical techniques.

6.3 DATA ANALYSIS

Analysis of data is of paramount importance to turn raw data into useful information by statistical and quantitative methods so that conclusions can be drawn. Data from questionnaires were firstly fed into the computerized database system, and statistical software, a Statistical Package [for the Social Sciences (SPSS)] and a Statistical Analysis System (SAS) was employed to aid analysis. Various statistically techniques were employed, including Cronbach's alpha coefficients, mean ranking, Kendall coefficient of concordance, Spearman rank-order correlation coefficient, *t*-test, principal components analysis, factor analysis, and multiple regression analysis.

6.3.1 Cronbach's Alpha Coefficients

The measurement reliability is essential to the validity of the results of the questionnaire survey (Shen, 2003). Cronbach's alpha coefficients were calculated to investigate the internal consistency among alternative items used to measure the same underlying construct. Akintoye (2000), and Diallo and Thuillier (2004) also adopted the approach to test the reliability of the Likert-type scale. The larger the value, the better the reliability in each component.

The technique was employed to examine the internal consistency among the responses under the constructs of the reasons, problems, barriers, criteria and factors of success for D&B projects.

6.3.2 Mean

Chan and Kumaraswamy (1996) adopted the 'mean score' method to establish the relative importance of reasons for delay in civil engineering projects in Hong Kong on a Likert scale from '1' to '5'. The method was used to determine the relative ranking from the responses of the clients, contractors and consultants on the reason, problem and barrier attributes. A rating scale from '1' to '7' was adopted in the research to further differentiate the difference in perceptions of the project participants on the ranking exercise. The mean scores of the respondents in ranking the success criteria were also determined to retain those that were considered indicators of success for D&B projects. The formula for the calculation of the mean score (MS) is as follows:

$$MS = \frac{\sum (f \times s)}{N}, \quad 1 \le MS \le 7 \qquad \text{............ } \textbf{\textit{Equation 6.1}}$$

where	s	=	score given by the respondents
	f	=	frequency of responses
	N	=	total number of responses

Diamantopoulos and Schlegelmilch (1997) defined mean rank as the sum of the ranks divided by the number of cases. A higher mean rank value in one attribute represents a higher importance level stressed by that particular category of respondents. The method has been employed by Dulaimi and Hong (2002) to examine the difference in opinions between two categories of contractors. The mean ranks calculated were used to compute the Kendall's Coefficient of Concordance (W) and the Spearman rank-order correlation coefficient (r_s).

6.3.3 Kendall's Coefficient of Concordance (*W*)

It is a technique used to measure the agreement among different sets of rankings by different groups (Chan, 1998). It was adopted to compare the level of agreement on the rankings among all respondents and within individual groups of clients, contractors and consultants by the following formula:

$$W = \frac{\sum_{i=1}^{N} (\overline{R}_i - \overline{R})^2}{N(N^2 - 1)/12} \quad , 0 \leq \text{index} \leq 1 \qquad \text{………… } \textbf{\textit{Equation 6.2}}$$

where N = Number of objects (or individuals) being ranked

$\overline{R}_i$ = Average of the ranks assigned to the ith object

$\overline{R}$ = The average of the ranks assigned across all objects

$N(N^2-1)/12$ = Maximum possible sum of the squared deviations

W ranges from 0 to +1. If there is a complete lack of consensus on the ranking of the barriers under study, *W* will be zero. By contrast, a perfect agreement will result in *W* having a value of one. Moreover, a high or significant value of *W* indicates that different parties are essentially applying the same standard in ranking the attributes (Chan et al., 2003a).

The technique was employed to test the hypotheses on the level of agreement of the ratings within particular groups of D&B project participants on the reasons for the wider adoption of the D&B method in the pubic sector, problems of running D&B projects and barriers to applying the D&B method.

While the Kendall method conducts an 'intra-group' comparison within the same group of respondents and compares the rankings of all respondents, the Spearman method conducts 'inter-group' comparisons with any two separate groups of respondents.

6.3.4 Spearman Rank-Order Correlation Coefficient (r_s)

The agreement between any two parties on their rankings of the attributes can be measured by the Spearman rank-order correlation coefficient (r_s):

$$r_s = 1 - \frac{6\sum D^2}{N(N^2-1)} \quad , 0 \leq \text{index} \leq 1 \qquad \ldots\ldots\ldots\ldots \textbf{\textit{Equation 6.3}}$$

where D = Differences between the ranks of corresponding values of X and Y
N = Number of pairs of values (X, Y) in the data

The method can be used to cross-compare the relative importance of the attributes from the different perceptions of the client-contractor, client-consultant and contractor-consultant groups by the mean ranking. To compute r_s between two sets of scores, it is necessary to rank-order them into two series (Siegel and Castellan, 1988). The coefficient ranges between –1 and +1. The value of +1 indicates a perfect linear correlation while negative values indicate negative correlations. When $r_s = 0$, there is no linear association (Chan, 1998).

The technique was employed to test the hypotheses on the level of agreement of the ratings between groups of D&B project participants on the reasons for the wider adoption of the D&B method in the pubic sector, problems of running D&B projects and barriers to applying the D&B method. Previous researchers have set similar hypotheses in applying W and $r_{s,}$ such as Chan and Kumaraswamy (1996), Mezher and Tawil (1998) and Chan et al. (2003a; 2003b).

While the Spearman test shows the level of agreement in ranking the barriers between two respondent groups, independent samples *t*-test is carried out to identify the particular attributes in which the two respondent groups, if any, show differences in the ranking exercise.

6.3.5 T-Test

The independent-samples *t*-test is used to compare the mean scores of one variable for two groups of cases (SPSS, 1997). It has been adopted by Cheng and Li (2001), in their partnering research, and is calculated by the following formula:

$$t = \frac{(\overline{X}_1 - \overline{X}_2)}{S_{\overline{X}_1 - \overline{X}_2}}$$

………… ***Equation 6.4***

where $\overline{X}_1, \overline{X}_2$ = Sample means of two populations

$S_{\overline{X}_1 - \overline{X}_2}$ = Estimated standard error of the different between two means

If the value obtained is less than the specified alpha level (P = 0.05 or P = 0.01) used in testing the set of hypothesis, the null hypothesis is rejected and it is concluded that the two populations are different (Pavkov and Pierce, 2001). By contrast, values greater than the specified alpha level conclude that insufficient evidence exists to suggest that the two populations are different. Such a technique was applied to the research to further identify the particular attributes which have been ranked differently by the paired respondent group concerned from the Spearman test. It also tests for differences in rankings between groups of respondents on the success criteria.

The paired-samples t test, which compares the means of two variables for a single group, was also used in testing the model developed from the research (Chapter 10).

6.3.6 Principal Components Analysis

The technique can be applied to compositional data, which consists of observations x_1, x_2, …, x_n, for which each element of x_i is a proportion, and the elements of x_i are constrained by the sum of the unity (Jolliffe, 2002). Assuming that there are p variables, the use of the principal components analysis gives the following p linear combinations:

$$\xi_1 = w_{11}x_1 + w_{12}x_2 + \ldots + w_{1p}x_p$$
$$\xi_2 = w_{21}x_1 + w_{22}x_2 + \ldots + w_{2p}x_p \ldots$$
$$\xi_p = w_{p1}x_1 + w_{p2}x_2 + \ldots + w_{pp}x_p$$

………… ***Equation 6.5***

where ξ_1, ξ_2, …, ξ_p are the p principal components and w_{ij} is the weight of the jth variable for the ith principal component. Moreover, this relationship is expressed as:

$$w_{i1}^2 + w_{i2}^2 + \ldots + w_{ip}^2 = 1; \qquad i = 1, \ldots, p$$

………… ***Equation 6.6***

Sharma (1996) believed that the principal components analysis is an appropriate technique for developing an index, and the feature that the squares of the weights sum to one forms the project success index for D&B projects (PSI-D&B). In fact, the variances of the principal components are the eigenvalues of the matrix (Manly, 1986). According to Kaiser's rule, any principal components with a variance less than 1 are not worth retaining and the first principal component, ξ_1, accounts for the maximum variance in the data (Jolliffe, 2002).

Further to identifying the success criteria for D&B projects, the method was employed to compute the project success index from the perspectives of the client, contractor and consultant.

6.3.7 Factor Analysis

Factor analysis attempts to identify underlying variables or factors that explain the pattern of correlations within a set of observed variables. It is often used in data reduction by identifying a small number of factors that explain most of the variables observed in such larger number of variables (SPSS, 1997). This technique is powerful to reduce and regroup the factors identified from a larger number, to a smaller and more critical one by factor scores of the responses. It is indeed possible that all of the variables contribute to the same factor, and only a subset of variables characterizes the factor as indicated by their large coefficients. The general expression for the estimate of the *j*th factor, F_j is

$$F_j = \sum_{i=1}^{p} W_{ji}X_i = W_{j1}X_1 + W_{j2}X_2 + \ldots + W_{jp}X_p \qquad \text{………… } \textbf{\textit{Equation 6.7}}$$

where the W_i's are factor score coefficients and p is the number of variables. The technique involves a 2-step process, factor extraction and factor rotation. The primary objective of the first stage is to make an initial decision about the number of factors underlying a set of measured variables, and the first extracted factor accounts for the largest amount of the variability among the measured variables (Green and Salkind, 2003). However, the factors are typically not very interpretable and so the factors are rotated to make them more meaningful. The responses obtained from the research questionnaire on ranking the success factor variables of D&B projects were therefore reorganized into factor categories, which are used as independent variables for further analysis. Trost and Oberlender (2003) pointed out that factor analysis can be employed to overcome the obstacles presented by the multicollinearity problem and the factor scores are also used to test the reliability of the model (Chapter 10).

6.3.8 Multiple Linear Regression Analysis

Multiple linear regression analysis is a general statistical technique used to analyze the relationship between a single dependent variable and several independent variables. The technique can be used to relate a number of independent variables to a dependent variable by studying the relations among variables. As more than one independent variable is investigated in this research, multiple regression analysis is adopted to handle the multiple independent variables to identify the predictors of success for D&B projects. Allison (1999) claimed that multiple regression makes it possible to combine many variables to produce optimal predictions of the dependent variable and the Multiple Linear Regression (MLR) model is defined as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i; \qquad i = 1, \dots, N$$

…… ***Equation 6.8***

where	Y	=	Dependent or response variable
	$X_2, X_3, \ldots, X_k$	=	Explanatory variables or regressors
	$\beta_1, \beta_2, \ldots, \beta_k$	=	Regression coefficients
	ε	=	Error term
	N	=	Size of the population

Partial regression plots are also performed to check for violations of assumptions in multiple regression by plotting the dependent variable against the independent variable (Hair et al., 1998). The technique was employed to test the hypothesis at Stage 2 of the investigation. It also identifies those factors that have a strong correlation to the success of D&B projects and indicates the relationships between the critical success factors and the success criteria of D&B projects in order to develop the conceptual model. Fig. 6.5 illustrates the Stages 1 and 2 in the investigation of the research.

6.4 CHAPTER SUMMARY

The chapter has introduced the research process and the various approaches which meet the research objectives. The processes of conducting structured interviews and developing the research questionnaire were also presented, and the statistical techniques employed were described. The results of Stage 1 on the application of the D&B method in the Hong Kong setting will be presented and discussed in the following chapter, and those of Stage 2 will be outlined in Chapters 8 and 9.

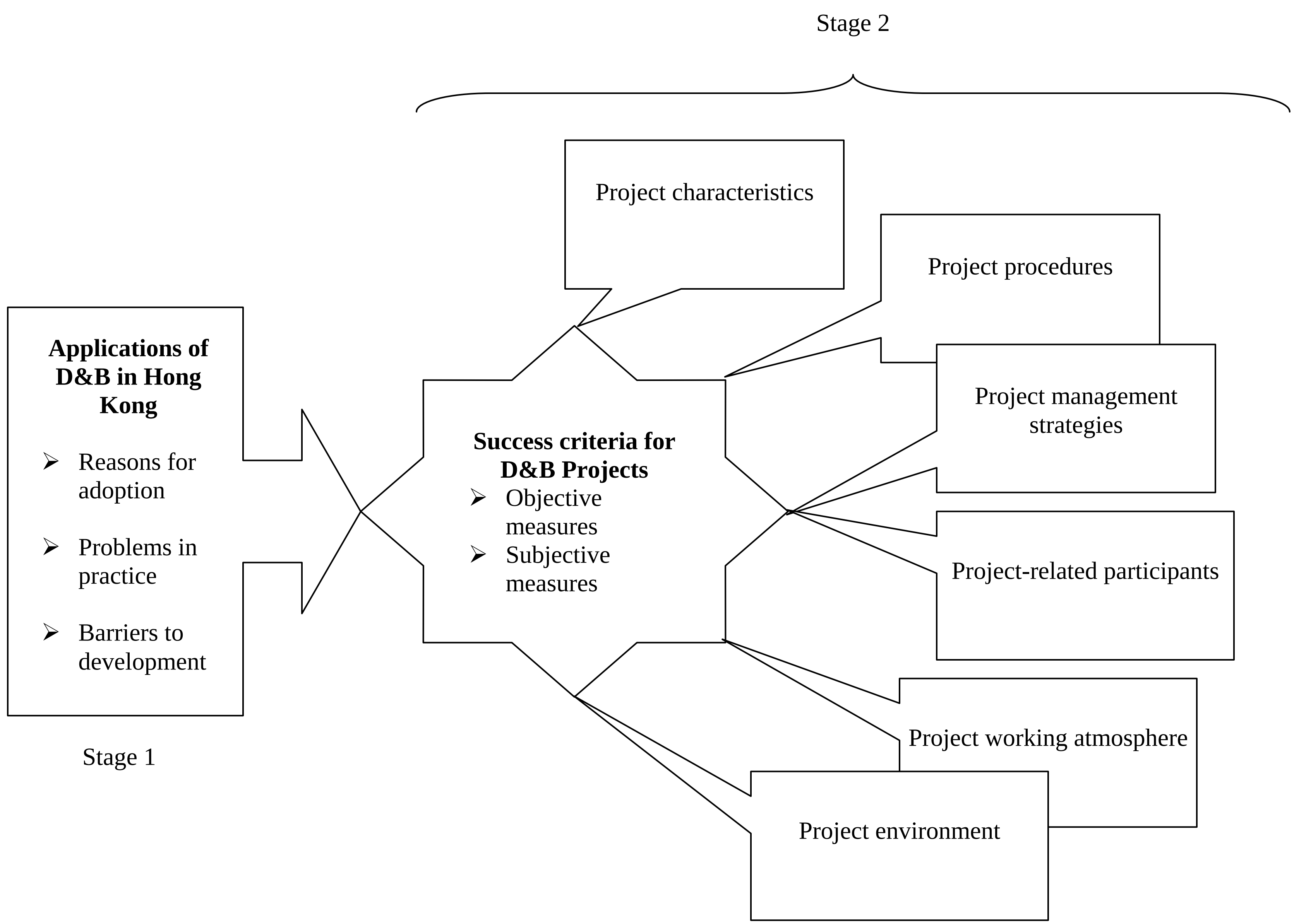


Fig. 6.5 Stages 1 & 2 investigations

CHAPTER 7 APPLICATION OF DESIGN-BUILD IN THE PUBLIC SECTOR OF HONG KONG

7.1 INTRODUCTION

Chapters 2 and 3 provided a desk study of the Stage 1 investigation and this chapter presents the analysis of an empirical study on the application of the design-build method. The demography of data of the research is firstly described. Then the results of assessing the drivers for a wider application of the D&B method will be presented. More emphasis is also placed on evaluating the factors which inhibit the application of the D&B method in the Hong Kong setting, including the problems of running D&B projects and the barriers to the development of the D&B method. Discussions of the results then follow to complete the Stage 1 investigation on the application of the D&B method in Hong Kong.

7.1.1 Research Data

The research questionnaires were sent to 248 D&B participants in the construction industry of Hong Kong. 21 questionnaires were returned undelivered for reasons such as removal of office, thus reducing the number of questionnaires sent out to 227. Follow-up telephone calls were made to the D&B organizations to confirm whether the respondents had received the questionnaires and to further encourage the target D&B practitioners to participate in the survey. As a result, 88 completed questionnaires were received from the population. Moreover, 3 respondents provided their perceptual opinions on more than one D&B projects, giving a sample of 92 responses for subsequent analyses.

Section 1 contained questions which sought background information on the respondents. All the respondents stated their positions, which are shown in Table 7.1.

Table 7.1 Categories of respondents

Rank	**Director**	**Manager**	**Professional**	**Other**
Number (%)	18 (20)	32 (36)	33 (38)	5 (6)

More than half (56%) of the responses received were from persons holding senior positions at the Directorial and Managerial level in their respective D&B firms. The professional group in the survey comprised architects, engineers and surveyors who were involved in D&B projects. The 'Other' category included a Project Coordinator and various Site Agents. The senior practitioners in the survey were from various professional disciplines in the construction industry (see Table 7.2 for the professional affiliation of the respondents).

Table 7.2 Professional affiliation of respondents

Affiliation	**Number of responses (%)**
Architect	20 (23)
Builder	20 (23)
Quantity Surveyor	18 (20)
Building Surveyor	5 (6)
Building Services Engineer	1 (1)
Engineer	20 (23)
Project Manager	2 (2)
Manager	2 (2)

The respondents represented major stakeholders in D&B projects. Almost half of the respondents (45%) work for contractor organizations while nearly one-quarter of them (23%) work for clients. Almost one third of the respondents (32%) were from consultancies, with 10% from architectural firms, 10% from quantity surveying (Q.S.) consultancy firms, 10% from engineering consultancy firms and 2% from project management consultancy firms (Fig. 7.1).

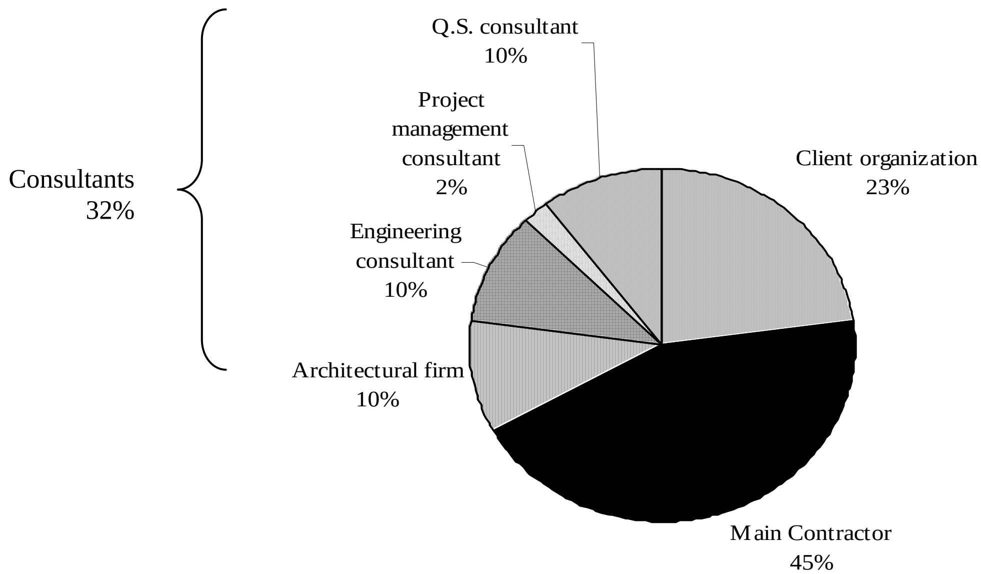


Fig. 7.1 Types of organizations to which respondents were affiliated

With the exception of the two respondents who did not specify the highest qualification which they had obtained, most respondents (>80%) held bachelor's or higher degrees while others were members of professional bodies, such as The Royal Institute of Chartered Surveyors and The Chartered Institute of Builders (Table 7.3).

Table 7.3 Highest academic qualification obtained by the respondents

Highest Qualification Obtained	Number of responses (%)
Diploma/Certificate	12 (14)
Bachelor's Degree	33 (38)
Postgraduate Diploma	12 (14)
Master's Degree	25 (28)
Doctorate Degree	1 (1)
Others	3 (3)
No response	2 (2)

Almost half of the respondents (45%) had 20 or more years experience in the construction industry, and more than half of the respondents (52%) were from large organizations with more than 500 employees. D&B is increasingly used in Hong Kong and this is illustrated by the fact that more than half of the respondents (52%) had experience in two or more D&B projects.

For purposes of comparing and contrasting perceptions, the data samples were classified into three categories by major D&B project stakeholders, namely client, contractor and consultant groups. Of the 92 responses received, 22 were from client organizations, 40 from contractor organizations and 30 from consultancies (Appendix G). The respondents were asked to rate each attribute of the respective constructs on a seven-point Likert scale to indicate the level of agreement, ranging from '1' equal to 'Strongly Disagree' to '7' equal to 'Strongly Agree'. The data were input into SPSS and statistical techniques were employed to analyze the data.

The measurement reliability of the questionnaire was firstly evaluated by Cronbach's alpha coefficients to investigate the internal consistency among the attributes of the respective constructs on the Likert scale. The results are summarized in Table 7.4 and attached as Appendices H.1, I.1, and J.1 respectively.

Table 7.4 Measurement reliability of constructs

Construct	Cronbach's alpha coefficients
Reasons for the increasing use of D&B in the public sector of Hong Kong (16 items)	0.890
Problems in running D&B projects (16 items)	0.808
Barriers to D&B development in Hong Kong (16 items)	0.800

The coefficients obtained exceed the common threshold of 0.7 as suggested by Shen (2003), indicating the high degree of reliability of the data collected. Comparisons were made to examine any significant difference in perceptions by the intra- and inter-group ratings of clients, contractors and consultants on the drivers, problems and barriers to the implementation of the D&B system.

7.2 DRIVERS FOR A WIDER ADOPTION OF DESIGN-BUILD IN THE PUBLIC SECTOR OF HONG KONG

Globally, there is an increasing tendency to adopt the D&B method to deliver construction projects. In some countries, like the UK and Japan, D&B is more widely used in the private sector whereas in the US, Singapore and Hong Kong, it is more widely used in the public sector. In Hong Kong, the government has introduced D&B contracts and administrative procedures for construction works to encourage the use of D&B in the public sector. Other reasons for the wider adoption of this method are explored in this chapter.

7.2.1 Data Matrix

Section 14 of the research questionnaire provided 16 reason attributes, and 20 client responses, 37 contractor responses and 26 consultant responses were obtained for the list of reasons. The descriptive statistics of means, standard deviation and rankings of the reasons for the wider adoption of the D&B method are shown as Appendix H.2.

(1) <u>Mean</u>

The mean was computed to rank the perceptions of the client, contractor and consultant respondents on the reasons for the wider adoption of the D&B method in the public sector of Hong Kong. Table 7.5 shows the results.

'D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design', 'the D&B contractor bears all risks related to the project, including management, financial and design matters', and 'the one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members' were considered as the top three reasons for the implementation of the D&B method.

Table 7.5 Results on the ranking of reasons and 'intra-group' comparisons
(Note: The shaded area represents the top ranks on the drivers for the D&B method.)

Reason	All respondents		Client Group		Contractor Group		Consultant Group	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	5.45	1	5.33	1	5.61	2	5.36	1
The D&B contractor bears all risks related to the project, including management, financial and design matters	5.45	1	5.15	3	5.79	1	5.21	2
The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	5.33	3	5.33	1	5.51	3	5.11	3
D&B enables the government to maximize the use of resources and design expertise from the private sector	5.10	4	5.10	4	5.23	6	5.00	4
The project size in the public sector makes D&B feasible to apply	4.98	5	4.90	7	5.08	7	4.86	6
The buildability of project design in D&B projects ensures a higher success rate in public sector projects	4.93	6	4.57	10	5.28	4	4.71	9
The good track record of past D&B projects in the public sector enhances its further adoption	4.92	7	4.76	9	4.97	10	4.96	5
D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	4.90	8	4.95	6	5.08	7	4.61	10
D&B provides the public sector client with a guaranteed cost	4.90	8	4.81	8	5.27	5	4.43	11
D&B secures a reasonable and competitive price for government projects	4.83	10	4.57	10	5.05	9	4.75	8
The public sector is more willing to try new procurement systems	4.73	11	4.30	14	4.85	11	4.86	6
The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	4.53	12	5.10	4	4.38	16	4.26	12
D&B reduces disputes and arbitration	4.51	13	4.14	16	4.85	11	4.25	13
D&B gives rise to a win-win situation for all players	4.45	14	4.33	13	4.64	14	4.25	13
D&B provides the public sector with a more innovative and efficient image because of the simplified structure	4.36	15	4.48	12	4.69	13	3.79	16
D&B provides the public sector client with a guaranteed completion date	4.34	16	4.19	15	4.51	15	4.14	15
Number	83		20		37		26	
Kendall's coefficient of concordance (W)	0.133		0.199		0.118		0.204	
Level of significance	0.000		0.000		0.000		0.000	

(2) <u>Kendall's Coefficients of Concordance (*W*)</u>

Kendall's coefficients of concordance (*W*) were computed to ascertain whether there were any significant 'intra-group' differences among the respondents; and among the client, contractor, and consultant groups respectively. Table 7.5 shows the results, which are also attached as Appendices H.3-H.6. The Kendall's coefficients of concordance (*W*) for the rankings of reasons for all respondents, and those for the client, contractor and consultant groups were 0.133, 0.199, 0.118 and 0.204 respectively. The null hypothesis that the respondents' ratings among the respondents and within the respective participant groups on the reasons for the wider adoption of the D&B method in the public sector are unrelated to each other was rejected at a 0.001 significance level. Thus it can be concluded that there is agreement among the respondents in each of the client, contractor and consultant groups, and also among all D&B participants, on the ranking of the reasons for the wider adoption of the D&B method in the public sector at a 0.001 significance level.

(3) <u>Spearman Rank-Order Correlation Coefficient (r_s)</u>

The Spearman rank-order correlation coefficient (r_s) was computed to assess the 'inter-group' differences among the paired groups of client-contractor, client-consultant and contractor-consultant respondents. An attempt was made to test whether there was any significant disagreement on the ranking of the reasons in the paired respondent groups, i.e., the client-contractor, client-consultant and contractor-consultant groups.

Table 7.6 Spearman rank correlation test between groups of respondents for reasons

Group	***Client***	***Contractor***	***Consultant***
Client	1.000	0.668*	0.774**
Contractor	0.668*	1.000	0.798**
Consultant	0.774**	0.798**	1.000

* $P<0.01$ (2-tailed).
** $P<0.001$ (2-tailed).

Table 7.6 and Appendix H.7 show that the computed r_s for the client-consultant group was 0.774 and that for the contractor-consultant group was 0.798, both at a 0.001 significance level. Moreover, the computed r_s of the client-contractor group was 0.668, a 0.005 significance level. Thus the null hypothesis that no significant disagreement exists between clients and consultants, clients and contractors, and contractors and consultants on the ranking of reasons for the wider adoption of the D&B method in the public sector is accepted. A discussion of the drivers and the similarities in rankings will be presented in the next section.

7.2.2 Discussion of Results on the Reason Rankings

(1) <u>Drivers for a Wider Use of the D&B Method</u>

Most of the reasons are related to the responsibilities of the contractor who is involved early in the design stage of the project so that the design can be made more buildable. D&B makes use of the contractor's expertise early at the design stage and this factor, the early introduction of contractor knowledge, was rated as the main reason by the respondents. This agrees with Chan and Yung (2000) who reported that D&B allows design input from outside architectural consultants, thus enabling an exchange of design ideas that may improve the quality of design. The designers can in turn take advantage of the advice and experience of the contractor with regard to the cost implication of the design. The contractor is also required to provide an 'all-in' service to the public sector client, from design to construction, where management and supervision is necessary to coordinate the designers and the sub-contractors. In fact, D&B is considered to be a risk management strategy and one major benefit of D&B is the transfer of risks from the client to the contractor. This agrees with the study of Chan (2000) who found that the single-point responsibility of the contractor reduces the client's risk on undefined origin of defects. The client has only one party to deal with, i.e., the contractor (Ndekugri and Turner, 1994). The single-point contact from the contractor also simplifies the communication process between the client and the various parties so that decisions can be turned into action more efficiently. This agrees with the study of Mo and Ng (1997) where both architects and builders considered the single point of responsibility for the client as an important advantage. As a result, more communication and interaction exist between the contractor and the designer (Chan, 2000; Chan and Yung, 2000).

(2) Similarities in Rankings

The respondents regarded 'D&B requires variations to be kept to a minimum, which is considered important in the public sector environment' and 'D&B secures a reasonable and competitive price for government projects' as moderately important. It is in fact preferable that variations be kept to a minimum in construction projects so as to avoid time delays and cost increases. Such variations are particularly undesirable in the public sector where the principle of public accountability needs to be observed. However, variations are unavoidable in construction projects. If they are not significant enough to affect the progress of works, the D&B project may not be delayed. It may be for this reason that respondents consider this factor only moderately important. Chan and Yung (2000) reported that the number of variation orders is reduced with the use of D&B. Moreover, the tendering procedures for D&B projects are clearly listed in the contract documents concerned and selective tendering, in which the tenders are technically screened through a prequalification process, is commonly adopted. Therefore, the selection process is similar to that for a construction project procured through the traditional design-bid-build method. Accordingly the respondents may not consider 'D&B secures a reasonable and competitive price for government projects' as an important reason.

The benefits of D&B have driven public sector clients to have their projects delivered by the D&B method. However, there is no single best way to deliver a project and the identification of problems in running D&B projects can draw the attention of the project stakeholders, especially in places like Hong Kong where D&B is increasingly being adopted.

7.3 PROBLEMS IN RUNNING PUBLIC-SECTOR DESIGN-BUILD PROJECTS IN HONG KONG

The drawbacks of the traditional design-bid-build procurement system have led project participants in the construction industry to opt for other procurement methods, like D&B, for their projects. However, no one procurement method is a panacea for all project types and an understanding of the problems in running D&B projects can help determine the critical success factors for the D&B method.

7.3.1 Data Matrix

Section 2 of the research questionnaire provided 16 problem attributes, and 19 client responses, 37 contractor responses and 28 consultant responses were obtained for the list of problems. The descriptive statistics of means, standard deviation and rankings of the problems in running D&B projects are attached as Appendix I.2.

(1) <u>Mean</u>

The mean was computed to rank the perceptions of the client, contractor and consultant respondents on the problems of running public-sector D&B projects in Hong Kong. The results of the ranking are shown in Table 7.7.

It was found that ‘the schedule was tight’, ‘stress was placed on the project by the client’ and ‘frequent changes were introduced by various end-users’ were considered

Table 7.7 Results on the ranking of problems and 'intra-group' comparisons

Problem Item	**All respondents**		**Client Group**		**Contractor Group**		**Consultant Group**	
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
The schedule was tight	5.73	1	5.55	1	6.03	1	5.47	1
Stress was placed on the project by the client	4.56	2	3.95	3	4.87	3	4.57	4
Frequent changes were introduced by various end-users	4.46	3	3.52	7	4.92	2	4.60	3
There was a conflict of interest between the design team members and the contractor	4.38	4	4.67	2	3.97	6	4.67	2
Frequent changes were introduced by various clients	4.20	5	3.55	6	4.64	4	4.07	5
It was difficult to reach a consensus on the client's requirements due to the different interpretations of the project participants	3.70	6	2.75	13	4.13	5	3.83	8
There was no room for innovation in that project	3.62	7	3.40	9	3.49	7	3.97	6
There was ambiguity in allocating the responsibilities in the contract	3.44	8	3.24	10	3.41	8	3.63	9
It was difficult to compare the contractor's proposal with the client's brief	3.32	9	2.71	14	3.21	10	3.93	7
D&B contractors were not competent with design issues	3.21	10	3.62	5	2.74	14	3.43	10
It was difficult to control workmanship in that project	3.14	11	3.76	4	2.64	16	3.40	11
The project participants were unclear about their roles in D&B	3.10	12	3.05	11	3.15	11	3.10	13
It was difficult to control design quality in that project	3.04	13	2.95	12	2.85	13	3.40	11
The provision of various services was poorly coordinated	2.97	14	3.43	8	2.71	15	2.97	14
It was hard to understand the client's requirements in the project	2.91	15	2.43	15	3.23	9	2.87	15
The scope of the D&B project was ill-defined	2.54	16	2.05	16	2.88	12	2.47	16

Note: The shaded area represents the top ranks on the major problems in running D&B projects.

by the respondents to be the top three problems in running D&B projects.

(2) Kendall's Coefficients of Concordance (*W*)

Table 7.7 and Appendices I.3-I.6 show that the Kendall's coefficients of concordance (*W*) for the rankings of problems for all respondents, and for the client, contractor and consultant groups were 0.284, 0.348, 0.360 and 0.284, respectively. The null hypothesis that the respondents' ratings among the respondents and within the respective participant group on the problems of running D&B projects are unrelated to each other was rejected at a 0.001 significance level. Thus it can be concluded that there is agreement among the respondents in each of the client, contractor and consultant groups, and also among all D&B participants, on the ranking of the problems of running D&B projects at a 0.001 significance level.

(3) Spearman Rank-Order Correlation Coefficient (r_s)

The computed r_s of the client-consultant group was 0.747 at a 0.005 significance level, and the computed r_s of the contractor-consultant group was 0.812 at a 0.001 significance level (Table 7.8 and Appendix I.7).

Table 7.8 Spearman rank correlation test between groups of respondents for D&B problems

Group	***Client***	***Contractor***	***Consultant***
Client	1.000	0.485	0.747*
Contractor	0.485	1.000	0.812**
Consultant	0.747*	0.812**	1.000

* P<0.01 (2-tailed).
** P<0.001 (2-tailed).

Thus the null hypothesis that no significant disagreement exists between clients and consultants, and between contractors and consultants on the ranking of problems in running D&B projects is accepted. However, the computed r_s of the client-contractor group was 0.485 at $P>0.05$. Thus significant disagreement exists between clients and contractors.

7.3.2 Discussion of the Results on the Problem Rankings

(1) Top Problems in Running D&B Projects

All participants ranked 'the schedule was tight' as the highest, a common problem in the Hong Kong construction industry and as a result, stress was placed on the project by the client, which then results in the third problem for the client and contractor respondents and the fourth for the consultant respondents. The consultants were harsh in approving the design by the contractor (Chan et al., 2000). Frequent changes in D&B projects are undesirable but are nevertheless introduced by various end-users, the problem ranked second by the participants. Chan et al. (2000) also reported that the large number of end-users in a D&B office building made it time consuming to deal with the different parties.

(2) Similarities in Rankings between Client and Consultant Groups

The Spearman rank correlation coefficient demonstrates similar agreement in rankings between the client and the consultant groups (Fig. 7.2).

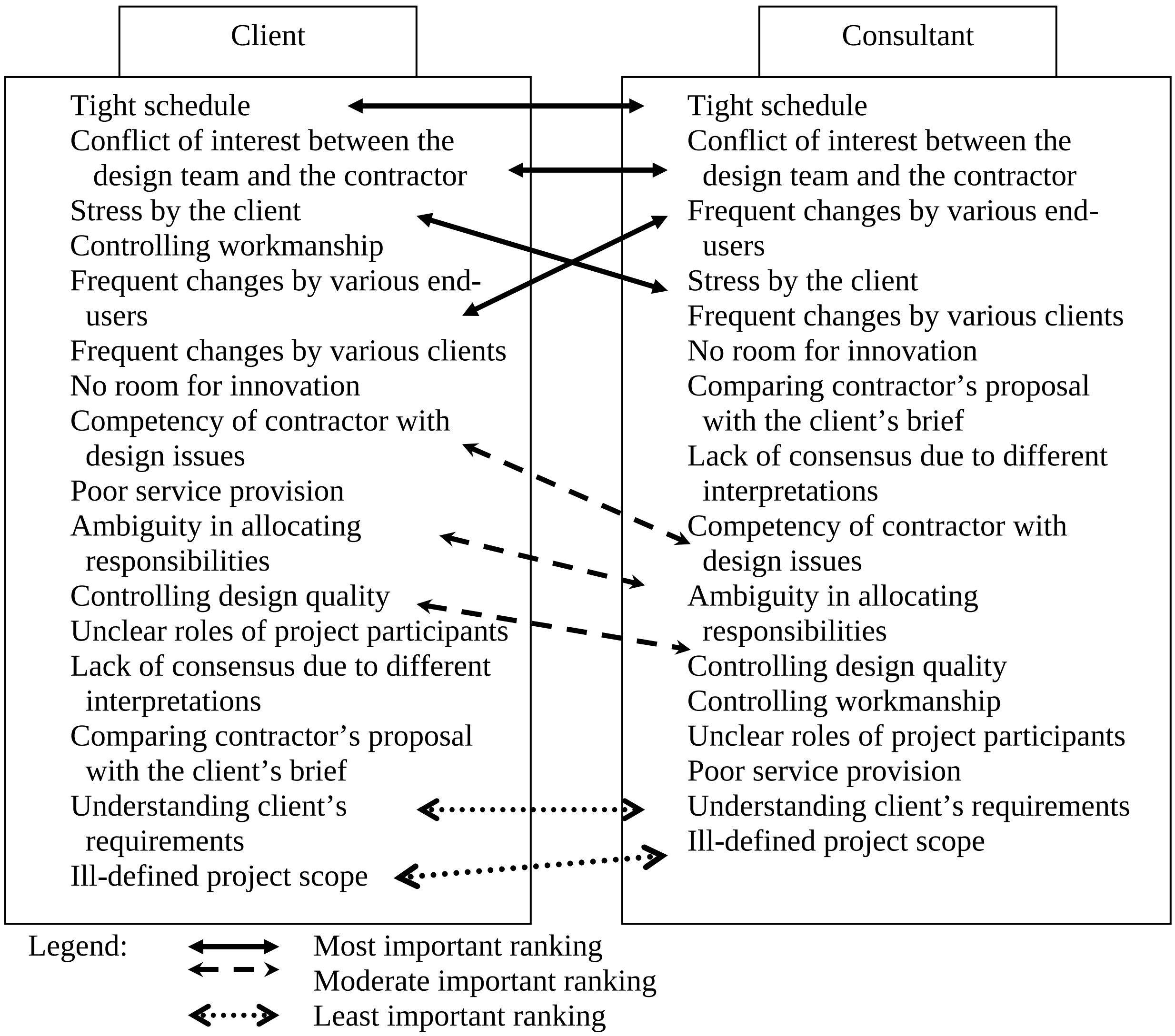


Fig. 7.2 Comparing perceptions of clients and consultants on the problems in running D&B projects

The client and consultant groups consider ‘the schedule was tight’, and ‘there was a conflict of interest between the design team members and the contractor’ as the foremost problems in running D&B projects. The attempt to achieve design certainty indeed exerts time pressure on design consultants (Chan et al., 2000). The lack of sufficient time hinders the consultants in producing good design solutions (Akintoye and Fitzgerald, 1995). Pearson and Skues (1999) explain the latter by stating that it is difficult for the consultants to criticize the employer, who is in fact the D&B contractor. The client and consultant respondents also agree that ‘frequent changes were introduced by various end-users’ and ‘stress was placed on the project by the client’ are the more important problems, that ‘it was difficult to control design quality in that project’ is moderately important, and that ‘the scope of the D&B project was ill-defined’ is the least important. Akintoye and Fitzgerald (1995) found that consultants perceive D&B as involving a sacrificing of product quality and design innovation. Chan et al. (1999) also reported that the quality of projects drops due to inadequate supervision.

(3) <u>Similarities in Rankings between Contractor and Consultant Groups</u>

Fig. 7.3 depicts the level of agreement in the contractor-consultant group. The contractors and the consultants ranked ‘the schedule was tight’, ‘frequent changes were introduced by various end-users’ and ‘stress was placed on the project by the client’ as the major problems in running D&B projects. Indeed, D&B provides for design to be done at a staggering speed (Akintoye, 1994). This group of respondents ranked ‘there was no room for innovation in that project’ and ‘there was ambiguity in allocating the responsibilities in the contract’ as moderate problems, and ‘the scope of the D&B project was ill-defined' as the least important problems. Indeed, clients seldom give contractors a free hand in terms of design ideas and materials specifications (Akintoye, 1994).

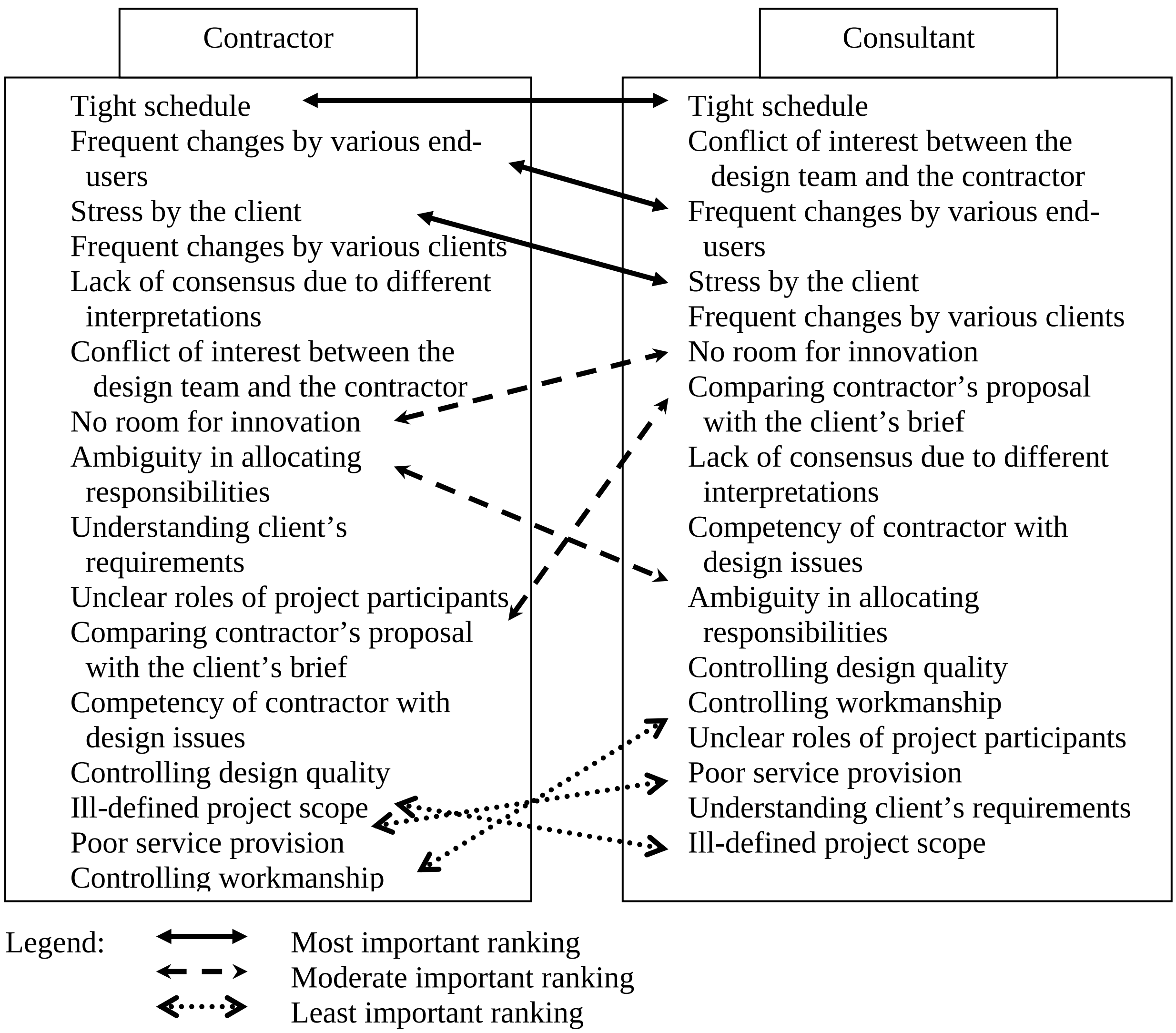
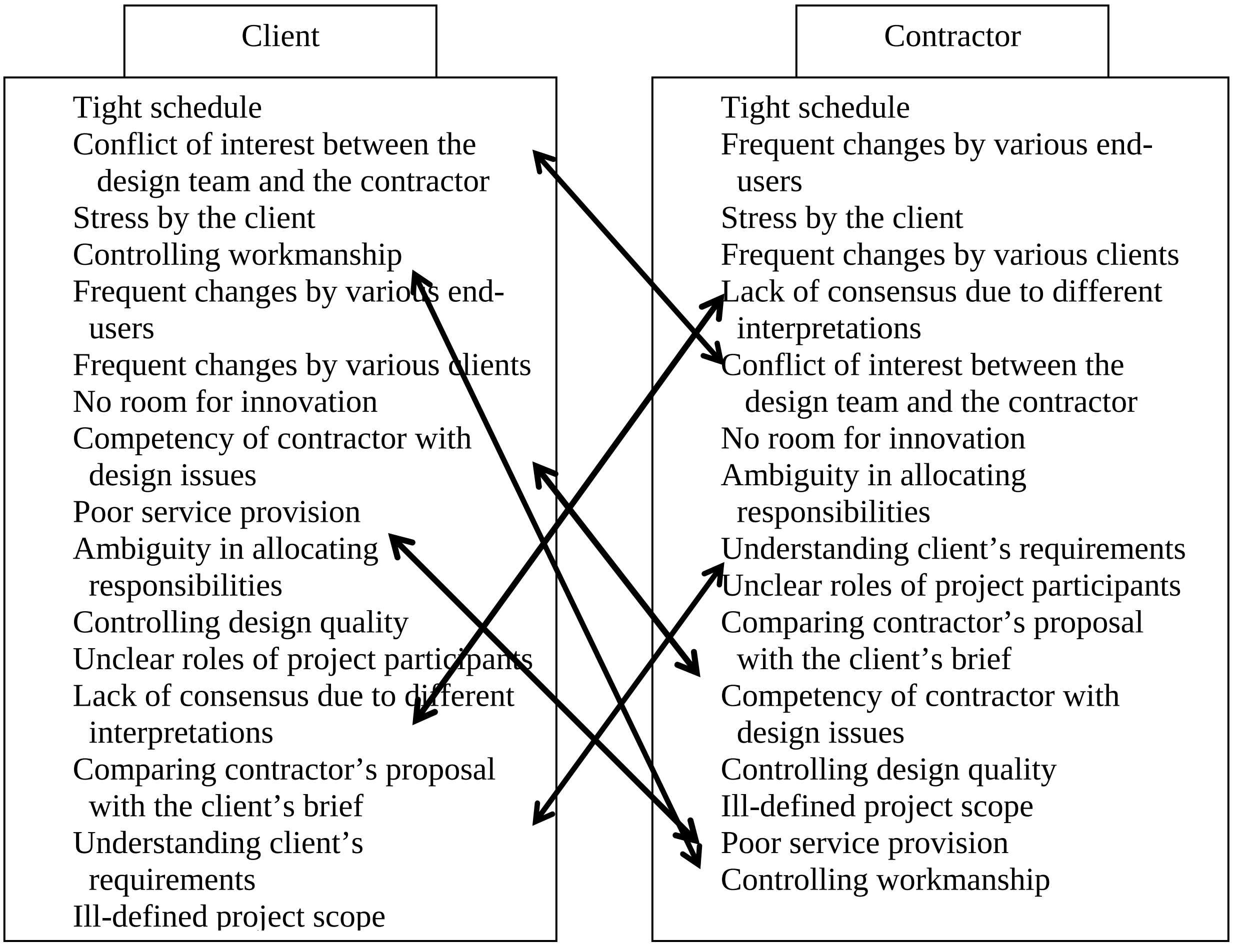


Fig. 7.3 Comparing perceptions of contractors and consultants on the problems in running D&B projects

(4) <u>Differences in Rankings between Clients and Contractors</u>

The Spearman rank-order correlation coefficients indicate that the client and contractor respondents rank the problems differently (Fig. 7.4). The clients ranked 'there was a conflict of interest between the design team members and the contractor' and 'it was difficult to control workmanship in that project' as important problems while the contractors ranked them as moderately important and least important respectively.



Legend: ⟷ Problem attributes with contrasting ranking

Fig. 7.4 Contrasting perceptions of clients and contractors on the problems in running D&B projects

This finding is consistent with the work of Chan et al. (1999) in which the contractors also ranked 'poor workmanship' as the least important. In fact, the client may agree that there is a conflict of interest between the designer and the contractor, which is essentially the only D&B team that is remunerated for its work. The client may also suffer from poor workmanship since the control is remote and the consultants cannot monitor the works on its behalf. By contrast, the clients ranked 'it was difficult to reach a consensus on the client's requirements due to the different interpretations of the project participants' and 'it was hard to understand the client's requirements in the project' as the least important problems while the contractors ranked them as important and moderately important respectively. Ndekugri and Turner (1994) identified conflicts between the brief and the contractor's proposal as one dispute area. This occurs because the scope of D&B projects is defined by the client, and if the scope is ambiguously drafted, it may result in claims by the contractor. Moreover, disputes may result from the different interpretations of the project participants in the D&B team, which is coordinated by the contractor as well as from the different views held by the client and the contractor. This finding is consistent with that of Chan et al. (2000) in the case of more complex projects. The contractors considered 'D&B contractors were not competent with design issues' and 'the provision of various services was poorly coordinated' as the least important problems while the clients ranked them as moderately important. Chan et al. (2000) also reported that D&B contractors were quite experienced, but had poor design knowledge. This may be attributable to the management and leadership of the D&B contractor who should be confident enough to coordinate both design and construction works.

The results indicated that no significant disagreement exists between clients and consultants nor between contractors and consultants on the ranking of problems in running D&B projects (Table 7.8). This may be due to the traditional role of the consultants who serve the client with their objectives in running the project. Under D&B, the contractor and consultant work in association with each other in delivering the project. They may have encountered similar problems in running the D&B project.

However, the Spearman rank correlation test indicates that significant disagreement exists between clients and contractors on the ranking exercise (Table 7.8). This is understandable. Clients, as financiers of D&B projects, may possess different expectations from those of contractors, who are service providers. Clients have high concern in controlling workmanship and service installation of a D&B project while contractors may target to meet client's basic requirements. Clients may consider that their project brief is problem free but contractors may think the otherwise. The differences in rankings between clients' and contractors' responses on the problems in running D&B projects have certain implications. When the D&B method is applied to construction projects, both clients and contractors should have a clear view of their roles in the D&B method. Clients should indicate their requirements clearly to avoid misunderstanding (Haviland, 1995). However, contractors in D&B projects are expected to provide design service for the client. If contractors do not have in-house design teams, they may have to employ outside design members (Akintoye, 1994; Ling, 1997). Apart from the design issues, contractors should also provide high quality of workmanship and coordinate various service installations for the D&B project to be successfully delivered (Nkado, 1995).

Previous researchers have included the barriers to D&B development as problems in the implementation of D&B projects and the following section analyses the barriers from the perceptions of the major D&B stakeholders in the construction industry of Hong Kong.

7.4 BARRIERS TO APPLYING THE DESIGN-BUILD PROCUREMENT SYSTEM IN HONG KONG

In addition to the problems that are not uncommon in construction projects, it is also necessary to investigate the barriers that impede the use of the D&B method so that project stakeholders can improve their decision-making in assessing the use of such an innovative procurement system.

7.4.1 Data Matrix

Section 3 of the research questionnaire provided 16 barrier attributes, and 20 client responses, 38 contractor responses and 27 consultant responses were obtained for the list of barriers. The descriptive statistics of means, standard deviation and rankings of the barriers that impede the use of the D&B method are attached as Appendix J.2.

(1) <u>Mean</u>

The mean was computed to rank the perceptions of the client, contractor and consultant respondents on the barriers to the use of the D&B method in Hong Kong. The results of the ranking are shown in Table 7.9.

'D&B contractors carry a high degree of risk and liability', 'a contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him', and 'it takes more effort to develop the client's requirements for D&B projects' were considered the top three barriers to the implementation of the D&B method.

(2) <u>Kendall's Coefficients of Concordance (*W*)</u>

Table 7.9 and Appendices J.3-J.6 show that the Kendall's coefficients of concordance (*W*) for the rankings of barriers for all respondents, and the client, contractor and consultant groups were 0.138, 0.150, 0.236 and 0.140, respectively. The null hypothesis that the respondents' ratings among the respondents and within the respective participant groups on the barriers to the use of the D&B method are unrelated to each other was rejected at a 0.001 significance level. Thus it can be concluded that there is agreement among the respondents in each of the client, contractor and consultant groups, and also among all D&B participants, on the barriers to the use of the D&B method at a 0.001 significance level. Moreover, the

Table 7.9 Results on the ranking of barriers and 'intra-group' comparisons

Barrier Item	**All respondents**		**Client Group**		**Contractor Group**		**Consultant Group**	
	Mean	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**
D&B contractors carry a high degree of risk and liability	5.40	1	4.71	3	5.77	1	5.50	1
A Contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	4.96	2	4.00	12	5.67	2	4.80	2
It takes more effort to develop the client's requirements for D&B projects	4.78	3	4.67	5	5.00	4	4.70	3
D&B contractors do not have in-house architects and engineers	4.77	4	5.09	1	4.74	5	4.53	4
There is a lack of promotion of D&B within the industry	4.71	5	4.85	2	5.03	3	4.23	11
There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	4.51	6	4.15	10	4.69	6	4.46	6
There is a lack of capable and experienced D&B contractors	4.34	7	4.68	4	4.13	9	4.43	7
There is a restriction on design flexibility in D&B projects	4.28	8	4.00	12	4.31	7	4.50	5
Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	4.16	9	4.14	11	4.31	7	4.07	13
There is a lack of D&B knowledge and experience in Hong Kong	4.12	10	4.24	8	4.00	11	4.20	12
There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	4.08	11	4.52	6	3.69	13	4.34	9
Clients prefer traditional practice to the D&B method	4.08	11	3.81	14	4.08	10	4.30	10
D&B contractors do not have sufficient design management expertise	4.07	13	4.45	7	3.56	15	4.37	8
Clients are not aware of the benefits of the D&B method	3.76	14	3.52	15	3.74	12	3.93	14
There is a negative impact on the image of the design team in the D&B method	3.57	15	4.23	9	3.18	16	3.60	15
Project participants do not have confidence in managing D&B projects successfully	3.41	16	3.19	16	3.56	14	3.40	16

Note: The shaded area represents the top ranks on the major barriers to the D&B method.

coefficients (*W*s) computed for the respective groups of clients, contractors and consultants were higher than that for all respondents, indicating that a higher level of agreement exists within the respondent groups.

(3) <u>Spearman Rank-Order Correlation Coefficient (r_s)</u>

The computed r_s of the client-consultant group was 0.518 at a 0.040 significance level and that of the contractor-consultant group was 0.687 at a 0.003 significance level (Table 7.10 and Appendix J.7).

Table 7.10 Spearman rank correlation test between groups of respondents for D&B barriers

Group	*Client*	*Contractor*	*Consultant*
Client	1.000	0.398	0.518*
Contractor	0.398	1.000	0.687**
Consultant	0.518*	0.687**	1.000

* $P<0.05$ (2-tailed).
** $P<0.01$ (2-tailed).

Thus the null hypothesis that no significant disagreement exists between clients and consultants, and contractors and consultants on the ranking of barriers to the use of the D&B method is accepted. However, the computed r_s of the client-contractor group was 0.398 at $P>0.05$. Thus significant disagreement exists between clients and contractors on the barrier ranking.

In addition to the subjective investigation on contrasting the differences in perceptions of the D&B project participants, the more objective method by statistical analysis was also used. Further to the result on the significant disagreement on the ranking of barriers between clients and contractors, the independent-samples *t*-test was conducted to identify the particular barrier attributes, the results of which are shown in Table 7.11 and attached as Appendix J.8.

Table 7.11 Comparison between clients' and contractors' rankings on the barrier attributes

Number	Barrier Item	T	Significance	Conclusion
1	***A Contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him***	-3.618	##0.001	**Reject Ho**
2	***It takes more effort to develop the client's requirements for D&B projects***	-0.554	0.582	**Not Reject Ho**
3	***There is a lack of capable and experienced D&B contractors***	1.505	0.138	**Not Reject Ho**
4	***There is a negative impact on the image of the design team in the D&B method***	2.693	##0.009	**Reject Ho**
5	***There is a restriction on design flexibility in D&B projects***	-0.697	0.489	**Not Reject Ho**
6	***D&B contractors carry a high degree of risk and liability***	-2.598	#0.012	**Reject Ho**
7	***There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements***	2.371	#0.021	**Reject Ho**
8	***Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients***	-0.268	0.790	**Not Reject Ho**
9	***Clients are not aware of the benefits of the D&B method***	-0.551	0.583	**Not Reject Ho**
10	***Clients prefer traditional practice to the D&B method***	-0.741	0.462	**Not Reject Ho**
11	***Project participants do not have confidence in managing D&B projects successfully***	-0.980	0.332	**Not Reject Ho**
12	***There is a lack of promotion of D&B within the industry***	-0.520	0.606	**Not Reject Ho**
13	***There are inadequate local legal precedents regarding D&B projects to follow in case of disputes***	-1.991	0.051	**Not Reject Ho**
14	***D&B contractors do not have sufficient design management expertise***	1.909	0.061	**Not Reject Ho**
15	***There is a lack of D&B knowledge and experience in Hong Kong***	0.562	0.576	**Not Reject Ho**
16	***D&B contractors do not have in-house architects and engineers***	0.739	0.463	**Not Reject Ho**

#P<0.05 (2-tailed); ##P<0.01 (2-tailed); T = t-statistic; Ho = No difference in mean score.

The independent-samples *t*-test shows that the client-contractor comparisons on the 4 barrier attributes, namely 'a contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him', 'there is a negative impact on the image of the design team in the D&B method', 'D&B contractors carry a high degree of risk and liability', and 'there is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements' were significant at the specified alpha level (P = 0.05 or P = 0.01; i.e., the shaded area). The null hypothesis that there is no difference between the means of the client and the contractor groups on these four problem attributes was rejected at P = 0.05 or P = 0.01. The reasons for these disparities will be discussed in section 7.4.2.2.

7.4.2 Discussion of Results on the Barrier Rankings

(1) <u>Similarities in Rankings</u>

The D&B project participants viewed high contractor risk as the most critical barrier to D&B development, which is undoubtedly unavoidable since the contractor is responsible for design, construction and management of D&B projects once he enters into a contract with the client. This finding agrees with that of Chan (2000) who considered 'excessive contractual risk to contractor' as one main disadvantage of the enhanced D&B method. Since many resources including time, capital and manpower are invested in the preparation of a tender, the contractor will suffer greatly if the contract is not awarded to him, the second ranked barrier. The absence of a sufficiently large D&B organization to house the designers and other consultants may hinder the practice of single-point contact of communication from the contractor, the fourth barrier.

The results show that the three respondent groups generally agree in ranking ‘it takes more effort to develop the client’s requirements for D&B projects’ as important, ‘there is a restriction on design flexibility in D&B projects’ as moderately important and ‘project participants do not have confidence in managing D&B projects successfully’ as less important barriers to D&B development. In fact, it is important to develop a clear brief for a project, which depends on the experience of the client who should be mindful so as to prevent claims from the contractor. Akintoye (1994) considered ‘difficulty in defining client’s requirements’ as one main reason for the future decline in the procurement of private sector civil engineering and refurbishment projects using the D&B method. In the survey by Ndekugri and Turner (1994), the client even commented that the reaping of the benefits of D&B depended on the clarity of the brief, which places further pressure on the client. However, the consultant respondents in the study of Chan and Yung (2000) claimed that few client organizations in Hong Kong are able to adequately and comprehensively design what they want, in a clear and precise manner at the outset of a contract. Ideally, D&B should enable the contractor to develop design with flexibilities in order to come up with alternative proposals. This correlates with Akintoye’s survey (1994) on contractors who agreed that clients should give contractors a free hand in terms of design ideas and material specifications. Project participants in the Hong Kong construction industry are experienced in tackling construction projects, which makes them confident enough to manage D&B projects so long as they are given the opportunity to tender for projects under such an alternative procurement system.

(2) <u>Differences in Rankings between Clients and Contractors</u>

The contractors ranked 'a contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him' and 'D&B contractors carry a high degree of risk and liability' as the most important barriers whereas the clients ranked them only moderately important. In fact, a contractor may invest huge resources in a D&B project and may suffer a loss if his tender is unsuccessful. High financial loss will be incurred if a D&B tender is unsuccessful. For a contractor, the preparation of a D&B tender is costly since he has to employ a whole team of consultants to prepare his bid (Chan et al., 2000). D&B has been considered a 'risk transfer' system where the contractor is required to bear the huge risks involved in designing, constructing and managing the project. Ndekugri and Turner (1994) claimed that D&B contractors are required to take on responsibility for design and are liable for design faults. Akintoye (1994) also considered 'difficulty in the apportionment of the risk involved' as one main reason for the future decline in the procurement of private sector civil engineering and refurbishment projects using the D&B method. The risk borne by the contractor is relatively high from the single point of responsibility and the engagement of independent checking has created a lot of confusion since the responsibility for checking has not been well defined (Chan, 2000; Chan and Yung, 2000). While the clients considered 'there is a negative impact on the image of the design team in the D&B method' and 'there is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements' as moderately important, the contractor considered them unimportant. In fact, the clients' views correlate with the discussion of Ndekugri and Turner (1994) who even claimed that the professions were hostile to the D&B concept. The D&B method requires the design team to do the design work and their expertise is still important and earns respect. Moreover, the contract sum for a D&B project should be large enough to cover the risks involved in the project and the client should prepare sufficient funding and provide appropriate contractual arrangements to safeguard their interests in case a dispute arises.

Similar to the results on the problem ranking, there is no significant disagreement between clients and consultants nor between contractors and consultants on the ranking of barriers to the D&B development. The consultants are employed by the client under the traditional method. As D&B can bring considerable benefits to the project initiator, the consultants may keep the best interest of the client in project delivery. In practice, the consultants may bear similar risks as those of the contractor and so the two parties may have similar attitudes to developing D&B.

Similarly, significant disagreement exists between clients and contractors on the ranking exercise (Table 7.10). As indicated in most literature, clients can transfer most of the risks to other parties under D&B system. On the contrary, the contractors are the party to absorb virtually all the risks and liabilities under this system (Harris, 1999). It is understandable why these two parties have divided views. In any competitive tendering exercise, there is only one winning contractor. Other contractors who fail to win the contract will suffer greatly in preparing the bid at their own expense (Tao, 1996). Without compensation from the client to cover the losses, the contractor may be hesitant to bid for D&B projects. As for clients, D&B projects place a heavy burden on them to define their brief clearly and precisely at an early stage. This will force clients to commit to the contractual and financial arrangements much sooner (Deakin, 1999; Works Bureau, 1999). These are just some pragmatic examples to illustrate why the client group and the contractor group have different views to barriers of applying D&B system in Hong Kong.

7.5 CHAPTER SUMMARY

The chapter reported on the analyses of the Stage 1 investigation. Design-build has been mostly adopted in public-sector projects, and there is no significant disagreement among the three major stakeholders on the reason ranking. Despite the benefits of D&B, its development is still at the germination stage in Hong Kong and its use is limited by a number of inhibitors. Significant disagreement exists between the client and the contractor on the ranking of problems of running D&B projects and of the barriers to D&B development. In order to enhance the successful delivery of D&B projects, the Stage 2 investigation placed more emphasis on determining the critical success factors for D&B projects.

CHAPTER 8 SUCCESS CRITERIA AND FACTORS FOR DESIGN-BUILD PROJECTS IN THE PUBLIC SECTOR OF HONG KONG

8.1 INTRODUCTION

The global use of the D&B method has aroused the interest of practitioners in defining the factors necessary for the success of D&B projects. The determination of critical factors can further enhance the success of project performance. The Stage 2 investigation aims at developing a conceptual model of success for D&B projects in the public sector of Hong Kong. This chapter firstly identifies the criteria of success for D&B projects from the empirical results obtained by the D&B project participants in the Hong Kong construction industry. To better indicate the success level of D&B projects, a Project Success Index for D&B projects (PSI-D&B) was developed with the use of principal components analysis, and the results of the PSI-D&B in Hong Kong are presented and discussed. The success factors identified in the literature are also classified into factor categories of the 92 responses by factor analysis for further investigation of the relationships between the success criteria and critical success factors of D&B projects.

8.1.1 Data Matrix

Section 11 of the research questionnaire provided 11 success criterion attributes. The respondents were asked to rate each attribute for the construct of success criteria on a seven-point Likert scale to indicate the level of importance, ranging from ‘1’ equal to 'Highly Unimportant' to '7' equal to 'Highly Important'. The data were input into SPSS and SAS for statistical analysis.

The measurement reliability of the questionnaire was evaluated by Cronbach's alpha coefficients to investigate the internal consistency among the attributes for the success criterion construct on the Likert scale. The results of the 92 responses are summarized in Table 8.1 and attached as Appendix K.1. The coefficient obtained is larger than the acceptable threshold (0.7), indicating a high degree of reliability.

Table 8.1 Measurement reliability of the construct of D&B success criteria

Construct	**Cronbach's alpha coefficients**
Success criteria for D&B projects (11 items)	0.84 (> 0.7)

8.2 SUCCESS CRITERIA FOR DESIGN-BUILD PROJECTS IN HONG KONG

The mean values of the 11 success criteria were then determined to indicate the degree of importance of the project success criteria for D&B projects from the perspectives of client, contractor and consultant. The results of the 92 responses are shown in Table 8.2 and attached as Appendix K.2.

Table 8.2 Mean values of success criteria for D&B projects

Rank	Criteria	Mean
1	Time	6.09
2	Cost	6.04
3	Quality	5.86
4	Functionality	5.92
5	Low accident rate	5.49
6	Minimal claims and disputes	5.38
7	Environmental consciousness	5.21
8	Aesthetic purpose	4.97
9	Learning value	4.60
10	Expectations of project participants	5.12
11	Professional image	4.85

Note: The shaded area represents the success criteria for D&B projects.

The seven-point Likert scale measured the perceptions of the D&B project participants on the relative importance of indicators of D&B project success. The criteria which scored ‘6’ or above were considered ‘important’ or ‘highly important’ by the D&B project participants as success criteria for D&B projects. Previous researchers, such as Songer and Molenaar (1996; 1997), and Chan (2000), considered quality and functionality as important indicators of D&B project success. Cheng (2001) and Chan et al. (2004a) represented the level of critical importance by a score of ‘4’ on a five-point Likert scale in their partnering studies, a common threshold in most construction research. The pro-rata technique gives a score of ‘5.6’ on a seven-point Likert scale as the equivalent of the score ‘4’ on a five-point Likert scale in representing the level of importance. Therefore, a score of ‘5.5’ or above is taken as the cut-off point for determining the important success criteria for D&B projects in the current study. The success criteria for D&B projects in Hong Kong, namely time, cost, quality and functionality, were developed from the literature and reinforced by empirical findings.

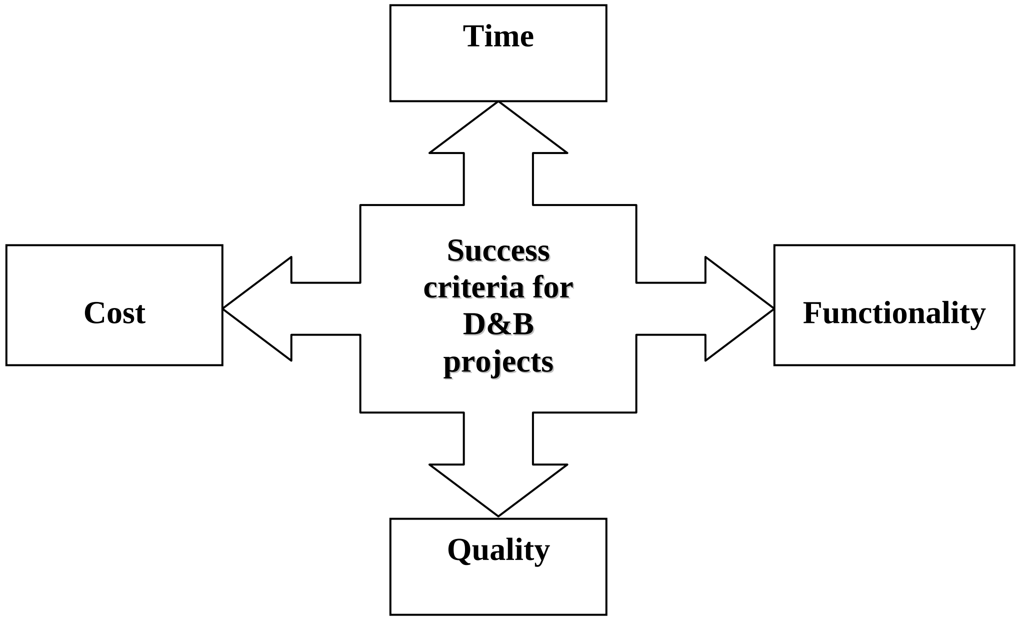


Fig. 8.1 Success criteria for D&B projects

8.3 DETERMINATION OF PROJECT SUCCESS INDEX FOR DESIGN-BUILD PROJECTS

Project success is an abstract term which means different things to different people. Therefore, the computation of an index can help in comparing the degree of success among different D&B projects. The technique of principal components analysis was applied to form new variables (indices) which are linear composites of the original variables (success criteria).

8.3.1 Principal Components Analysis

Principal components analysis forms new variables with principal component scores. Each new variable is a linear combination of the original variables, and the first new variable accounts for the maximum variance in the data (Sharma, 1996). The D&B project participants perceived that the success of D&B projects can be measured by time, cost, quality and functionality, which were identified as the variables to form the principal components scores. The results of the SAS analysis are summarized in Table 8.3 and attached as Appendix K.3.

Table 8.3 Principal components analysis of success criteria for D&B projects

Order	Item	Criteria	Eigenvectors	Eigenvalues
1st	**A**	***Time***	0.54	
	B	***Cost***	0.55	
	C	***Quality***	0.47	
	D	***Functionality***	0.42	2.19
2nd	**A**	***Time***	-0.48	
	B	***Cost***	-0.39	
	C	***Quality***	0.39	
	D	***Functionality***	0.69	0.84
3rd	**A**	***Time***	0.07	
	B	***Cost***	0.16	
	C	***Quality***	-0.79	
	D	***Functionality***	0.59	0.61
4th	**A**	***Time***	0.69	
	B	***Cost***	-0.72	
	C	***Quality***	-0.02	
	D	***Functionality***	0.08	0.36

The Eigenvalue-greater-than-one rule states that only those variables whose Eigenvalues are greater than one are retained; as a result, only the 1st order was retained. The Eigenvectors give the weights that are used in forming the following project success equation for D&B projects (PSI-D&B):

PSI-D&B = 0.54 Time + 0.55 Cost + 0.47 Quality + 0.42 Functionality

………… ***Equation 8.1***

and the sum of the squared weights of each principal component is one, i.e.,

$$0.54^2 + 0.55^2 + 0.47^2 + 0.42^2 = 1$$

(From ***Equation 7.5***)

Table 8.4 demonstrates the loadings and coefficients of the success criteria in the equation for PSI-D&B.

Table 8.4 Loadings and coefficients of success criteria in PSI-D&B equation

Success criteria	***Time***	***Cost***	***Quality***	***Functionality***
Loadings	0.797	0.819	0.703	0.626
Coefficients	0.54	0.55	0.47	0.42

In fact, the higher the loading of a variable, the more influential the variable is in forming the project success index for D&B projects. All the loadings are greater than the cut-off point of 0.5, indicating that the criteria are all influential in forming the project success index for D&B projects. Moreover, the magnitudes of the coefficients agree with those of the loadings. Therefore, the strengths of the four criteria affecting the overall success of a D&B project can be represented by their corresponding coefficients. Time and cost were shown to be indicators of success by the empirical study of the D&B project participants as well as by previous researchers. Moreover, D&B offers reduction in project time from the overlapping of design and construction, and better “value-for-money” option through the selection of alternative design proposals. Therefore, the performance of time and cost of a D&B project can significantly affect the overall success level as represented by the project success index, PSI-D&B.

8.3.2 Project Success Indices for Design-Build Projects in Hong Kong

It is obvious that project participants of the research would be satisfied with the performance of time, cost, quality and functionality if the respective performance of the D&B project is good. Section 12 was formulated with the purpose of collecting the perceptions of D&B project participants on their satisfaction levels for the performance of the success criteria of the D&B projects. The respondents were asked to rate each attribute for the construct of satisfaction with performance on a seven-point Likert scale to indicate the level of satisfaction, ranging from ‘1’ equal to ‘Very Low’ to ‘7’ equal to ‘Very High’. The data were input into SPSS, and statistical techniques were employed to analyze the data.

The measurement reliability of the questionnaire was evaluated by Cronbach’s alpha coefficients to investigate the internal consistency among the attributes for the construct of the perceptions of D&B project participants on project performance on the Likert scale. The results are summarized in Table 8.5 and attached as Appendix K.4. The coefficient obtained is larger than the acceptable threshold of 0.7, indicating a high degree of reliability.

Table 8.5 Measurement reliability of the construct of satisfaction level

Construct	Cronbach's alpha coefficients
Satisfaction level with the performance of D&B projects (12 items)	0.897(> 0.7)

The PSI-D&B provides an indicator for comparing the success level of D&B projects and sets a benchmark for quantifying the successful performance of a D&B project. While the performance of D&B projects can be measured objectively in terms of hard data, the perceptions of D&B project participants concerning project performance can be quantified by the PSI-D&B. Table 8.6 presents the PSI-D&B scores of 40 D&B projects in Hong Kong.

Table 8.6 PSI-D&B scores for 40 D&B projects

Project	PSI-D&B	Project	PSI-D&B	Project	PSI-D&B	Project	PSI-D&B
1	9.52	11	10.91	21	13.39	31	10.63
2	9.32	12	11.88	22	8.25	32	8.11
3	10.25	13	7.20	23	12.37	33	10.52
4	8.85	14	8.82	24	8.58	34	10.69
5	11.49	15	8.68	25	3.24	35	8.24
6	11.40	16	8.90	26	7.59	36	11.65
7	10.83	17	8.90	27	8.05	37	11.88
8	10.31	18	9.99	28	6.96	38	12.97
9	9.78	19	10.02	29	12.77	39	10.76
10	10.99	20	10.20	30	11.41	40	8.81

The respondents assessed the performance of their D&B projects in terms of time, cost, quality and functionality, and the PSI-D&B scores were calculated using Equation 8.1. A score of '1' was given to each of the four criteria in the equation if the respondent was not at all satisfied with the performance of the D&B project. Consequently, the smallest possible value of the PSI-D&B is 1.98 (in the event that each criterion scores '1') while the largest possible value is 13.86 (in the event that each criterion scores ‘7’). Therefore, Project 21 was the most successful, as it has the highest PSI-D&B score. The data used for the calculation of the PSI-D&B for D&B projects in Hong Kong are attached as Appendix K.5.

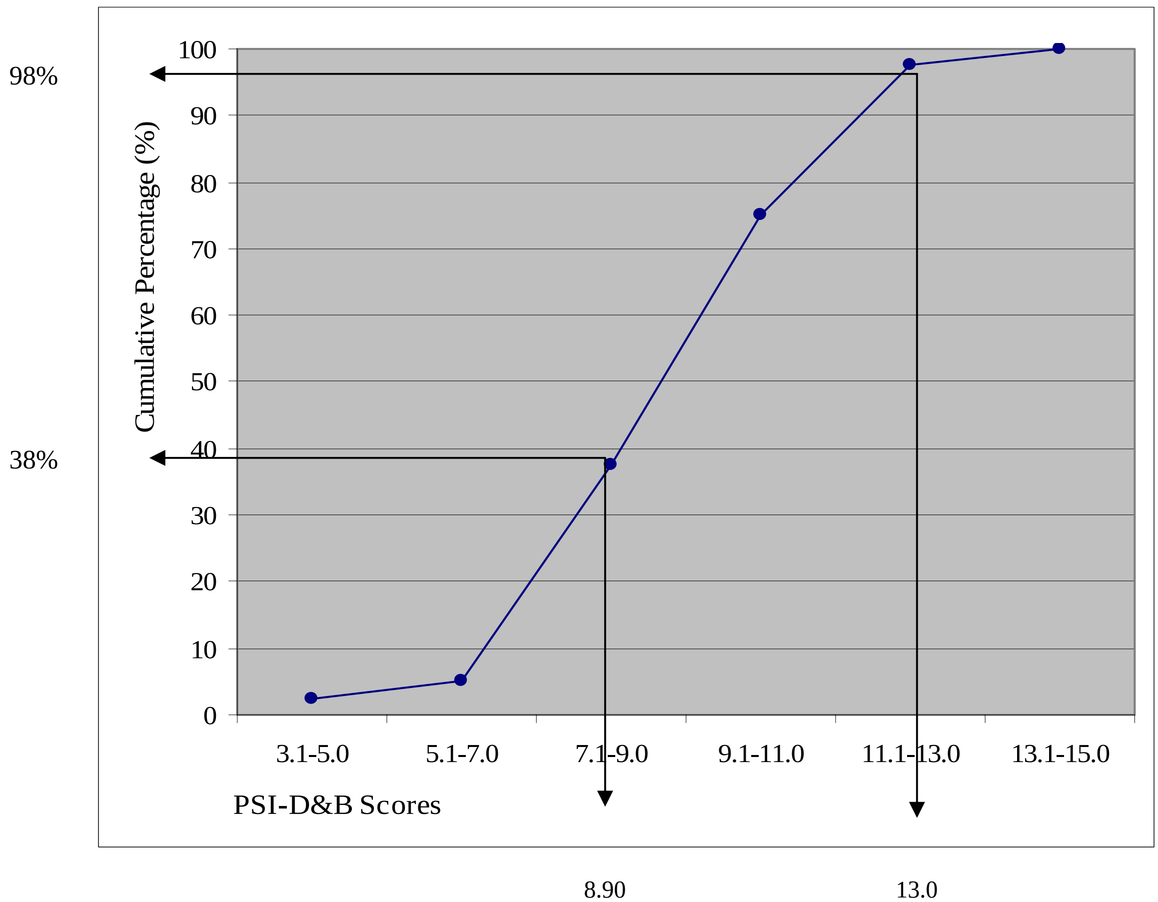


Fig. 8.2 Cumulative frequency distribution of PSI-D&B scores

Fig. 8.2 shows the cumulative percentage of PSI-D&B values for the D&B projects. The mean value is 9.88 and the median is 10.11. The percentiles can make project participants aware of how their projects score in relation to the average D&B projects. For instance, a project success index of 8.9 for a D&B project indicates that only 38% of the D&B projects scored below this figure, signifying that the performance of the project is not satisfactory. By contrast, a PSI-D&B score of 13 would indicate that the performance of a D&B project is highly satisfactory, with 98% of all the surveyed D&B projects scoring below this figure. In this manner, the performance of D&B projects can be compared for benchmarking purposes.

A D&B project can be a success or failure, a result which is determined by a number of factors. Therefore, the identification of the critical success factors should enhance the performance of D&B projects.

8.4 SUCCESS FACTORS FOR DESIGN-BUILD PROJECTS

Project success can be attributed to a number of factors. A comprehensive literature survey identified the factor variables which are related to the success level of a D&B project, and it should help in establishing the framework of success factors for D&B projects.

8.4.1 Data Matrix

Sections 4 – 9 of the research questionnaire presented the variables under the six factor categories which were defined from the literature. The respondents were asked to rate each attribute for the construct of success factors on a seven-point Likert scale and the data were input into SPSS for analysis. In the questionnaire, sections 4.1, 5.1, 5.2, 5.4, 5.5 and 7.1 asked for project and client information, and the remaining 98 factor variables were further examined to delete repetitive elements and combine similar items by taking the average of the scores (Appendix L.1). In fact, more than one question has been designed to measure the same attribute to reduce the chances of 'halo effect', which arises when the impression formed in one question caries into the next question (Kendall and Kendall 1999). Ultimately, 42 factor variables were established for factor analysis. The list of 42 factor variables and their corresponding labels is shown in Table 8.7 and attached as Appendix L.2.

Table 8.7 List of factor variables

Variable	Label
ctrskill	Contractor's input to the project
prjcompl	Complexity of the project
scopprjt	Scope of the project
cltreqrt	Clarity of client's requirements
prjattrc	Attractiveness of the project
inmgtaph	Adoption of innovative management approaches
phyenvir	Physical environment
econenvr	Economic environment
govtsupt	Political environment
soclsupt	Social environment
clttimeo	Client's emphasis on time
cltcosto	Client's emphasis on cost
clttrsrk	Client's emphasis on transfer of risk
cltsptrp	Client's emphasis on single point of responsibility
cltbrfdt	Client's ability to brief the design team
cltprdmk	Decision-making power of client
cltinvpj	Client's involvement in the project
clttcski	Technical skills of client's representative
cltpmski	Project management skills of client's representative
cltexpcp	Experience and capabilities of client's representative
cltcomad	Commitment and adaptability of client's representative
cottcski	Technical skills of contractor's design consultants

cotpmski	Project management skills of contractor's design consultants
cotexpcp	Experience and capabilities of contractor's design consultants
cotcomad	Commitment and adaptability of contractor's design consultants
cotsuppc	Support from the parent company of contractor's design consultants
ctrtcski	Technical skills of the construction team leader
ctrpmski	Project management skills of the construction team leader
ctrexpcp	Experience and capabilities of the construction team leader
ctrcomad	Commitment and adaptability of the construction team leader
ctrsuppc	Support from the parent company of the construction team leader
endstreq	End users' involvement in the design-build process
commwppt	Effectiveness of communication
pmufplng	Up-front planning efforts
pmctrsys	Effectiveness of control systems
pjmgtsys	Effectiveness of management systems
pmorgstr	Effectiveness of organizational structure
cltddeci	Delegation of decision-making authority from the client
ctrddeci	Delegation of decision-making authority from the construction team leader
cfdlvctr	Confidence level of the construction team leader
chigdbtm	Cohesiveness of the D&B team
dbtmwkat	Harmonious working relationships among project team members

The measurement reliability of the questionnaire was evaluated by Cronbach's alpha coefficients to investigate the internal consistency among the attributes for the construct of success factors on the Likert scale. The results are summarized in Table 8.8 and attached as Appendix L.3. The coefficient obtained is larger than the acceptable threshold of 0.7, indicating a high degree of reliability.

Table 8.8 Measurement reliability of the construct of success factors

Construct	Cronbach's alpha coefficients
Success factors of the D&B projects (42 items)	0.899 (>0.7)

8.5 FACTOR ANALYSIS

As there was a possibility that the 42 factor variables identified in the previous section were interrelated, factor analysis was employed to analyze the structure of interrelationships among the large number of variables by defining a set of common underlying factors (Hair et al., 1998). It can also be adopted in a regression model to predict results based on factor scores (SPSS, 1997). Factor analysis assumes that the observable variables are linear combinations of some underlying factors and it is used as a data reduction method for the independent variables (Kim and Mueller, 1978).

8.5.1 Extracting The Factors

Factor analysis is conducted through a two-stage process, factor extraction and factor rotation (Norusis, 1993). The goal of factor extraction is to determine the factors through principal components analysis. The linear combinations of the observed variables are then formed, and the first principal component is the combination that accounts for the largest amount of variance in the sample. Successive components explain progressively smaller portions of the total sample variance, and all are uncorrelated with each other. The goal of the second stage, factor rotation, is to make the factors more interpretable. The results of the factor analysis of the 42 independent variables are shown in Table 8.9 and attached as Appendix L.4.

Table 8.9 Variances explained by the success factor variables

Component	Eigenvalue	Percentage of variance explained	Cumulative percent of variance explained
1	11.03	26.27	26.27
2	3.96	9.43	35.70
3	3.39	8.06	43.76
4	2.82	6.71	50.47
5	2.34	5.58	56.05
6	2.02	4.82	60.87
7	1.82	4.34	65.21
8	1.41	3.36	68.57
9	1.39	3.31	71.88
10	1.24	2.95	74.82
11	1.10	2.61	77.44
12	1.01	2.41	79.85
13	0.89	2.11	81.96
14	0.82	1.95	83.91
15	0.79	1.89	85.80
16	0.68	1.62	87.41
17	0.59	1.41	88.82
18	0.57	1.35	90.18
19	0.46	1.10	91.28
20	0.45	1.07	92.35
21	0.37	0.88	93.24
22	0.32	0.76	94.00
23	0.28	0.66	94.66
24	0.27	0.64	95.30
25	0.25	0.59	95.88
26	0.24	0.58	96.46
27	0.20	0.48	96.94
28	0.18	0.42	97.36
29	0.17	0.41	97.77
30	0.16	0.38	98.15
31	0.14	0.3	98.48
32	0.11	0.26	98.74
33	0.10	0.23	98.97
34	0.08	0.19	99.16
35	0.08	0.18	99.34
36	0.06	0.15	99.49
37	0.06	0.14	99.63
38	0.05	0.12	99.75
39	0.04	0.09	99.83
40	0.03	0.08	99.91
41	0.02	0.06	99.97
42	0.01	0.03	100.00

The Eigenvalue represents the total variance explained by each factor. For instance, the linear combination formed by component 1 has a variance of 11.03, which accounts for 26.27% of the total variance of the 42 factor variables. To determine the appropriateness of factor analysis, the Barlett's test of sphericity was carried out for the presence of correlations among the variables. It tests the hypothesis that the correlation matrix is an identity matrix, which means that there is no relationship among the items (Pett et al., 2003). The value of the test statistic for sphericity should be large and the associated significance level should be small in order to suggest that the population correlation matrix is not an identity matrix (SPSS, 1997). Therefore, factor analysis is suitable since the value of the Barlett's test of sphericity is large at a 0.001 significance level (Table 8.10).

Table 8.10 KMO and Bartlett's test on the 42 success factor variables

Barlett's test of sphericity	*2292
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy	0.635

* $P<0.001$

A second indicator of the strength of the relationship among items is the partial correlation coefficient. The Kaiser-Meyer-Olkin test (KMO) is a measure of sampling adequacy that compares the magnitudes of the partial correlation coefficients. It can range between 0 and 1, and small values for the KMO measure indicate that a factor analysis of the variables may not be suitable (Norusis, 1993). Kaiser (1974) recommended KMO values of greater than 0.5 as acceptable (Table 8.11).

Table 8.11 Acceptable level of KMO value

KMO value	Degree of common variance
0.90 – 1.00	Marvelous
0.80 – 0.89	Meritorious
0.70 – 0.79	Middling
0.60 – 0.69	Mediocre
0.50 – 0.59	Miserable
0.00 – 0.49	Don’t factor

The KMO value as indicated in Table 8.10 is 0.635, which is considered acceptable for factor analysis (Norusis, 1993).

Several procedures have been proposed for determining the number of factors for further analysis. Hair et al. (1998) and Cheung et al. (2000) reported that only factors with Eigenvalues greater than 1 are considered significant. Moreover, the factor extraction process should be terminated when a threshold for maximum variance extracted (e.g., 75-80%) has been achieved. Table 8.9 shows that almost 80% of the total variance is attributable to the first twelve factors. Therefore, a model with twelve factors is considered adequate to represent the data. The scree test can also be used to identify the optimum number of factors that can be extracted before the amount of unique variance begins to dominate the common variance structure. Fig. 8.3 shows the scree plot of the factor variables.

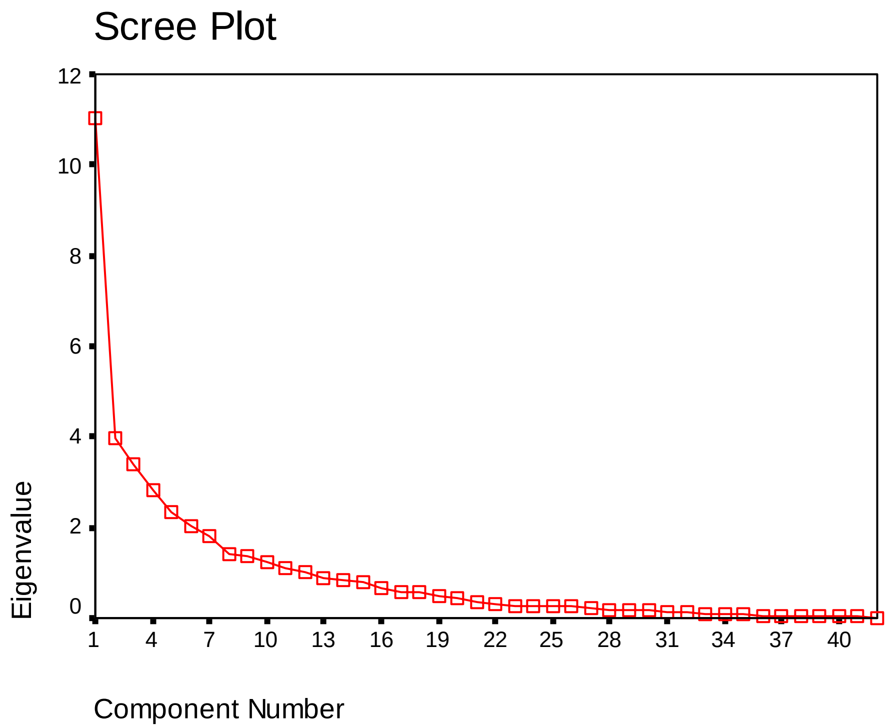


Fig. 8.3 Scree plot of the success factor variables

The scree test is derived by plotting the Eigenvalues against the number of factors in their order of extraction, and the shape of the resulting curve is used to evaluate the cut-off point. The point at which the curve first begins to straighten out is considered to indicate the maximum number of factors to extract, and Fig. 8.3 demonstrates that the curve begins to level off at factor 12.

8.5.2 Interpreting The Factors

The unrotated principal component analysis indicates only the relationship between individual factors and the variables, and it is sometimes difficult to interpret the pattern (SPSS, 1997). To identify the factors, it is necessary to group the variables that have large loadings for the same factors (Norusis, 1993). Moreover, the grouping of variables is based on their factor loadings, which indicate the degree of association of a variable with the factor (Ofori and Chan, 2001). Therefore, a variable which appears to have the highest loading in one factor belongs to that factor, and Trost and Oberlender (2003) suggest that the value of factor loading should fall between 0.4 and 0.9. In factor analysis, a factor is named by examining the largest values linking the factor to the measured variables in the rotated factor matrix, and the final number of factors is based on the rotated solution that is most interpretable (Green and Salkind, 2003). The oblique rotation, Promax, was adopted, and was found to yield substantively meaningful factors (Norusis, 1993). Table 8.12 shows the factor loadings of the variables, which are larger than 0.5 and hence should all be included (Pett, 2003).

Table 8.12 Factor loadings of the success factor variables

Factor	Success factor label	Factor loading	Percentage of variance explained	Cumulative percent of variance explained
F1	Project management skills of client's representative	0.807		
	Client's involvement in the project	0.802		
	End users' involvement in the design-build process	0.788		
	Commitment and adaptability of client's representative	0.771		
	Decision-making power of client	0.762		
	Delegation of decision-making authority from the client	0.760		
	Experience and capabilities of client's representative	0.680		
	Technical skills of client's representative	0.667	26.268	26.268

Table 8.12 Factor loadings of the success factor variables (Cont'd)

F2	Project management skills of the construction team leader	0.937		
	Experience and capabilities of the construction team leader	0.910		
	Commitment and adaptability of the construction team leader	0.871		
	Technical skills of the construction team leader	0.853		
	Support from the parent company of the construction team leader	0.677	9.434	35.702
F3	Up-front planning efforts	0.805		
	Effectiveness of communication	0.796		
	Effectiveness of control systems	0.791		
	Effectiveness of management systems	0.781		
	Effectiveness of organizational structure	0.726	8.059	43.761
F4	Experience and capabilities of contractor's design consultants	0.870		
	Technical skills of contractor's design consultants	0.846		
	Commitment and adaptability of contractor's design consultants	0.828		
	Project management skills of contractor's design consultants	0.767		
	Support from the parent company of contractor's design consultants	0.623	6.707	50.468
F5	Harmonious working relationships among project team members	0.831		
	Confidence level of the construction team leader	0.827		
	Cohesiveness of the D&B team	0.813		
	Delegation of decision-making authority from the construction team leader	0.753	5.581	56.050
F6	Scope of the project	0.692		
	Client's ability to brief the design team	0.655		
	Clarity of client's requirements	0.626	4.818	60.868
F7	Contractor's input to the project	0.792		
	Attractiveness of the project	0.770		
	Complexity of the project	0.619	4.340	65.208
F8	Client's emphasis on time	0.826		
	Client's emphasis on cost	0.649		
	Political environment	0.583	3.361	68.569

Table 8.12 Factor loadings of the success factor variables (Cont'd)

F9	Adoption of innovative management approaches	0.836	3.308	71.877
F10	Client's emphasis on single point of responsibility	0.721		
	Client's emphasis on transfer of risk	0.581	2.947	74.824
F11	Physical environment	0.738		
	Social environment	0.604	2.611	77.435
F12	Economic environment	0.729	2.414	79.849

8.6 FACTORS OF SUCCESS FOR DESIGN-BUILD PROJECTS

In fact, factor analysis does not attach labels to the factors and the substantive meaning given to a factor is typically based on the examination of what the high loading variables measure (Kim and Mueller, 1978). The principal components analysis with Promax rotation on the 42 success factor variables produced twelve factor categories, which are labeled and described below.

8.6.1 Factor 1 (F1) – Competency of Client Body (CPC_CLT)

This factor describes the effectiveness of the client and its representative in the D&B project. It is concerned with the technical and project management skills of the client's representative, the client's involvement in the project, the commitment and adaptability of the client's representative, the decision-making power of the client, the delegation of decision-making authority from the client, and the experience and capabilities of the client's representative. In some D&B projects, the end-user is the same as the client and the end user's involvement in the design-build process is also included in the factor. As all factor variables are related to the competency of the client or its representatives, it is labeled as "Competency of Client Body".

8.6.2 Factor 2 (F2) – Competency of Construction Team Leader (CPC_CTR)

This factor describes the effectiveness of the construction team leader. It includes the technical and project management skills of the construction team leader, the experience and capabilities of the construction team leader, the commitment and adaptability of the construction team leader and support from the parent company of the construction team leader. Since all these variables are related to the competency of the construction team leader, this factor is labeled as "Competency of Construction Team Leader".

8.6.3 Factor 3 (F3) – Effectiveness of Project Management Action (EFF_PMA)

This factor demonstrates the various project management strategies adopted in a D&B project. It comprises up-front planning efforts, and the effectiveness of various management strategies, including communication, control systems, management systems and organizational structure. This factor is therefore labeled as "Effectiveness of Project Management Action".

8.6.4 Factor 4 (F4) – Competency of Contractor's Design Consultants (CPC_COT)

This factor describes the effectiveness of the contractor's consultants. It includes the experience and capabilities of the contractor's design consultants, the technical and project management skills of the contractor's design consultants, the commitment and adaptability of the contractor's design consultants, and support from the parent company of the contractor's design consultants. As all factor variables are related to the competency of the contractor's design consultants, it is labeled as "Competency of Contractor's Design Consultants".

8.6.5 Factor 5 (F5) – Working Relationships among Project Team Members (WKR_MBR)

This factor summarizes the effects of the working relationships among project team members. It is represented by the harmonious working relationships among project team members and the cohesiveness of the D&B team. As the contractor is the project leader in a D&B project, the confidence level of the construction team leader and the delegation of decision-making authority from the construction team leader may also affect the working environment of the project team and are therefore included in the factor. All factor variables have effects on the working atmosphere in a D&B project and so this factor is labeled as "Working Relationships among Project Team Members".

8.6.6 Factor 6 (F6) – Client's Input in the Project (CLT_INT)

This factor contains three factor variables, namely scope of the project, client's ability to brief the design team and clarity of client's requirements. It concerns the client's ability to brief the design team members and the clarity of the client's requirements in the scope of the project. Since all factor variables rely on the client's input, it is labeled as "Client's Input in the Project".

8.6.7 Factor 7 (F7) – Project Attractiveness (PJT_ATR)

This factor describes the features of the D&B project for contractor's input. It also describes the flexibility and complexity of the D&B project. As all factor variables describe the project features, this factor is labeled as "Project Attractiveness".

8.6.8 Factor 8 (F8) – Client's Emphasis on Time and Cost (CLT_T&C)

This factor describes the emphasis of the client on the objectives of time and cost. Since the factor loading of the political environment is relatively lower than the factor loadings of the other two factor variables, this factor is labeled as "Client's Emphasis on Time and Cost".

8.6.9 Factor 9 (F9) – Application of Innovative Management Approaches (APP_IMA)

This factor represents a single variable, which concerns the adoption of innovative management approaches, such as value management and partnering. Hence, it is labeled as "Application of Innovative Management Approaches".

8.6.10 Factor 10 (F10) – Client's Emphasis on Risk Transfer (CLT_RTR)

This factor summarizes the risk attitude of the client on the single point of responsibility and the transfer of risk. Most clients make use of the single point of responsibility to transfer risks in D&B projects and so this factor is labeled as "Client's Emphasis on Risk Transfer".

8.6.11 Factor 11 (F11) – Physical and Social Environments (P&S_ENV)

This factor describes the effects of the two factor variables, namely external physical and social environments with similar factor loadings. Therefore, it is labeled as "Physical and Social Environments".

8.6.12 Factor 12 (F12) – Economic Environment (ECO_ENV)

This factor is represented by a single variable, the economic environment under which the D&B project is delivered. Hence, it is labeled as "Economic Environment".

8.7 REVISED MODEL FOR THE RESEARCH

The literature review provided the frameworks of success criteria and factors, which have been described in previous chapters. The frameworks were further modified by statistical analysis of the empirical data from D&B project participants in the Hong Kong construction industry. Based on the literature study and the empirical survey, the success of a D&B project can be measured using four main criteria, which may be affected by the twelve factor categories (Fig. 8.4).

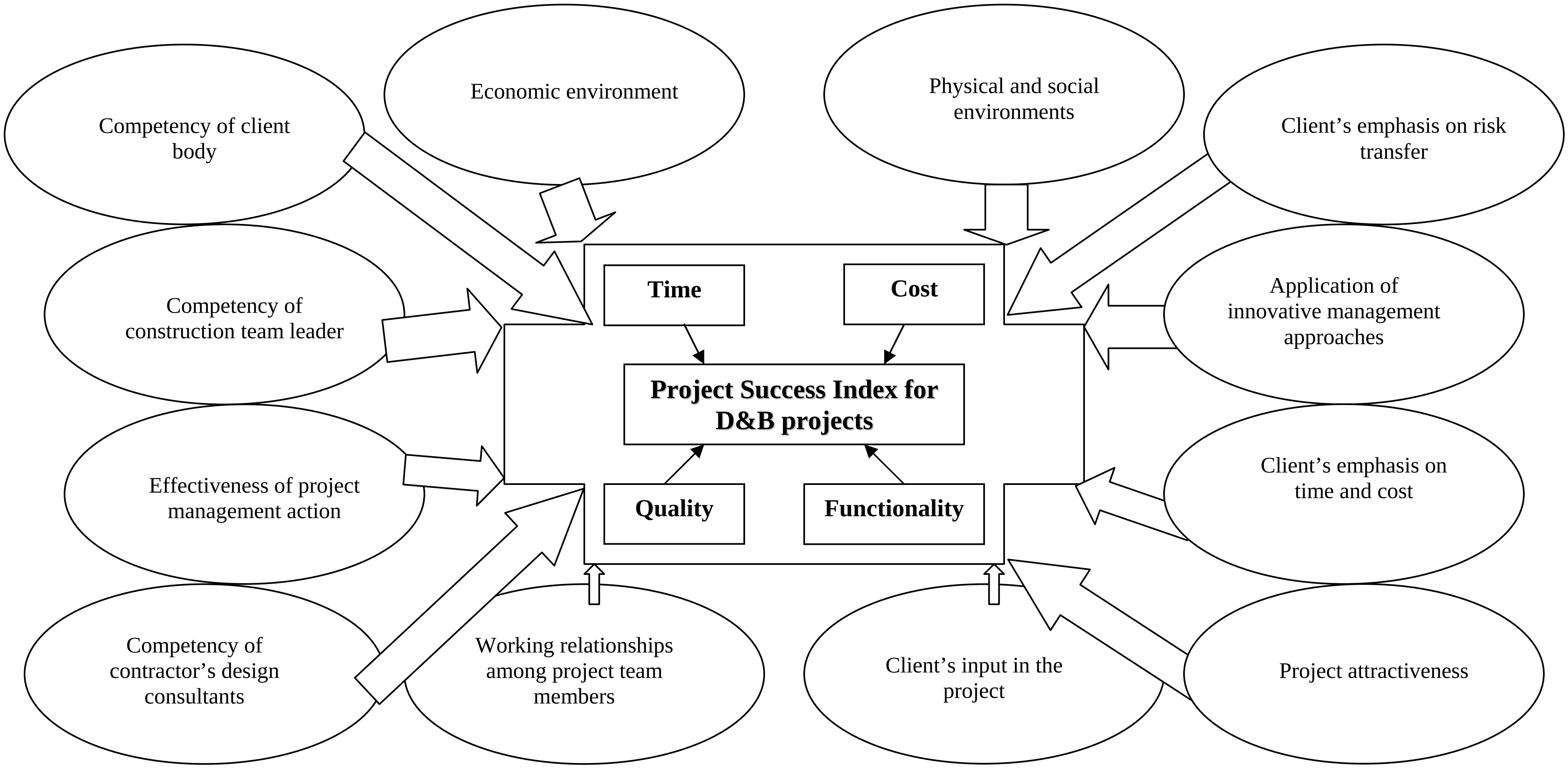


Fig. 8.4 Revised research model

8.8 CHAPTER SUMMARY

Project success is an abstract concept, and the identification of success criteria and factors enables project performance to be improved. This chapter stated the success criteria of D&B projects in terms of time, cost, quality and functionality, and it quantified the success concept by establishing the project success index for D&B projects using the perceptions of D&B project participants. The success variables developed from the literature were re-grouped into twelve factor categories by statistical analysis of the 92 responses. To enhance success for D&B projects, there is a need to establish a model to investigate the relationship between the success criteria and factors, which are demonstrated and discussed in Chapter 9.

CHAPTER 9 CRITICAL SUCCESS FACTORS FOR DESIGN-BUILD PROJECTS IN THE PUBLIC SECTOR OF HONG KONG

9.1 INTRODUCTION

Achieving success in a construction project is an important goal of project participants. While the success criteria and the contributing factors have been identified in the previous chapters, an investigation into the causal relationships between the factors and the criteria can further enhance the success level of a D&B project. Identification of critical success factors in delivering D&B projects can even improve both project performance and D&B team management strategies. This chapter establishes the relationships between the dependent variables (success criteria) and independent variables (success factors) in delivering D&B projects by regression analysis. The results of the analyses will be presented and discussed for the success criteria determined in the research. The order of significance of the critical success factors will also be indicated based on their frequency of occurrence in the analysis so as to complete the Stage 2 investigation on developing a conceptual model of success for D&B projects in Hong Kong.

9.1.1 Data Matrix

Sections 12 and 13 of the research questionnaire measured the performance of a D&B project from the perspectives of D&B project participants and the estimated data collected from the project respectively. Chan et al. (2000) claimed that project participants would be satisfied if the performance of the success criteria for a project was good. While the research aims at developing a conceptual model based on the perceptions of the D&B project participants, the responses collected from Section 12 on the level of satisfaction can reflect the perceptual opinions of the respondents to represent the performance of a D&B project. The respondents were asked to rate each attribute on a seven-point Likert scale to indicate the level of satisfaction on project performance between '1', or 'Very Low', and '7', 'Very High'. The data were input into SPSS and statistical techniques were employed to analyze the data.

9.2 MULTIPLE REGRESSION ANALYSIS

Multiple regression analysis is a statistical technique used to analyze the relationship between a single dependent variable (criterion) and several independent variables (success factors). It describes the process of constructing a mathematical expression or equation used to represent the behaviour of the phenomenon being studied (Black, 1997). The sets of regression equations were specified in Chapter 6 as follows:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \varepsilon_i; \qquad i = 1, \ldots, N$$

(From ***Equation 6.7***)

In the regression equation, β_0 represents the intercept while $\beta_1, \beta_2, \ldots, \beta_k$ are regression coefficients which denote the estimated change in the dependent variable Y for a unit change of the independent variables $X_2, X_3, \ldots, X_k$. The prediction error, ε, or the residual, is the difference between the actual and predicted values of the dependent variable. Moreover, the sum of squared errors (SSE) provides a measure of prediction errors while the sum of squares regression (SSR) determines a measure of prediction success. As a result, the total sum of squares (TSS) is defined as the sum of SSE and SSR (Hair et al., 1998):

$$\sum_{i=1}^{n}(y_i - \bar{y})^2 = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 + \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2$$

…… ***Equation 9.1***

where	$\bar{y}$	=	Average of all observations
	y_i	=	Value of individual observation *i*
	$\hat{y}$	=	Regression coefficients

Observations that are inappropriate representations of the population from which the sample is drawn are defined as outliers (Hair et al., 1998), and are eliminated from further analysis. In fact, the level of prediction accuracy can be expressed by the coefficient of determination (R^2), which is the sum of squares regression to the total sum of squares. R^2 ranges from 0 to 1. R^2 is zero when there is no linear relationship between the dependent and independent variables, and it is 1 if there is a perfectly linear relationship. However, R^2 is influenced by the number of independent variables relative to the sample size (Hair et al., 1998). To compare across regression equations involving different numbers of independent variables or different sample sizes, the adjusted coefficient of determination (adjusted R^2) is calculated to reflect the goodness of fit of the model.

9.2.1 Assumptions in Multiple Regression Analysis

The main assumptions about the relationships between the dependent and independent variables are (Norusis, 2002; Hair et al., 1998):

(1) The observations are independent: The predicted value is not related to any other prediction.

(2) The relationship between the two variables is linear: The relationships between the dependent variable and each independent variable should be linear since it represents the degree to which the change in the dependent variable is associated with the independent variable.

(3) For each value of the independent variable, there is a normal distribution of values of the dependent variable.

(4) The distributions have the same variance: The variance of the distribution of the dependent variable should be constant for all values of the independent variable.

As the error term arises through the interplay of several forces, the randomness of the error term can indicate that the omitted effects are small (Pindyck and Rubinfeld, 1998). Therefore, the use of residuals can check the assumptions of independence, linearity, normality, and constant variance by the associated plots, which can aid in the validation of the assumptions (SPSS, 1997). Norusis (2002) suggested the use of studentized deleted residuals for analyzing residuals, which describes the studentized residual for a case when the case is excluded from the computation of the regression statistics. While the assumptions of independence, linearity and constant variance can be tested by plotting the standardized deleted residuals against the standardized predicted values, normality can be observed by the normal probability plot which displays cumulative normal distribution as a straight line (Belsley et al., 1980). The linear relationship between each success criterion and each critical success factor can also be verified by the respective partial regression plots. If regression assumptions are met, there is no pattern in the data points (Norusis, 2002).

In fact, regression analyses are also affected by multicollinearity, which occurs when a single independent variable is highly correlated with a set of other independent variables (Hair et al., 1998). Multicollinearity may be present since the elements in the questionnaire may be closely related to each other and factor analysis has been employed to overcome the obstacles presented by the problem of multicollinearity (Trost and Oberlender, 2003). The variance inflation factor (VIF) measures the degree of multicollinearity among the independent variables, and small VIF values indicate that multicollinearity does not exist in the data (Hair et al., 1998; Norusis, 2002). Results from the plots are attached as Appendix M, which give cumulative normal distribution as a straight line and a random pattern in the data points. Moreover, small VIF values are obtained to indicate that multicollinearity does not exist. Therefore, the regression assumptions are met, suggesting that the data are appropriate for multiple linear regression analyses.

9.3 THE REGRESSION MODELS

Multiple linear regression analysis was employed to study the relationships between the criteria (dependent variables) and factors (independent variables) of success for D&B projects. The initial data in developing the regression models are obtained from the original 92 responses, excluding the cases that have missing values for some of the variables. A stepwise variable selection was adopted to identify the critical success factors that can predict the performance of the success criteria. It is the most commonly used method for model building (Norusis, 2002). It operates by removing variables whose importance diminishes since their predictive power drops to a non-significant level when another independent variable is added to the model (Hair et al., 1998).

In order to obtain a consistent pattern across the multiple regression anaylsis and to generate a fairly representative model, those truly distinctive observations were identified and designated them as outliers. Outliers can arise from errors in the data and the inherent variability of the data, such as intentional misreporting or sampling error. Since outliers can significantly increase error variance and reduce the power of statistical tests, the removal of outliers is a legitimate measure to generate a best-fit curve (Osborne and Overbay, 2004). Previous researchers recorded outliers at the two standard deviations level (Belsley et al., 1980; Drew and Skitmore, 1992; Chan and Kumaraswamy, 1999; Chan et al., 2005). In the research, those data which deviate from the best curve by two standard deviations or more are deleted as outliers, and a minimum of thirty cases is maintained to ensure statistical integrity (Leedy, 1997; Chan and Kumaraswamy, 1999). The results of multiple linear regression for each success criterion give an equation which contains a constant (intercept) and partial regression coefficients for each of the critical success factors. The partial regression coefficient indicates how much the value of the dependent variable changes when the value of that independent variable increases by one and the values of the other independent variables do not change (Norusis, 2002). A positive coefficient means that the predicted value of the dependent variable increases when the value of the independent variable increases. Moreover, the observed significance level for all of the coefficients is less than 0.05 to be included in the model. To determine which variable has the greatest impact, the standardized beta coefficients are examined which reflect the relative impact on the dependent variable of a change in one standard deviation in that variable. The results of regressions on the project success indices of D&B projects and the respective four criteria of success are presented.

9.3.1 Project Success Index (PSI-D&B)

The Project Success Index for D&B projects (PSI-D&B) has been developed in the research to indicate the level of success of D&B projects and the PSI-D&B were calculated on the data for the research. The results of the regression analysis are presented in Table 9.1 and attached as Appendix M.1.

Table 9.1 Multiple regression analysis for PSI-D&B

Variables	Standardized beta coefficients	Significance level	Adjusted R square
Project attractiveness (PJT_ATR)	0.417	< 0.001	
Effectiveness of project management action (EFF_PMA)	0.371	< 0.001	
Application of innovative management approaches (APP_IMA)	0.275	0.005	0.549

The data for the project success index of D&B projects (PSI-D&B) were obtained from Equation 8.1, which is a composite measure of the success criteria of time, cost, quality and functionality for D&B projects. The critical success factors for PSI-D&B include the project attractiveness, the effectiveness of project management action and the application of innovative management approaches, and the multiple regression equation for PSI-D&B is:

$$\textbf{PSI-D\&B} = \mathbf{10.291 + 0.664\ PJT\_ATR + 0.602\ EFF\_PMA + 0.441\ APP\_IMA}$$

………… ***Equation 9.2***

Moreover, 54.9 % of variance of D&B project success is explained by the variables. Since the project attractiveness has the highest beta coefficient, it is the most powerful predictor for the project success index.

9.3.2 Time

One major benefit of the D&B method is fast-tracking, and the project duration can be shortened by overlapping the design and construction phases. The results of the regression analysis are presented in Table 9.2 and attached as Appendix M.2.

Table 9.2 Multiple regression analysis for Time

Variables	Standardized beta coefficients	Significance level	Adjusted R square
Project attractiveness (PJT_ATR)	0.368	< 0.001	
Effectiveness of project management action (EFF_PMA)	0.349	0.001	
Application of innovative management approaches (APP_IMA)	0.316	0.001	0.526

Time can be assessed from the perceptions of the D&B project participants on the satisfaction level. The critical success factors for time performance are the same as those for PSI-D&B, which include the project attractiveness, the effectiveness of project management action and the application of innovative management approaches. The multiple regression equation for time performance is:

Time = 4.959 + 0.487 PJT_ATR + 0.456 EFF_PMA + 0.426 APP_IMA

………… ***Equation 9.3***

Moreover, 52.6 % of variance of the time performance is explained by the variables. Since the project attractiveness has the highest beta coefficient, it is the most powerful predictor for time performance.

9.3.3 Cost

Cost can be assessed from the perceptions of the D&B project participants on the satisfaction level. The results of the regression analysis are presented in Table 9.3 and attached as Appendix M.3.

Table 9.3 Multiple regression analysis for Cost

Variables	Standardized beta coefficients	Significance level	Adjusted R square
Project attractiveness (PJT_ATR)	0.254	0.027	
Client's input in the project (CLT_INT)	0.445	< 0.001	
Application of innovative management approaches (APP_IMA)	0.416	0.001	0.398

The critical success factors for cost performance include the project attractiveness, the client's input in the project and the application of innovative management approaches, and the multiple regression equation for cost performance is:

$$\textbf{Cost} = \mathbf{5.457 + 0.249\ PJT\_ATR + 0.403\ CLT\_INT + 0.376\ APP\_IMA}$$

………… ***Equation 9.4***

Moreover, 39.8 % of variance of the cost performance is explained by the variables. Since the client's input in the project has the highest beta coefficient, it is the most powerful predictor for cost performance.

9.3.4 Quality

The quality of a D&B project has attracted much attention as the contractor has become responsible for both design and construction. The results of the regression analysis are presented in Table 9.4 and attached as Appendix M.4.

Table 9.4 Multiple regression analysis for Quality

Variables	**Standardized beta coefficients**	**Significance level**	**Adjusted R square**
Effectiveness of project management action (EFF_PMA)	0.390	0.001	
Working relationships among project team members (WKR_MBR)	0.346	0.004	0.386

Quality can be assessed from the perceptions of the D&B project participants on the satisfaction level. Improved quality can result from increased effectiveness of project management action and harmonious working relationships among project team members, and the multiple regression equation for quality performance is:

$$\textbf{Quality} = \textbf{4.799} + \textbf{0.342 EFF\_PMA} + \textbf{0.287 WKR\_MBR}$$

………… ***Equation 9.5***

Moreover, 38.6 % of variance of the quality performance is explained by the variables. Since the effectiveness of project management action has the highest beta coefficient, it is the most powerful predictor for quality performance.

9.3.5 Functionality

Functionality can be assessed from the perceptions of the D&B project participants on the satisfaction level. The results of the regression analysis are presented in Table 9.5 and attached as Appendix M.5.

Table 9.5 Multiple regression analysis for Functionality

Variables	**Standardized beta coefficients**	**Significance level**	**Adjusted R square**
Effectiveness of project management action (EFF_PMA)	0.467	< 0.001	0.205

Increased functionality can be predicted by increased effectiveness of project management action, and the multiple regression equation for functionality is:

$$\textbf{Functionality} = \textbf{5.517} + \textbf{0.379 EFF\_PMA}$$

………… ***Equation 9.6***

Moreover, 20.5 % of variance of the functionality performance is explained by the single variable. As a result, the conceptual model of success for D&B projects in the public sector of Hong Kong was developed and is illustrated in Fig. 9.1.

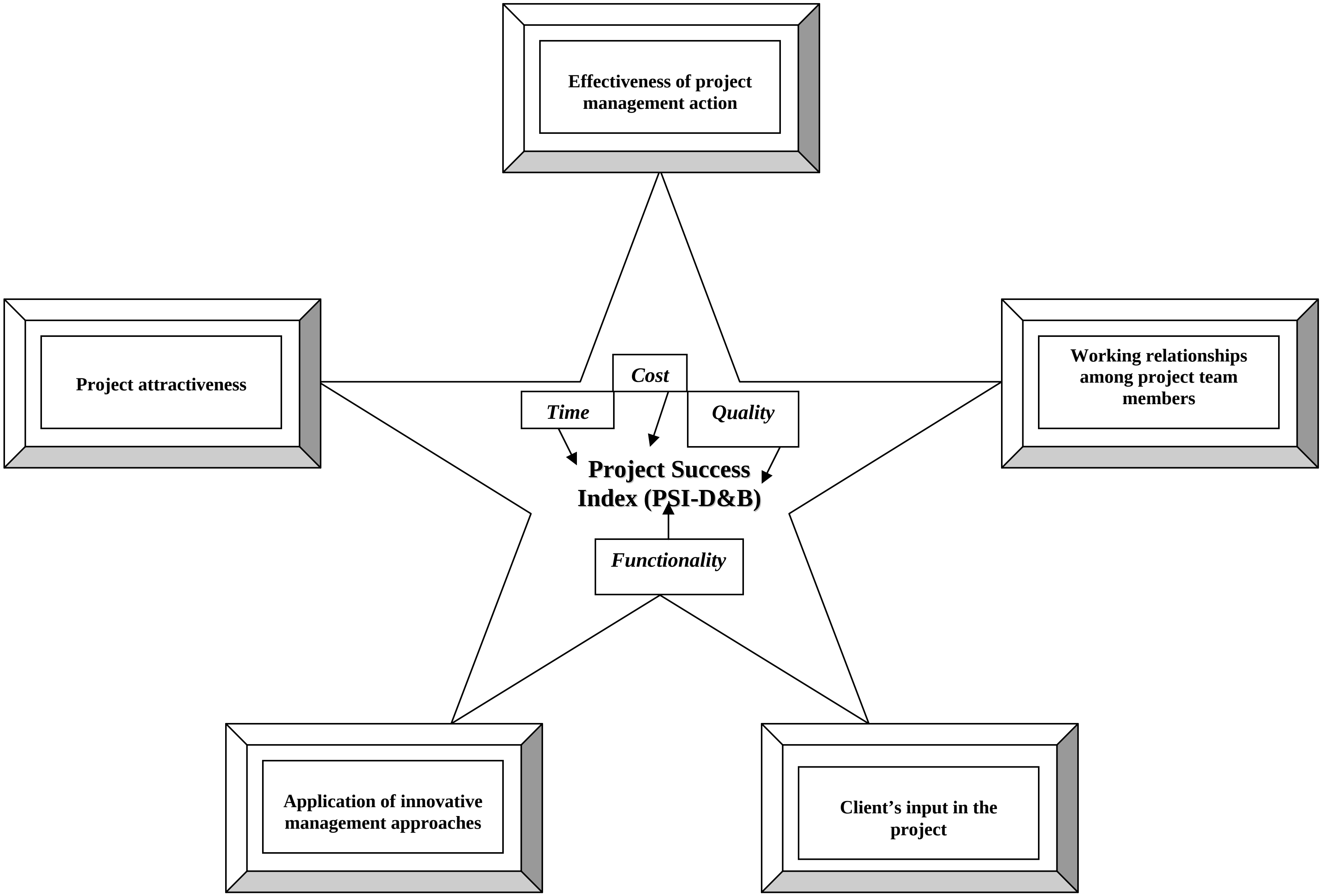


Fig. 9.1 Conceptual model of D&B project success

Multiple regression analysis has assisted in developing a conceptual model to link the critical success factors to the criteria of success for D&B projects, based on the data from the Hong Kong construction industry. It has identified five critical success factors and the second principal hypothesis in Stage 2 investigation can be revised as:

"The success of a design-build project is a function of the project attractiveness, client's input in the project, effectiveness of project management action, application of innovative management approaches and working relationships among project team members."

9.4 RELATIVE STRENGTHS OF CRITICAL SUCCESS FACTORS OF DESIGN-BUILD PROJECTS

To further study the relative strength of the critical success factors on enhancing success for D&B projects, the beta coefficients are taken into consideration. If an independent variable has the greatest number of the highest beta coefficient among other independent variables, such variable is considered the most important determinant in the regression model, which is regarded as having the first order of significance. Table 9.6 summarizes the beta coefficients of the critical success factors with respect to the criteria of success for D&B projects.

Table 9.6 Beta coefficients of critical success factors for D&B projects

	F3 – Effectiveness of Project Management Action (EFF_PMA)	**F5 – Working Relationships among Project Team Members (WKR_MBR)**	**F6 – Client's Input in the Project (CLT_INT)**	**F7 – Project Attractiveness (PJT_ATR)**	**F9 – Application of Innovative Management Approaches (APP_IMA)**	**Adj. R^2**
PSI-D&B	0.371			0.417	0.275	0.549
Time	0.368			0.349	0.328	0.526
Cost		0.445	0.254		0.416	0.398
Quality	0.390	0.346				0.386
Functionality	0.467					0.205
Total	4	2	1	2	3	

Legend:

	: variables with the highest beta coefficient in the respective success criterion

Effectiveness of Project Management Action (EFF_PMA) has three of the highest beta coefficients and is classified as the first order of significance. Working Relationships among Project Team Members (WKR_MBR) and Project Attractiveness (PJT_ATR) have one of the highest beta coefficients and are classified as the second order of significance. Client's Input in the Project (CLT_INT) and Application of Innovative Management Approaches (APP_IMA) are classified as the third order of significance. After identifying the factors that have strong predictive powers on the success of D&B projects, the next section discusses how the factors affect the performance level of the D&B projects.

9.4.1 First Order of Importance

Effectiveness of Project Management Action (EFF_PMA) has three of the highest beta coefficients in the success criteria of time, quality and functionality. It has the greatest number of the highest beta coefficients among other factors; therefore, it has the greatest impact on the success of D&B projects. The research suggests that

"More effective project management action increases the performance of time, quality and functionality."

It also has a positive relationship with the overall success of a D&B project, thereby suggesting that

"Improved project management action enhances the overall success of a D&B project."

Effective project management action can shorten project time since proper planning from site to office can allow optimum overlaps between design and construction phases. Deakin (1999) reported that project management action and proper contract documentation can improve the quality performance of a D&B project. The development of standard procedures can also provide clear guidelines on submissions that would save time from missing information. Moreover, the organization structure can indicate the participants in the project and so information can be directed to the right party. The simplified project organization structure can also reduce the possibilities for friction, delay and additional costs (Hong Kong Institute of Architects, 1998). Effective means of communication can safeguard transmission of messages among project participants from site to office in order to reduce abortive work. Pearson and Skues (1999) described the specific controls in the design development process and the approval of design applied to a D&B project, which are fundamental to satisfying functional requirements. They suggested preparing a project procedures manual to ensure effective understanding of the roles and responsibilities of all the key participants to facilitate successful project implementation. The quality of the project can also be maintained through quality control plans. Regular monitoring of construction works can further improve the quality of workmanship, and the implementation of an approved quality system can guarantee the quality standard of the D&B project (Leung, 1999). Detailed planning at the design stage can also ensure that the client's requirements have been considered in order to achieve the functionality of the D&B project. Smith (1999) pointed out that regular meetings with the project participants can collect responses on the design and hold discussions on specification matters, and that a properly planned project programme can enhance project performance.

The factor of effectiveness of project management action is associated with four of the five identified success criteria for D&B projects, and Fig. 9.2 shows the impact of this factor on the various performance measures.

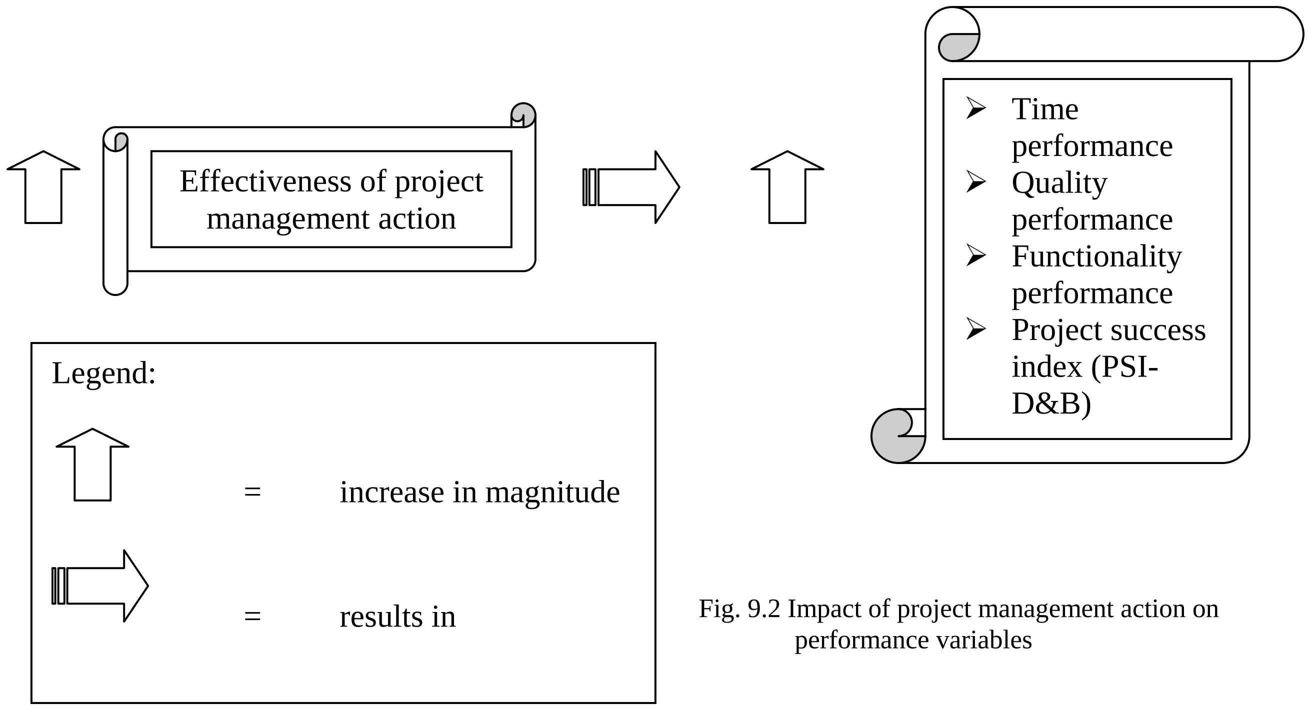


Fig. 9.2 Impact of project management action on performance variables

9.4.2 Second Order of Importance

Working Relationships among Project Team Members (WKR_MBR) and Project Attractiveness (PJT_ATR) are the next most significant factors affecting the success level of D&B projects. The former has one of the highest beta coefficients in the cost success criterion while the latter has one highest beta coefficient in the success index of D&B projects. The research shows that

(1) <u>Working Relationships among Project Team Members</u>

Working Relationships among Project Team Members has significant effects on the performance of D&B projects, and the research shows that

"Better working relationships among project team members results in better cost performance of D&B projects."

It also has a positive relationship with the quality performance of a D&B project, thereby suggesting that

"Improved working relationships among project team members leads to higher quality performance of D&B projects."

The harmonious working relationships among project team members can allow a clear flow of communication on matters of cost and quality. Kaiyama (1995) showed that cooperative working relationships benefit the client in all aspects of time, cost and quality. The cohesive D&B team can also keep monitoring and controlling on the cost and quality aspects. Potter and Sanvido (1994) demonstrated the need for a cohesive and well-integrated D&B team and showed that it was critical to the success of a project. Tan (1995) also suggested that the team approach can encourage project participants to work together closely for a cost-effective design through an optimum balance of design, buildability and cost. This idea was echoed by Cockayne (1996) who believed that the success of a D&B project depends largely on the relationships within the D&B team and a clear understanding of the roles, responsibilities and obligations of each team member. Murray (1995) and Hemlin (1999) pointed out that an atmosphere of mutual trust and understanding among project participants can help solve client's problems and improve the performance of a D&B project. Moreover, the contractor, being the leader of the D&B team, should be confident in his decision-making in order to improve cost performance and maintain the quality of the project. The D&B project participants should also integrate themselves fully into a team to improve cost and functionality performance (Hemlin, 1999). If adequate decision-making power is delegated to the consultants, the cost and quality performance can be improved since the respective professionals, such as quantity surveyors and architects, have been consulted to provide information for the D&B project. Chan et al. (2000) also found that the commitment of the project team to the D&B project was one of the most important factors contributing to the overall successful project performance.

The factor of working relationships among project team members is associated with two of the five identified success criteria for D&B projects, and Fig. 9.3 shows the impact of this factor on the various performance measures.

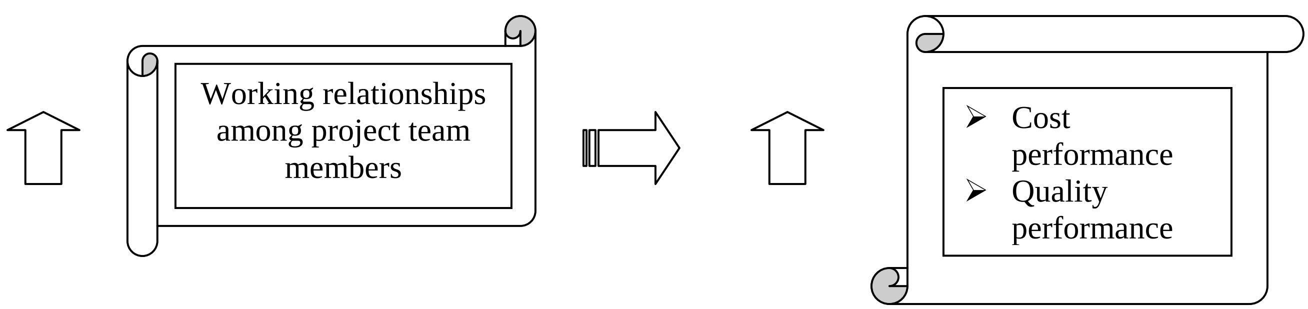


Fig. 9.3 Impact of working relationships among project team members on performance variables

(2) Project Attractiveness

Project Attractiveness is another critical success factor for D&B projects, and the research suggests that

"The attractiveness of D&B projects is positively associated with the time performance and its overall success level."

If a D&B project is prestigious and has a high value to the contractor, the contractor naturally will put forth extra effort to accomplish the project. D&B makes the best use of the contractor's input early at the design stage, thus saving much time since the buildability of the project has been improved. Lamont (1996) suggested that the buildability incorporated in the tender can produce savings in cost and time, and Hashim (1995) agreed that the concept of buildability in the design results in early completion of the project. Moreover, the contractor's special skills can improve the construction method for the D&B project and time can be saved by maximum utilization of the available resources. Lamont (1999) pointed out that incorporating the contractor's expertise and the available resources into the tender can produce time and cost savings. Harris (1999) also believed that D&B allows the contractor to optimize the design and methods of construction with cost benefits. Moreover, the D&B project should be flexible so that the contractor can provide alternative solutions for the client to choose the best value option. Leung (1999) suggested that the contractor should be allowed to design structures to suit their construction method so that the performance of the D&B project can be improved.

The contractor may also be attracted to the unique nature of the D&B project so that each tenderer can submit a distinctive proposal based entirely on the expertise of the D&B team. This idea was shared by Ling and Liu (2004) who showed that project-related variables affect the success level of D&B projects. The complexity of the project can also screen the more capable contractors from the less competent ones so that the D&B contract can be awarded to the right contractor. Blake (1999) reported that D&B allows a complex project to be implemented in a more cost effective manner within a shorter time span.

The factor of project attractiveness is associated with two of the five identified success criteria for D&B projects, and Fig. 9.4 shows the impact of this factor on the various performance measures.

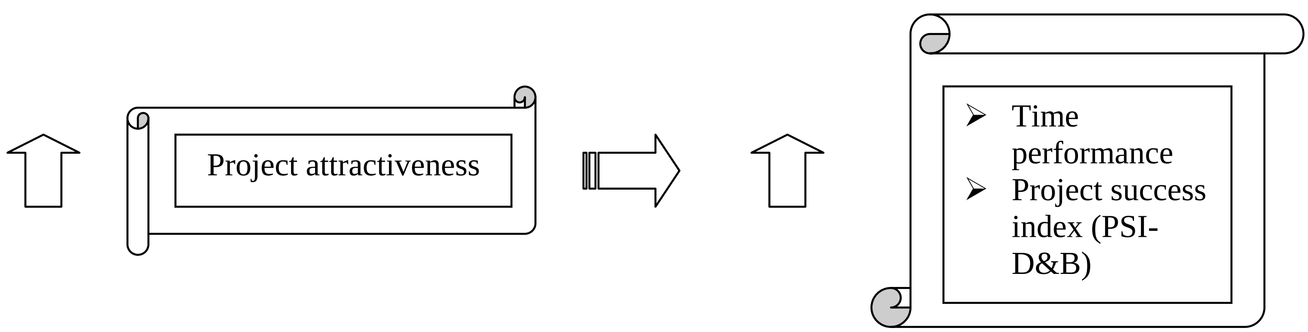


Fig. 9.4 Impact of project attractiveness on performance variables

9.4.3 Third Order of Importance

(1) <u>Client's Input in the Project</u>

Client's Input in the Project (CLT_INT) is one identified factor associated with the success level of D&B projects, and the research shows that

"Client's input in the project is positively associated with the cost performance of D&B projects."

The project should have a well-defined scope so that the budget can be spent only on the necessary work that is included in the contract. Cockayne (1996) stressed that the definition and scope of the client's requirements largely determines the success of a D&B project. This idea was echoed by Songer and Molenaar (1997) who found that well-defined scope and shared understanding of scope have a high impact on D&B project success. If the scope of work is not clearly defined, variation orders may be formed, adding to the initial contract sum because of the potential disruption to the design process (Leung, 1999). As the client, in most cases, is the initiator of the project, he should be able to brief the design team effectively so that project participants are clear about the contract works that are cost significant. The client should also state the requirements clearly at the early start of the project so that the contractor can design and construct to the client's requirements. Hemlin (1999) opined that the contractor can better control project cost by interpreting the client's requirements clearly. As a result, abortive work can be reduced and the cost performance can be improved because of the client's input in the design (Deakin, 1999). If the client's requirements are not clear, the contractor will recover costs for errors and omissions from the client, which negatively affects the cost performance of the D&B project (Hemlin, 1999). Fig. 9.5 shows the impact of this factor on the cost performance of D&B projects.

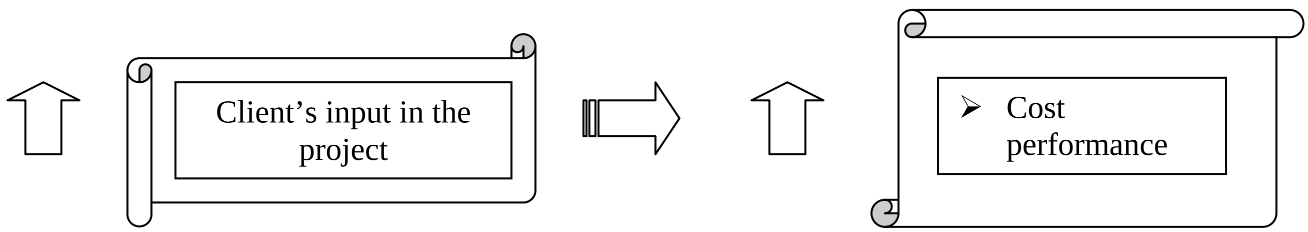


Fig. 9.5 Impact of client's input in the project on performance variables

(2) Application of Innovative Management Approaches

Application of Innovative Management Approaches (APP_IMA) has a significant impact on the performance of D&B projects, and the research suggests that

"Adoption of innovative management approaches can result in higher time and cost performance, and the overall success level of D&B projects."

Value management is a value enhancement exercise that seeks to provide the best value-for-money option for the project. Kaiyama (1995) stressed that the objective of value management is to eliminate those costs that do not contribute to value. Cheng (1995) reported that value management has been carried out in D&B projects to eliminate costs without additional value. Therefore, the adoption of value management can lead to better cost-performance without adversely affecting the quality performance (Fong et al., 1998). Shen et al. (2004) described that value management has been considered in the process of client's requirements, and its essential feature is function analysis, which enables a systematic identification and clear definition of the client's requirements. Perera and Karunasena (2004) also pointed out that value management can provide a structured and systematic approach to achieving the necessary functions of a project at the lowest resulting cost. This process can further be adopted as a quality assurance process to ensure achieving the required quality targets. Therefore, the quality and functionality performance can be improved. In fact, value management requires teamwork at the early stage of a project where project participants meet together with the aim of optimizing cost in the project. Such an arrangement can further be achieved by the use of partnering which stresses mutual trust among project participants.

Partnering is a simple process of establishing good relationships between contracting parties, and it is designed to minimize job costs and schedule overruns (Chan et al., 2004b). Therefore, significant time can be saved from communication among project participants who share common goals for the D&B project. Mo and Ng (1997) regarded partnering as an effective dispute resolution strategy and a commitment to achieve project success by all project participants. It was also found that the use of partnering can enhance the overall performance of construction projects. Deakin (1999) pointed out that the use of partnering can enhance the quality performance of a D&B project while Hemlin (1999) suggested that the true D&B team should be a partnership among the client, contractor and consultant. Pearson and Skues (1999) also described the importance of a team approach to the successful delivery of D&B projects, and believed that partnering enables the contractor to proceed with work prior to resolving disputes. Chan et al. (2000) further advised the D&B practitioners to focus on teamwork and partnering for successful project implementation, and indeed, project partnering was found to provide construction projects with improved time and cost benefits to both clients and contractors (Chan et al., 2004b).

The factor of application of innovative management approaches is associated with three of the five identified success criteria for D&B projects, and Fig. 9.6 shows the impact of this factor on the various performance measures.

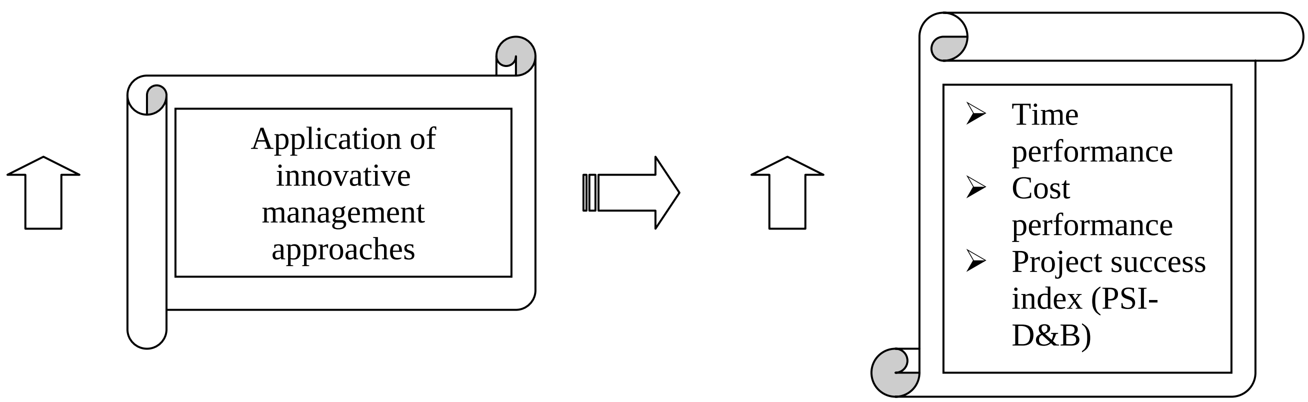


Fig. 9.6 Impact of application of innovative management approaches on performance variables

9.5 RELATIONSHIPS BETWEEN CRITICAL SUCCESS FACTORS AND SUCCESS CRITERIA OF D&B PROJECTS

The research has identified critical success factors for a D&B project and established the relationships between the critical success factors and the success criteria. Effectiveness of project management action has the strongest direct relationship with the time and quality performance, and the overall success of a D&B project. Moreover, client's input in the project has the strongest direct relationship with the cost performance. It also has a strong direct relationship with the quality performance of a D&B project. While the factor of working relationships among project team members has a strong direct relationship with the cost and quality performance, project attractiveness has a similar relationship with time performance and the overall success of a D&B project, and the client's emphasis on time and cost is directly related to the functionality performance of a D&B project. Also, the application of innovative management approaches has a strong direct relationship with the time and cost performance, and the overall success of a D&B project. One other critical success factor, Economic Environment, has a strong direct relationship with the functionality and quality performance of a D&B project. Fig. 9.7 describes the relationships between the critical success factors and the success criteria of D&B projects.

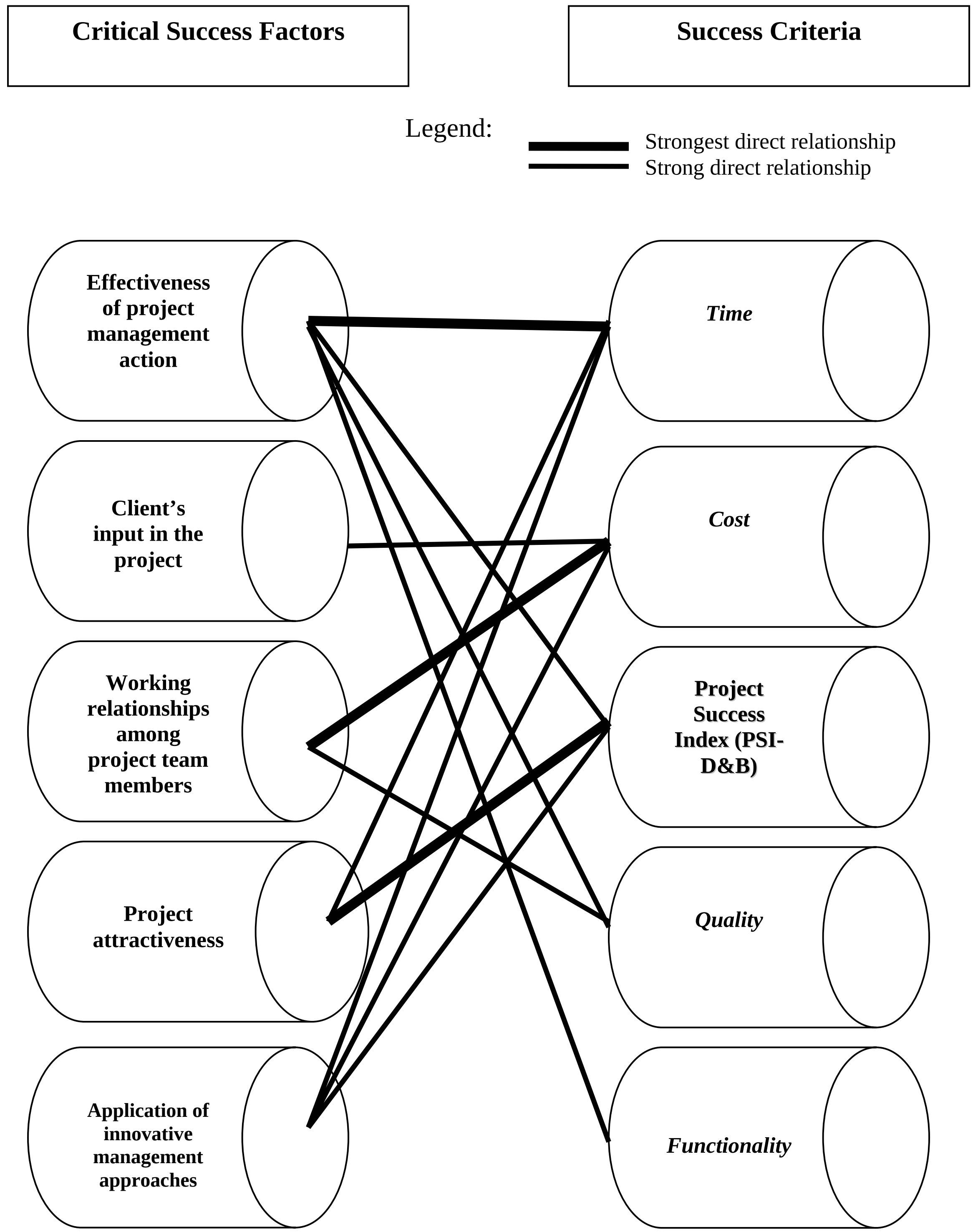


Fig. 9.7 Relationships between critical success factors and success criteria

9.6 FACTORS NOT INCLUDED IN THE MODEL

Seven factors as postulated in the research model (Fig. 8.4) are found not to be significantly associated with the success of D&B projects. These factors are: (1) competency of client body, (2) competency of construction team leader, (3) competency of contractor's design consultants, (4) client's emphasis on time and cost, (5) client's emphasis on risk transfer, (6) physical and social environments, and (7) economic environment. In Hong Kong, most project participants are well adapted to the construction working environment, which has been operating in the traditional manner for a long time. Project participants in the Hong Kong construction industry have acquired the necessary design and construction skills but they are unclear about their roles in the D&B method. Chan et al. (2002) pointed out that project participants' understanding and acceptance of the new roles and responsibilities in D&B projects are vital to project success. Therefore, the competency of the project participants may not be the most critical consideration for the success of a D&B project, which may rely heavily on proper project management action, client's input on project requirements and a harmonious working environment among project team members. The factor of client's emphasis on risk transfer has been criticized by the contractor since D&B has been misused as a risk dumping strategy to shift the risk from the client and the contractor party. If the client places much emphasis on time and cost, the quality of the project may be sacrificed since the contractor has to chase the schedule within budget. While the client may enjoy the benefit of a single point of responsibility, it would be problematic for the contractor to bear all the risks of the D&B project, thereby imposing negative impact on the working relationships among project team members. Therefore, client's emphasis on time and cost, and the emphasis on risk transfer may not be critical to D&B project success. In fact, project participants are experienced in making assessments on the physical environment at tendering stage and weathers in Hong Kong can be predicted with high accuracy. The Hong Kong construction industry is also considered to be relatively stable with few, if any, strikes from social groups against a construction project procured under the D&B method. The economic environment may not affect the choice of procurement systems, which is mainly based on the nature of projects. As a result, economic, physical and social environments are not critical to the success of D&B projects in Hong Kong.

9.7 CHAPTER SUMMARY

This chapter presented the results of multiple linear regressions between the success factors and the success criteria of D&B projects, and has shown how these factors affect the performance level of D&B projects. It suggested that the effectiveness of project management action, the client's input in the project, the working relationships among project team members, the attractiveness of the project and the application of innovative management approaches are the critical success factors for D&B projects. The research model will be verified both quantitatively and qualitatively in the next chapter.

Chapter 10 Testing of the Model

10.1 INTRODUCTION

The results of Stage 2 investigations on developing a conceptual model of success for design-build projects in the public sector of Hong Kong were discussed in the last chapter. In order to examine the reliability of the model, the research collected five test samples from the Hong Kong construction industry and the data were described and analyzed with statistical techniques. Structured interviews were also conducted with D&B project participants in the Hong Kong construction industry to collect their responses about the level of agreement with the research findings, and the process of testing is presented in the chapter.

10.2 DATA MATRIX

In order to test the reliability of the model, five more sets of data were collected from D&B project participants in the Hong Kong construction industry. These data sets are independent of those used to derive the regression models, and the details of the five cases are summarized in Table 10.1.

Table 10.1 Details of the test samples

Case	Project Type	Position of respondent	Years of experience in the construction industry
1	Residential	Project Manager	More than 20 years
2	Residential	Director	More than 20 years
3	Office	Director	More than 20 years
4	Office	Associate Director	More than 20 years
5	Residential	Director	More than 20 years

All respondents hold senior positions in their respective organizations and have more than 20 years of experience in the construction industry. Each of the respondents was given a set of validation questionnaires, which was revised from the research questionnaire. A sample is attached as Appendix N. The data were input into the SPSS statistical software for the calculation of factor scores.

10.3 METHOD OF TESTING

The factor scores can be used to represent the values of the factors and to examine their relationships with the dependent variables (Norusis, 1993). The calculation of a factor score can be estimated using a linear combination of the items that load on that factor. For case k, the score for the jth factor is estimated as

$$F_{jk} = \sum W_{ji}X_{ik}$$

where X_{ik} is the standardized value of the ith variable for case k and W_{ji} is the factor score coefficient for the jth factor and the ith variable. While Sections 1 and 2.1 of the validation questionnaire collected data of the respondent and the D&B project respectively, Sections 2.2, 3 to 7 were set to collect data from respondents rating each success factor attribute on a seven-point Likert scale, and the data were input into SPSS for analysis. Pett at al. (2003) further described the method of testing. To estimate a respondent's score on a particular factor in each test sample, all of the individual's scores on the factor variables in the test samples were standardized, weighted by a generated factor score coefficient for the factor under consideration, and then summed across all items. Take the value of Factor 1 in Case 1 as an example,

Value for Factor 1 (CPC_CLT) in Case 1 = (-0.5) (0.039) + (-0.77067) (-0.088) + … + (-1.09545) (0.001) + (-0.70711) (-0.04) + (-0.44721) (0.007) + (0.39563) (0.008) + … + (0.44721) (-0.01) + (-0.7303) (0.066) + (0.35082) (-0.019) + (0.25646) (0.02) + … + (0.83666) (0.163) + (1.09545) (0.053) + … + (0.58132) (-0.058) + (0.04925) (-0.008) = ***0.699358***

The factor scores of the five test samples are presented in Table 10.2 and attached as Appendix O.1.

Table 10.2 Factor scores of the test samples

	CPC_CLT	CPC_CTR	EFF_PMA	CPC_COT	WKR_MBR	CLT_INT
Case 1	***0.699358***	0.09665	-0.75213	-0.093654	0.60084	-0.399036
Case 2	-0.883489	-1.59846	-0.820029	-0.556923	-1.267055	0.631318
Case 3	-0.687771	-0.234099	0.121433	-0.700258	1.111919	-1.096185
Case 4	0.43618	0.193555	-0.417052	0.04627	-1.02364	-0.430365
Case 5	0.435725	1.54235	1.867772	1.304571	0.577938	1.294268

Table 10.2 Factor scores of the test samples (cont'd)

	PJT_ATR	CLT_T&C	APP_IMA	CLT_RTR	P&S_ENV	ECO_ENV
Case 1	-0.101563	-1.014305	-0.052446	-0.720652	-0.740233	0.361945
Case 2	-0.73763	0.572397	-1.040285	-0.253955	0.646866	-1.084723
Case 3	-0.087693	-0.581313	0.242434	-0.07232	0.164375	0.190343
Case 4	0.177325	0.595961	0.046308	0.281862	-0.866843	0.33564
Case 5	0.74956	0.427262	0.803988	0.765066	0.795838	0.196791

The corresponding factor scores of each case were then substituted into the multiple regression equations of PSI-D&B (***Equation 9.2***), time (***Equation 9.3***), cost (***Equation 9.4***), quality (***Equation 9.5***) and functionality (***Equation 9.6***) generated in the research. Take the multiple regression equation of PSI-D&B for Case 1 as an example,

PSI-D&B = 10.291 + 0.664 PJT_ATR + 0.602 EFF_PMA + 0.441 APP_IMA

(From ***Equation 9.2***)

Substitute the factor scores of **PJT_ATR, EFF_PMA** and **APP_IMA**,

Computed value of PSI-D&B for Case 1 = 10.291 + (0.664) (-0.101563) + (0.602) (-0.75213) + (0.441) (-0.052446) = ***9.75***

As a result, the computed values of the five success criteria for the five test samples can be obtained from substituting the respective factor scores into the corresponding multiple regression equations. Moreover, the respondents were asked to express their satisfaction level with the performance of the four identified success criteria for the D&B projects in Section 8 of the validation questionnaire, which were described as 'actual' for the performance of the respective success criterion. The actual value of the project success index for D&B projects (PSI-D&B) can be obtained from the equation derived from the research:

PSI-D&B = 0.54 Time + 0.55 Cost + 0.47 Quality + 0.42 Functionality

(From ***Equation 8.1***)

Therefore, the actual values of PSI-D&B for the five test samples can be obtained from substituting the actual values of the corresponding success criterion. The results are shown in Table 10.3.

Table 10.3 Computed and actual values of the performance measures of the five test samples

	PSI-D&B		**Time**		**Cost**		**Quality**		**Functionality**	
	Computed	***Actual***	***Computed***	***Actual***	***Computed***	***Actual***	***Computed***	***Actual***	***Computed***	***Actual***
Case 1	***9.75***	10.32	4.54	5	5.25	5	4.71	5	5.23	6
Case 2	8.85	9.71	3.78	6	5.14	4	4.15	5.5	5.21	4
Case 3	10.41	11.88	5.07	6	5.08	6	5.16	6	5.56	6
Case 4	10.18	7.92	4.87	4	5.35	4	4.36	4	5.36	4
Case 5	12.27	13.63	6.52	7	6.47	7	5.60	6.5	6.22	7

To demonstrate the reliability of the model, comparisons were made between the computed and actual values of the five performance measures in the test samples.

10.3.1 Analysis of the Paired Data

The paired-samples *t* test was employed to analyze the results of the same attribute under two different conditions (Norusis, 2002). The test was performed to detect whether there is significant difference between the computed and actual values of the five performance measures, and the statistic was given by

$$t = \frac{\overline{D}}{S_D / \sqrt{N}}$$

………… ***Equation 10.1***

where D is the observed difference between the two means, S_D is the standard deviation of the differences of the paired observations and N is the number of pairs. To test whether there is any significant difference between the computed and actual values, the null hypothesis that there is no difference for a paired data is formulated and is rejected if the significance level is smaller than 0.05 (Norusis, 2002). The data were input into SPSS, and the results are presented in Table 10.4 and attached as Appendix O.2.

Table 10.4 Paired-samples *t* tests of the performance measures of the five test samples

Paired differences	**PSI-D&B**	**Time**	**Cost**	**Quality**	**Functionality**
Mean	-0.399	-0.641	0.257	-0.601	0.117
Standard deviation	1.530	1.109	0.994	0.657	1.074
Standard error of mean	0.684	0.496	0.445	0.294	0.480
***t*-value**	-0.58	-1.29	0.58	-2.05	0.24
Significance (2-tailed)	0.59	0.27	0.59	0.11	0.82

The mean difference is the difference between the mean scores of the computed and actual values of the five performance measures. Since the two-tailed significance for all performance measures is larger than 0.05, there is insufficient evidence to reject the null hypothesis that there is no difference for the paired data (computed and actual values) of the five performance measures.

10.4 STRUCTURED INTERVIEWS WITH D&B PROJECT PARTICIPANTS

While quantitative analyses have provided evidence to test the reliability of the model, structured interviews were also conducted with three D&B project participants in the Hong Kong construction industry to collect their viewpoints from their hands-on experience in running D&B projects. Two respondents from the validation questionnaire survey agreed to conduct the structured interviews as well and one other respondent was invited to take part in the structured interviews. All interviewees are at Directorate grade and each has more than 20 years of experience in the construction industry. Each of them also has experience in running three or more D&B projects in Hong Kong, and they were asked for comments on the findings from the research, including:

1. ***Project success of a D&B project can be measured in terms of time, cost, quality and functionality.***
2. ***Project success of a D&B project is directly affected by the attractiveness of the project, the effectiveness of project management action and the application of innovative management approaches.***
3. ***Time performance of a D&B project is directly affected by the project attractiveness, the effectiveness of project management action and the application of innovative management approaches.***
4. ***Cost performance of a D&B project is directly affected by the project attractiveness, the client's input in the project and the application of innovative management approaches.***
5. ***Quality performance of a D&B project is directly affected by the effectiveness of project management action and the working relationships among project team members.***
6. ***Functionality performance of a D&B project is directly affected by the effectiveness of project management action.***

The findings of the research were verified by the personal opinions of the interviewees based on their practical experience in running D&B projects. Each interview lasted about one hour, and the details are attached as Appendix P.

All respondents agreed that the criteria of time, cost, quality and functionality can be applied to measure the success of a D&B project. While Respondent 1 stressed that project management action is essential to bringing about faster decision-making, Respondent 2 simply agreed, and Respondent 3 demonstrated that control of system formwork can shorten project time. They also believed that the client's input can control cost and confirm end-users' requirements. For the critical success factors of the third order of significance, the respondents agreed that the application of innovative management approaches can bring about teamwork. Respondent 1 emphasized that all team players can work with trust and understanding, and Respondent 3 pointed out that a good working atmosphere in the project reduced discussions of trivial work, and so time can be saved.

In general, the interviewees agreed with the results generated from the research. They suggested that effective project management action can increase the chance of attaining project success, and rapid response from the client can help reduce abortive work, resulting in better cost and quality performance. Innovative management approaches, such as partnering and value management, have also been adopted by the respondents, resulting in better time and cost performance. Other critical success factors are also considered important to associate with the performance of D&B projects.

10.5 CHAPTER SUMMARY

This chapter has provided evidence to test the reliability of the model developed from the research and concluded that there is insufficient evidence to reject the null hypothesis that there is no difference for the computed values of the five performance measures and the actual values from the test group at a 0.05 significance level. Structured interviews also demonstrated that the D&B project participants in the Hong Kong construction industry agreed with the overall findings derived from the research. The overall conclusions of the investigations and the contributions of the research will be presented in the next chapter.

CHAPTER 11 CONCLUSIONS

11.1 INTRODUCTION

The research provided an in-depth study of the applications of the design-build procurement system in Hong Kong with a view to developing a conceptual model of success for D&B projects. This chapter will first review the objectives and hypotheses set for the research. It will then present the conclusions of the research findings. The contributions to theoretical knowledge and the applications of the research are also highlighted, and recommendations are made for future research work.

11.2 REVIEW OF RESEARCH WORK

The aims of the research were to study the application of the D&B method to building projects and to develop a conceptual model of success for D&B building projects in the Hong Kong setting. The research was carried out to meet these objectives set out in Chapter 1:

a) Evaluate the current practice of the D&B method in the public sector of Hong Kong.
b) Formulate a framework of factors and criteria of success for D&B projects.
c) Compute an index to indicate the success level of a D&B project.

d) Identify those factors that have strong predictive powers for the success of D&B projects.

e) Develop a conceptual model to link the critical success factors to the performance of D&B projects.

The goal was to provide a better understanding of the reasons for and inhibitors to running D&B projects for the further development of a model of criteria and factors of success for D&B projects. This can help project participants determine the performance of their D&B projects and enhance the success of project delivery.

The research was divided into two stages of investigation, and two principal hypotheses were formulated. Stage 1 investigation evaluated the current practice of the D&B method, and a hypothesis was formulated to test the consistency of the major D&B stakeholders on rankings through intra- and inter-group comparisons of the drivers, problems and barriers of the D&B method. In Stage 2 investigation, another hypothesis was formulated to test whether the success of a D&B project is a function of the project characteristics, project procedures, project management strategies, project-related participants, project work atmosphere and project environment so as to develop a conceptual model of success for D&B projects.

Various research approaches were employed to meet the objectives of the research. A comprehensive literature review was conducted to provide a consolidated foundation for the investigation of the drivers and inhibitors to running D&B

projects, and the factors and criteria of success for D&B projects. The literature review also provided a framework of attributes for the development of a research questionnaire to collect data for empirical findings. In the pilot study, the draft research questionnaire was revised based on the suggestions during structured interviews with the D&B project participants, and the data collected were analyzed by statistical tools in SPSS and SAS programmes. The results were then presented and discussed with support from previous literature, and tested with both quantitative and qualitative measures.

11.3 GENERAL CONCLUSIONS FROM THE RESEARCH

The findings generated from the research have provided valuable insights into existing knowledge, and the following conclusions were drawn from the research.

11.3.1 Application of the Design-Build Procurement System in Hong Kong

The current practice of the D&B method was evaluated by comparing and contrasting the perceptions of the major D&B project participants on (1) drivers for a wider adoption of the D&B method in the public sector, (2) problems of running D&B projects and (3) barriers to the choice of the D&B method.

Sixteen driver attributes were developed from literature and the analysis showed that 'D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design', 'the D&B contractor bears all risks related to the project, including management, financial and design matters', and 'the one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members' have been considered as the drivers for a wider adoption of the D&B method in the public sector. Moreover, there is agreement among the D&B project participants on the ranking of the reasons for a wider adoption of the D&B method in the public sector.

Another attempt was made to examine the perceptions of the D&B project participants on the problems of running D&B projects. Sixteen problem attributes were developed from literature. The analysis shows that 'the schedule was tight', 'stress was placed on the project by the client' and 'frequent changes were introduced by various end-users' have been regarded as the top three problems of running D&B projects. The concordance test confirmed that there is agreement among all D&B project participants on the ranking of the problems of running D&B projects. Moreover, the Spearman test demonstrated that no significant disagreement exists between the client-consultant and contractor-consultant groups but significant disagreement exists between the client and contractor respondents on the ranking exercise. The differences in rankings between client and contractor responses on the problems in running D&B projects have certain implications. When the D&B method is applied to construction projects, both clients and contractors should be clear of their roles in the D&B method.

A further attempt was made to investigate the main barriers to the D&B development in Hong Kong, and sixteen barrier attributes were established from literature. The analysis indicates that ‘D&B contractors carry a high degree of risk and liability’, ‘a contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him’, and ‘it takes more effort to develop the client’s requirements for D&B projects’ are the top three barriers to applying the D&B method. The concordance test also confirmed that there is agreement among all D&B project participants on the ranking of barriers and a higher level of agreement exists among the respective groups of clients, contractors and consultants. While the Spearman test showed that no significant disagreement exists between the client-consultant and contractor-consultant groups, significant disagreement exists between the client and contractor respondents on the ranking exercise. The independent-samples *t*-test was then adopted to identify four barriers with ranking differences, namely ‘a contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him’, ‘there is a negative impact on the image of the design team in the D&B method’, ‘D&B contractors carry a high degree of risks and liability’, and ‘there is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements’. The differences in rankings between client and contractor responses on the barriers to developing the D&B method have some implications on their attitudes to promote D&B.

11.3.2 Conceptual Model of Success for D&B Projects

The concept of project success remains vague among project participants, and the goal of the research was to indicate the success level of a D&B project. The D&B project participants perceived time, cost, quality and functionality as the important criteria for the success of D&B projects, and the equation for representing the success level of D&B projects was formulated by means of an index to indicate the performance of a D&B project. Moreover, forty-two success factor variables were developed from literature and grouped into twelve underlying factors by Factor Analysis. Stepwise Multiple Regression analysis was next employed to identify factors which have strong predictive powers for the success of D&B projects, and to establish how these factors affect the performance level of D&B projects.

The research suggested that the effectiveness of project management action is the best predictor for the success of D&B projects, followed by working relationships among project team members and project attractiveness. Other factors that also proved to be strong predictors for success include the client's input in the project and the application of innovative management approaches. Fig. 11.1 demonstrates the relative strengths of the predictors for success of D&B projects developed from the research.

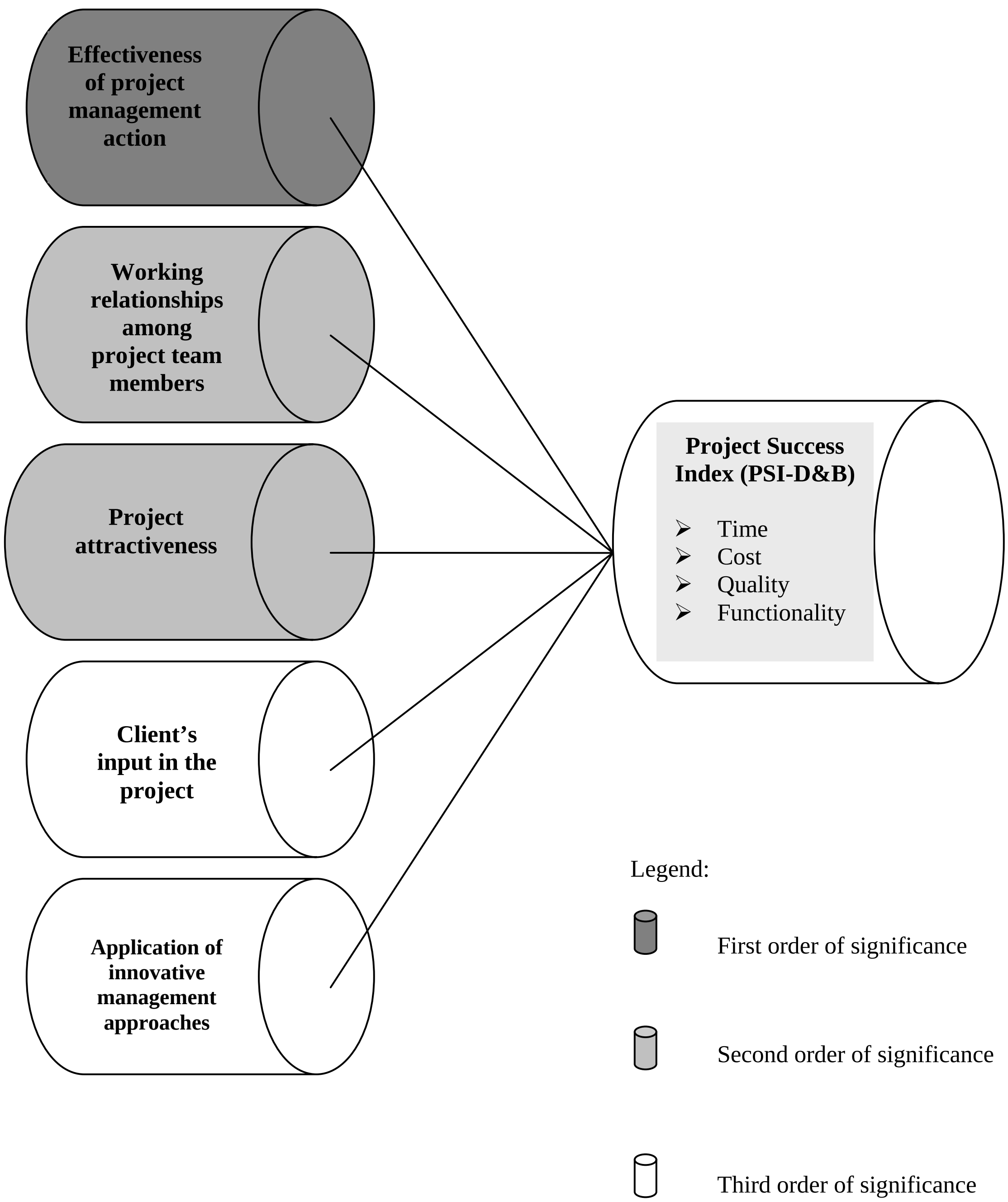


Fig. 11.1 Relative strengths of predictors for success of D&B projects

Chan (1996b) conducted research in the determinants of construction projects in the Hong Kong construction industry and established 15 determining factors to ten performance measures. In his research, he identified "effectiveness of construction team leader" as the most determining factor with the first order of significance. Other models of project success have also been described in Chapter 4. The following conclusions were drawn on the relationships between the success criteria and critical success factors of D&B projects:

1. More effective project management action increases the performance of time, quality and functionality, and the overall success of D&B projects.
2. Better working relationships among project team members results in better cost and quality performance of D&B projects.
3. The attractiveness of D&B projects is positively associated with the time performance and its overall success level.
4. Client's input in the project is positively associated with the cost performance of D&B projects.
5. Adoption of innovative management approaches, such as partnering and value management, can result in higher time and cost performance, and the overall success of D&B projects.

The conceptual model developed from the research was further tested through both quantitative and qualitative approaches. A test group of five D&B project participants in the Hong Kong construction industry was invited to complete questionnaires for validation purposes, and the data were collected to compute the factor scores of each test sample. The computed and actual values of the project success indices for D&B projects and the performance measures of time, cost, quality and functionality were then calculated. The paired-samples *t* test was also employed to analyze the paired data of each success criterion, and the results showed that the computed values derived from the multiple regression models are good predictors of the project success index and of the performance of the four success criteria for D&B projects. Structured interviews with three D&B project participants in Hong Kong also showed that the results are reasonable and reliable.

11.4 VALUE OF THE RESEARCH

The research initiated a comprehensive investigation of success for D&B projects in the Hong Kong construction industry. It presents the current application of the D&B method in the local context and provides a review of previous studies on significant ingredients and indicators of success for delivering D&B projects. A pilot study with D&B project participants and an industry-wide questionnaire survey were also conducted to glean information and personal perceptions from the local D&B participants, and the research findings were confirmed to be influential to knowledge development and applicable to D&B project management.

11.4.1 Contributions to Knowledge

The research adopted a response-based approach to evaluating the current practice of the D&B method in terms of the reasons for the wider adoption of the D&B method in the public sector, the problems of running D&B projects and the barriers to the choice of the D&B method. The analyses for internal consistency and correlations enable D&B project participants to realize the perceptions held by other project team members of the benefits of the D&B method with respect to the objectives set for their projects. This can enhance decision-making and provide a clearer idea of the inhibitors that impede the healthy development of the D&B method. While the barriers may not be eradicated at an early stage of D&B development, the team members can focus on the problems in running D&B projects to formulate project management strategies accordingly. This research provided sound evidence that there is agreement among the D&B clients, contractors and consultants on the ranking of the reasons, which is absent between clients and contractors on the problem and barrier rankings.

The research was original in developing a conceptual model of success for D&B projects in the local context. It identified time, cost, quality and functionality as the important success criteria of D&B projects. In fact, the concept of Key Performance Indicators (KPIs) has been applied recently to enable the measurement of projects in the construction industry for benchmarking purposes. The current research further established the project success index for D&B projects (PSI-D&B) from the perspectives of the D&B project participants on the success criteria of D&B projects. This was done in order to combine the various dependent variables to represent the overall success of D&B projects. The move from KPI to PSI-D&B has provided valuable insights to the performance measures of D&B projects in the construction industry.

While success is considered as the result of a construction process, it is necessary to determine the factors that contribute to the outcome of a D&B project. The research adopted various approaches to analyze these success factors, and the relationships between critical success factors and success criteria of D&B projects from the statistical analyses of the data derived from a research questionnaire in the local context were studied. The predictors for D&B project success were also determined which reaffirmed the previous findings from literature while also enriching the knowledge base for the D&B procurement system.

11.4.2 Applications of the Research

This study presented the application of the D&B method in Hong Kong with comparisons of the responses of the D&B participants so that the team players can better understand the local practice of the D&B method. Chang and Ibbs (1998) described measurement as an essential step in any control process. The identification of success criteria can provide project participants with indicators to attain success for their D&B projects. In recent years, a set of Key Performance Indicators (KPIs) has been produced and used to assess the performance of projects for benchmarking and control purposes (Kroese and Al-jibouri, 2003). These KPIs provide targets for the construction industry against which performances can be measured. Moreover, Critical Success Factors (CSFs) can provide participants with a focus for what they should be aware of in order to ensure the success of a project. In fact, an evaluation of the CSFs for D&B projects is likely to lead to a better appreciation of D&B benefits and problems. Such an improved understanding can generate essential strategies to alleviate the root causes of poor performance and ineffective communication. Moreover, the identification of critical success factors of D&B projects can develop a 'best practice' D&B framework to form basic guidelines and structures for implementing successful D&B projects in future. Effective strategies can also be suggested for preparing project procedures manuals, for project controls, and for conducting D&B workshops and writing manuals to enhance project performance. The D&B project participants can allocate resources accordingly.

The computation of the project success index for D&B projects (PSI-D&B) can further be used as an indicator to assess whether a D&B project is a success or a failure. By identifying the factors that have a strong effect on project performance, practitioners can set up an effective management system to run D&B projects with excellent performance. Corrective measures can then be taken before major problems occur. Such a framework can also be used to examine and review past projects, as well as to maximize the likelihood of success for future projects. Benchmarking is an effective way of helping organizations to deliver better services through continuous improvement. The results of this work can be used by building clients, construction management teams and project management consultants to establish benchmark measures for D&B project success. The plot of PSI-D&B and the pool of D&B projects also enable project participants to know the relative position of the performance of their projects so that improvements can be made. Construction companies can therefore benchmark their performance to enable them to identify strengths and weaknesses.

The research should also help in setting a benchmark for D&B research and provides a further research platform for examining alternative procurement methods. The results of the study can be used as a basis for an international study in Asia, Europe or North America. Such an extension of the research will aid the understanding of managing D&B projects in different cultures, particularly in the Asia-Pacific region. This would allow project team members to concentrate on the more important variables and manage them well, thereby improving the potential for project success. Moreover, academic programmes in construction management can be enriched and students can be trained in the skills needed to manage D&B projects efficiently and effectively. Such an understanding can provide a foundation for developing uniform guidelines and practices on a global basis, and generate further insights into the study curriculum in the industry. It also enables an exchange of culture and practice worldwide.

11.5 RESEARCH IMPLICATIONS

The D&B method was found to improve the performance of construction projects (Retherford, 1998). The research suggests that there is significant disagreement between clients and contractors on ranking the problems of running D&B projects. Therefore, both parties should share a common understanding if they are the problem contributors. It was also discovered that the predictors for time performance are identical to those for the overall success performance of D&B projects (PSI-D&B). Therefore, if those critical success factors are properly managed, the benefits of time from the D&B method can better be observed. Moreover, the critical success factor of the application of innovation management approaches is found to have relationships with three performance measures, one fewer than the most important determinant (Table 9.6). In fact, D&B fosters partnering by encouraging more coordination and communication among project participants (Yates, 1995). Partnering attempts to establish harmonious working relationships among project stakeholders through a mutually developed, formal strategy of commitment and communication aimed at a ‘win-win’ outcome for all parties (Chan et al., 2004). It is believed that through participation in D&B projects, project team members can gradually improve their adverse relationships developed in the traditional procurement system. It is teamwork and partnering that will result in project success in the years ahead.

11.6 LIMITATIONS OF THE RESEARCH

The research adopted a response-based approach to develop the conceptual model of success for D&B projects; hence, the analyses are based on the perceptions of D&B participants. In fact, the limited sample size and the difficulty in quantifying the attributes may result in low adjusted coefficients of determination (adjusted R^2) for the regression models of cost, quality and functionality (<0.5). The increasing number of D&B projects makes it possible to collect more objective data in generating the project success index. The increase in sample size may also affect the rankings of success criteria in the project success equation for D&B projects. Moreover, the scope of the research is confined to the Hong Kong context and differences might be observed if samples were collected in a worldwide manner.

11.7 RECOMMENDATIONS FOR FUTURE WORK

D&B is at a development stage in Hong Kong and is employed mainly in the public sector. When more D&B projects are launched, further studies can be carried out to study the determinants of success for D&B projects in the private sector. Other regression models with higher adjusted R^2 can be constructed with larger sample size. Similar research can also be conducted on a global basis so that industry participants can master the alternative procurement method. The model can also be modified by testing for differences between groups on the success criteria in developing the project success equation. The best industry practice of successful

D&B projects can then be generated and used as a benchmark measure for future projects. A further research platform examining different types of D&B projects, such as the building type and civil engineering type, can also be set up to compare and contrast the conceptual models developed from different project types. Similar techniques can also be applied to other procurement methods, such as management contracting and construction management for project success studies.

11.8 CHAPTER SUMMARY

The research met the objectives set out in Chapter 1, and the main conclusions and the value of the research were summarized. In fact, more research on the topic can be conducted, and future research directions have been suggested. It is believed that the current research provides insights on the knowledge of procurement and also provides practical benefits to construction practitioners.

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APPENDIX A

SAMPLE OF INVITATION LETTER FOR STRUCTURED INTERVIEWS

Receiver's Address

Date

Dear,

Re: Request for an Interview

I am a PhD candidate at the Department of Building and Real Estate of The Hong Kong Polytechnic University under the joint supervision of Dr. Albert Chan and Prof. David Scott. My research topic is '*A Conceptual Model of Success for Design and Build Projects in the Public Sector of Hong Kong*'. The main objectives of this project are to formulate a framework to measure project success for design-build projects, to identify those factors that are essential for running a successful design-build project in the Public Sector and to study how the factors affect the performance level of the project. The ultimate goal is to develop a conceptual model to link the critical success factors to the project performance of design-build projects.

I would like to request for your kind permission to conduct an interview for my research project. The interview time is approximately one hour. You are free to use English or Cantonese during the interview and I would like to record the whole conversation by an electronic recorder so that the tasks of transcription and translation can be done with high accuracy. The questions and information sheets for the project are enclosed herewith for your reference. It would be highly appreciated if you could help me complete the information sheets before our interview to facilitate the interview process. I strongly believe that your experience and expertise is highly valuable to the academics and practitioners in the industry.

Your professional advice would be of great significance in drawing a representative conclusion for my research study and of great value to improvements for future projects. If you are willing to help me with my project, could you please contact me at your earliest convenience at 9313- or by e-mail to edmond.lam@

Thank you for your kind attention and consideration. I am looking forward to hearing from you soon.

Sent by:

Mr. Edmond W.M. Lam
PhD Candidate
The Hong Kong Polytechnic University
Encl.

Endorsed by:

Dr. Albert P.C. Chan
Associate Professor
The Hong Kong Polytechnic University

APPENDIX B

DOCUMENTS FOR STRUCTURED INTERVIEWS

B.1 Sample of interview questions

B.2 Sample of project information sheets

Questions for Interviews in the Pilot Study

Background Information

1. How do we define ‘design-build’ in the public sector?
2. Why is D&B more popularly used in the public sector of Hong Kong?
3. What are the difficulties of running D&B projects?
4. Does your company do any research in D&B projects?
5. Do you favour the use of D&B?
6. How do you think about the development of D&B in Hong Kong?

Project Characteristics

1. Why is D&B adopted in the project?
2. What do you think is the most suitable project type for the D&B procurement method?
3. How is the brief developed in the D&B contract?

Contract Procedures

1. Who initiates the project delivery method for a project?
2. In what ways do you think does the release of the HK Government Design and Build Contract help the implementation of the D&B project delivery method?
3. What are the main differences between the 1992 edition and the 1999 edition?
4. What do you think are the amendments in the Contract to make contractors more incentive to provide alternative solutions?
5. What are the main differences in selecting the contractor for a D&B project when compared to that under the traditional design-bid-build system?

Project Management Action

1. What do you think are the effective measures to control the quality of design and workmanship of a D&B project?
2. What are the mechanisms to check that the details of the contractor’s proposals match with those of the employer’s requirements?
3. Is there any control system on the feedbacks of clients, consultants, contractors and even the end-users in regard to the briefing stage of a D&B project?
4. Are there any other more innovative management approaches adopted in the D&B project?
5. As D&B is one kind of alternative procurement system, how can you manage a D&B project efficiently with different project nature?
6. As HK does not have a pool of D&B specialist contractors, how can the D&B experience be gathered?

Project Performance

1. What do you think are the major criteria to measure success for D&B projects?
2. Is there any time delay or cost overrun?
3. Are you satisfied with the D&B Project?

Project Success Factors

1. What do you think are the success factors for D&B projects?

****Thank you for your invaluable knowledge and experience****

To: Edmond Lam   Fax No.: 2764-5131   Contact Mobile: 9313-

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

INFORMATION SHEETS FOR DESIGN-BUILD PROJECTS

Please fill in the blanks or tick the appropriate answer for the D&B project.

1. Project Name: ______________________________

2. Classification of Project: ❑ Quarter ❑ Offices building ❑ Maintenance depot

   ❑ Godown ❑ Hospital ❑ Slaughterhouse ❑ Services Facilities ❑ Roadworks

   ❑ Quarry ❑ Others; please specify: ______________

3. What type of tendering method was used?

   ❑ Open tendering ❑ Selective tendering ❑ Negotiation tendering

   ❑ Others; please specify: ______________________________

4. Was there any other more innovative management principle applied in the Project?

   ❑ Partnering ❑ Value Management/Engineering ❑ Others; please specify: __________

5. Maximum number of floors below ground level (if applicable): ______________

6. Maximum number of floors above ground level (if applicable): ______________

7. Total gross floor area (if applicable): ______________ m^2

8. Original contract sum at tender award: HK $______________ Million

9. Final contract sum at completion: HK $______________ Million

10. Project commencement date: ______________________

11. Practical completion date: ______________________

12. Actual completion date: ______________________

13. Original construction period at tender stage: ______________ (calendar days / working days)*

14. Final project duration: ______________ (calendar days / working days)*

15. Total agreed E.O.T.: ______________________ (calendar days / working days)*

* Please delete as appropriate

16. Number of claims and disputes that arose during the construction period: ____________________

17. What percentage of the contract sum did the claims and disputes represent in terms of cost? ___%

18. What percentage of the contract period did the claims and disputes represent in terms of time?

    ___%

19. Number of accidents that arose during the construction period: ______________________

20. Number of complaints received caused by the environmental issues: ________________________

21. The parties (with contact persons and phone nos.) involved in this project:

    a. Client: ____

    b. Main contractor: ____

    c. Architect/ Engineer: ____

    d. Project Management Consultant (if any): _______________________________

    e. Structural Engineer (if any): ____

    f. E & M Engineer (if any): ____

    g. Quantity Surveyor (if any): ____

    h. Others; please specify ____

** Thank you for your information**

APPENDIX C

SAMPLE OF RESEARCH QUESTIONNAIRE

Instruction

This questionnaire intends to collect responses from different professionals in D&B projects in Hong Kong. Please answer all questions with reference to a *D&B project* you have involved in and use another set of questionnaire if you have experience for more than one D&B projects. Kindly show your perceptions to all items by ticking *ONE* appropriate box for your answer.

1. About The Respondent

1. Your Position: ______________________________

2. Professional affiliation: ❑ Architect ❑ Builder ❑ Quantity surveyor ❑ Engineer
   ❑ Others; please specify: ______________________

3. Highest academic qualification obtained: ❑ Diploma/Certificate ❑ Bachelor's Degree
   ❑ Postgraduate Diploma ❑ Master's Degree
   ❑ Doctorate Degree ❑ Others: ___________

4. Years of experience in the construction industry:
   ❑ less than 5 years ❑ 5 to 9 years ❑ 10 to 14 years ❑ 15 to 19 years
   ❑ 20 years or more

5. Type of organization in which you are working:
   ❑ Client organization ❑ Main Contractor ❑ Architectural firm
   ❑ Engineering consultant ❑ Project management consultant ❑ Q.S. consultant
   ❑ Sub-contractor ❑ Others; please specify:________________

6. Size of your organization: ❑ 100 staff or below ❑ 101-200 staff ❑ 201-300 staff
   ❑ 301-400 staff ❑ 401-500 staff ❑ Over 500 staff

7. Please indicate your experience in running design-build projects.
   ❑ Experience for one D&B project.
   ❑ Experience for two D&B projects.
   ❑ Experience for three or more D&B projects.
   ❑ Others; please specify: ____

2. About The Problems in Running D&B Projects

Please rate the following problems that the D&B project had brought to you and other project participants.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. It was difficult to reach a consensus on the client's requirements due to the different interpretations of the project participants	❑	❑	❑	❑	❑	❑	❑
2. It was hard to understand the client's requirements in the project	❑	❑	❑	❑	❑	❑	❑
3. There was a conflict of interest between the design team members and the contractor	❑	❑	❑	❑	❑	❑	❑
4. D&B contractors were not competent with design issues	❑	❑	❑	❑	❑	❑	❑
5. It was difficult to control design quality in that project	❑	❑	❑	❑	❑	❑	❑
6. It was difficult to control workmanship in that project	❑	❑	❑	❑	❑	❑	❑
7. Frequent changes were introduced by various clients	❑	❑	❑	❑	❑	❑	❑
8. Frequent changes were introduced by various end-users	❑	❑	❑	❑	❑	❑	❑
9. The schedule was tight	❑	❑	❑	❑	❑	❑	❑

2. About The Problems in Running D&B Projects (Cont'd)

Please rate the following problems that the D&B project had brought to you and other project participants.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
10. There was no room for innovation in that project	❑	❑	❑	❑	❑	❑	❑
11. It was difficult to compare the contractor's proposal with the client's brief	❑	❑	❑	❑	❑	❑	❑
12. Stress was placed on the project by the client	❑	❑	❑	❑	❑	❑	❑
13. There was ambiguity in allocating the responsibilities in the contract	❑	❑	❑	❑	❑	❑	❑
14. The provision of various services was poorly coordinated	❑	❑	❑	❑	❑	❑	❑
15. The project participants were unclear about their roles in D&B	❑	❑	❑	❑	❑	❑	❑
16. The scope of the D&B project was ill-defined	❑	❑	❑	❑	❑	❑	❑
17. Others; please specify: ____	❑	❑	❑	❑	❑	❑	❑

3. About The Barriers to D&B Development in Hong Kong

Please rate the following barriers that hinder the healthy development of D&B in Hong Kong.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	❑	❑	❑	❑	❑	❑	❑
2. It takes more effort to develop the client's requirements for D&B projects	❑	❑	❑	❑	❑	❑	❑
3. There is a lack of capable and experienced D&B contractors	❑	❑	❑	❑	❑	❑	❑
4. There is a negative impact on the image of the design team in the D&B method	❑	❑	❑	❑	❑	❑	❑
5. There is a restriction on design flexibility in D&B projects	❑	❑	❑	❑	❑	❑	❑
6. D&B contractors carry a high degree of risk and liability	❑	❑	❑	❑	❑	❑	❑
7. There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	❑	❑	❑	❑	❑	❑	❑
8. Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	❑	❑	❑	❑	❑	❑	❑
9. Clients are not aware of the benefits of the D&B method	❑	❑	❑	❑	❑	❑	❑
10. Clients prefer traditional practice to the D&B method	❑	❑	❑	❑	❑	❑	❑
11. Project participants do not have confidence in managing D&B projects successfully	❑	❑	❑	❑	❑	❑	❑
12. There is a lack of promotion of D&B within the industry	❑	❑	❑	❑	❑	❑	❑
13. There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	❑	❑	❑	❑	❑	❑	❑
14. D&B contractors do not have sufficient design management expertise	❑	❑	❑	❑	❑	❑	❑
15. There is a lack of D&B knowledge and experience in Hong Kong	❑	❑	❑	❑	❑	❑	❑
16. D&B contractors do not have in-house architects and engineers	❑	❑	❑	❑	❑	❑	❑
17. Others; please specify: ____	❑	❑	❑	❑	❑	❑	❑

4. About The Project

4.1 Project scope details (Optional)

1. Name of project (Contract No.; if appropriate): ____________________
2. Type of project: ❑ Building work ❑ Civil work ❑ Foundation work ❑ E&M work
   ❑ Others; please specify: ______________
3. Type of D&B used: ❑ Traditional D&B ❑ Enhanced D&B ❑ Novated D&B
   ❑ Others; please specify: ______________
4. Classification of project: ❑ Residential ❑ Office Building ❑ Maintenance Depot
   ❑ Godown ❑ Hospital ❑ Slaughterhouse ❑ Services Facilities
   ❑ Roadworks ❑ Quarry ❑ Others; please specify: ______________
5. Nature of project: ❑ New work ❑ Refurbishment ❑ Redevelopment
   ❑ Extension ❑ Fitting-out ❑ Others; please specify: ______________
6. Progress of project: ❑ Completed ❑ On-going
7. Maximum number of floors below ground level (if applicable): ______________
8. Maximum number of floors above ground level (if applicable): ______________
9. Gross floor area (if applicable): ______________ m^2
10. Original contract sum at tender award: HK $______________ Million
11. Final contract sum at completion: HK $______________ Million
12. Total amount of V.O.: HK $______________ Million
13. Project commencement date: ______________
14. Practical completion date: ______________
15. Total agreed E.O.T.: ______________ working days
16. Original construction period at tender stage: ______________ (calendar days / working days)*
17. Number of claims and disputes that arose during the construction period: ______________
18. Number of reported accidents that arose during the construction period: ______________
19. Number of environmental complaints that arose during the construction period: ______________

4.2 Project features

Please rate the following statements to reflect the special features of the D&B project.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The physical conditions of the site were complex	❑	❑	❑	❑	❑	❑	❑
2. It was difficult to get access to or within the site	❑	❑	❑	❑	❑	❑	❑
3. The coordination of design and installation was complicated	❑	❑	❑	❑	❑	❑	❑
4. The contractor’s input could achieve the buildability of design	❑	❑	❑	❑	❑	❑	❑
5. The procedures for quality management were complex	❑	❑	❑	❑	❑	❑	❑
6. This project was housed with various types of building services	❑	❑	❑	❑	❑	❑	❑
7. This project required a heavy use of new technology	❑	❑	❑	❑	❑	❑	❑
8. This project had a well defined scope	❑	❑	❑	❑	❑	❑	❑
9. The client’s requirements of this D&B project were clear	❑	❑	❑	❑	❑	❑	❑
10. The project enabled the contractor to utilize special skills	❑	❑	❑	❑	❑	❑	❑
11. The project was flexible enough to allow alternative solutions	❑	❑	❑	❑	❑	❑	❑
12. This project was unique to other D&B projects	❑	❑	❑	❑	❑	❑	❑
13. This project could be considered innovative	❑	❑	❑	❑	❑	❑	❑
14. This project was attractive to tenderers	❑	❑	❑	❑	❑	❑	❑

* Please delete as appropriate

5. About The Project Procedures

1. Which conditions of contract did the D&B project adopt?
   General Conditions of Contract for: ❑ Building Works ❑ D&B Works ❑ Civil Works
   ❑ Others; please specify: ____

2. What type of tendering methods was used for this D&B project?
   ❑ Open ❑ Selective ❑ Negotiation ❑ Others; please specify: _________________

3. Was there any innovative management approach adopted?
   ❑ No (go to No. 6) ❑ Partnering (go to No. 4) ❑ Value management (go to No. 5)
   ❑ Partnering & Value management (go to Nos. 4 & 5) ❑ Others; please specify:_____________

4. i) Who initiated it? _______________________
   ii) How many workshops were conducted? ______
   iii) Who were involved? _____________________
   iv) Was there regular review meeting? ❑ Yes ❑ No
   v) Was there a charter signed? ❑ Yes ❑ No
   vi) What was the dispute resolution mechanism?
   ____

5. i) Who initiated it? _______________________
   ii) How many workshops were conducted? ______
   iii) Who were involved? _____________________
   iv) Was there regular review meeting? ❑ Yes ❑ No
   v) Was there a report signed? ❑ Yes ❑ No
   vi) What was the value management technique?
   ____

6. About The Project Environments

Please rate the following statements to indicate the project environment under which the D&B project was subjected to.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The disturbance of the physical environment (e.g., weather, ground conditions) to the project was minimal	❑	❑	❑	❑	❑	❑	❑
2. The prevailing economic environment was positive	❑	❑	❑	❑	❑	❑	❑
3. The government provided resources to the D&B project	❑	❑	❑	❑	❑	❑	❑
4. The society did not act against the D&B project	❑	❑	❑	❑	❑	❑	❑
5. Participants from other industries (e.g., manufacturing, business) showed a supportive attitude to the D&B project	❑	❑	❑	❑	❑	❑	❑
6. The overall environment was supportive to the D&B project	❑	❑	❑	❑	❑	❑	❑

7. About The Project-related Participants

7.1 Client details

1. Organization of client: ____
2. Nature of client: ❑ Public ❑ Private ❑ Others; please specify: _________________
3. Years of experience with the client
   ❑ less than 5 years ❑ 5 to 9 years ❑ 10 to 14 years ❑ 15 to 19 years
   ❑ 20 years or more
4. Size of client organization
   ❑ Large corporation (500+ employees)
   ❑ Medium sized (50+ to 500 employees)
   ❑ Small sized (up to 50 employees)
5. Main business of client organization
   ❑ Construction ❑ Non-construction

7.2 Client objectives

Please rate the following statements that best describe the emphasis of the client's project objectives.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Competitive tender price	❑	❑	❑	❑	❑	❑	❑
2. Timely completion	❑	❑	❑	❑	❑	❑	❑
3. Certainty of time	❑	❑	❑	❑	❑	❑	❑
4. Certainty of cost without fluctuation	❑	❑	❑	❑	❑	❑	❑
5. Availability of competent contractors	❑	❑	❑	❑	❑	❑	❑
6. Clear end-users' requirements	❑	❑	❑	❑	❑	❑	❑
7. Complexity of project	❑	❑	❑	❑	❑	❑	❑
8. Flexibility for changes	❑	❑	❑	❑	❑	❑	❑
9. Transfer of risk	❑	❑	❑	❑	❑	❑	❑
10. Single point of responsibility	❑	❑	❑	❑	❑	❑	❑
11. Familiarity with the project	❑	❑	❑	❑	❑	❑	❑

7.3 Competency measures of the client

Please rate the following statements that best describe the competency of the client.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Ability to effectively brief the design team	❑	❑	❑	❑	❑	❑	❑
2. Ability to quickly make authoritative decisions	❑	❑	❑	❑	❑	❑	❑
3. Ability to effectively define the roles of the participants	❑	❑	❑	❑	❑	❑	❑
4. Ability to contribute ideas to the design process	❑	❑	❑	❑	❑	❑	❑
5. Ability to contribute ideas to the construction process	❑	❑	❑	❑	❑	❑	❑

7.4 Competency measures of the client's representative

Please rate the following statements that best describe the competency of the client's representative.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Technical skills	❑	❑	❑	❑	❑	❑	❑
2. Planning skills	❑	❑	❑	❑	❑	❑	❑
3. Organization skills	❑	❑	❑	❑	❑	❑	❑
4. Coordinating skills	❑	❑	❑	❑	❑	❑	❑
5. Leadership skills	❑	❑	❑	❑	❑	❑	❑
6. Controlling skills	❑	❑	❑	❑	❑	❑	❑
7. Experience and capabilities	❑	❑	❑	❑	❑	❑	❑
8. Commitment to meeting the targets of time, cost and quality	❑	❑	❑	❑	❑	❑	❑
9. Early and continued involvement in the project	❑	❑	❑	❑	❑	❑	❑
10. Adaptability to changes in the project plan	❑	❑	❑	❑	❑	❑	❑
11. Working relationship with others	❑	❑	❑	❑	❑	❑	❑
12. Support from the parent company	❑	❑	❑	❑	❑	❑	❑

7.5 Competency measures of the contractor's consultants

Please rate the following statements that best describe the competency of the contractor's consultants.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Technical skills	❑	❑	❑	❑	❑	❑	❑
2. Planning skills	❑	❑	❑	❑	❑	❑	❑
3. Organization skills	❑	❑	❑	❑	❑	❑	❑
4. Coordinating skills	❑	❑	❑	❑	❑	❑	❑
5. Leadership skills	❑	❑	❑	❑	❑	❑	❑
6. Controlling skills	❑	❑	❑	❑	❑	❑	❑
7. Experience and capabilities	❑	❑	❑	❑	❑	❑	❑
8. Commitment to meeting the targets of time, cost and quality	❑	❑	❑	❑	❑	❑	❑
9. Early and continued involvement in the project	❑	❑	❑	❑	❑	❑	❑
10. Adaptability to changes in the project plan	❑	❑	❑	❑	❑	❑	❑
11. Working relationship with others	❑	❑	❑	❑	❑	❑	❑
12. Support by parent company	❑	❑	❑	❑	❑	❑	❑

7.6 Competency measures of the construction team leader

Please rate the following statements that best describe the competency of the construction team leader.	Very High	High	Slightly High	Average	Slightly Low	Low	Very Low
1. Technical skills	❑	❑	❑	❑	❑	❑	❑
2. Planning skills	❑	❑	❑	❑	❑	❑	❑
3. Organization skills	❑	❑	❑	❑	❑	❑	❑
4. Coordinating skills	❑	❑	❑	❑	❑	❑	❑
5. Leadership skills	❑	❑	❑	❑	❑	❑	❑
6. Controlling skills	❑	❑	❑	❑	❑	❑	❑
7. Experience and capabilities	❑	❑	❑	❑	❑	❑	❑
8. Commitment to meeting the targets of time, cost and quality	❑	❑	❑	❑	❑	❑	❑
9. Early and continued involvement in the project	❑	❑	❑	❑	❑	❑	❑
10. Adaptability to changes in the project plan	❑	❑	❑	❑	❑	❑	❑
11. Working relationship with others	❑	❑	❑	❑	❑	❑	❑
12. Support by parent company	❑	❑	❑	❑	❑	❑	❑

7.7 Competency measures of the end users

Please rate the following statements that best describe the competency of the end users.	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Ability to effectively brief the needs to the D&B team	❑	❑	❑	❑	❑	❑	❑
2. Ability to contribute ideas to the design process	❑	❑	❑	❑	❑	❑	❑
3. Ability to contribute ideas to the construction process	❑	❑	❑	❑	❑	❑	❑

8. About The Project Management Strategies

Please rate the following statements that best describe the level of effectiveness of managerial strategies in the D&B project.	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Channels of communication systems	❑	❑	❑	❑	❑	❑	❑
2. Control mechanism, such as monitoring and updating	❑	❑	❑	❑	❑	❑	❑
3. Feedback channels	❑	❑	❑	❑	❑	❑	❑
4. Up-front planning efforts	❑	❑	❑	❑	❑	❑	❑
5. Quality system, like quality controls and assurance	❑	❑	❑	❑	❑	❑	❑
6. Safety system	❑	❑	❑	❑	❑	❑	❑
7. Risk management system	❑	❑	❑	❑	❑	❑	❑
8. Conflict management system	❑	❑	❑	❑	❑	❑	❑
9. Control of subcontractors	❑	❑	❑	❑	❑	❑	❑
10. Reporting system	❑	❑	❑	❑	❑	❑	❑
11. Development of standard procedures	❑	❑	❑	❑	❑	❑	❑
12. Regular meetings with the project participants	❑	❑	❑	❑	❑	❑	❑
13. Organizational structure	❑	❑	❑	❑	❑	❑	❑

9. About The Project Work Atmosphere

Please rate the following statements that best described the effects of human-related factors on the D&B project.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The client delegated adequate decision-making authority to the construction team leader	❑	❑	❑	❑	❑	❑	❑
2. The client delegated adequate decision-making authority to the contractor's consultants	❑	❑	❑	❑	❑	❑	❑
3. The construction team leader delegated adequate decision-making authority to the contractor's consultants	❑	❑	❑	❑	❑	❑	❑
4. The construction team leader was confident of the design of the D&B project	❑	❑	❑	❑	❑	❑	❑
5. The construction team leader was confident of the construction of the D&B project	❑	❑	❑	❑	❑	❑	❑
6. The D&B team was cohesive and well-integrated	❑	❑	❑	❑	❑	❑	❑
7. The team members enjoyed working relationships with one another	❑	❑	❑	❑	❑	❑	❑
8. The team members established satisfaction, expectations and values from the project	❑	❑	❑	❑	❑	❑	❑
9. The team members developed respect and mutual trust with one another	❑	❑	❑	❑	❑	❑	❑

10. About The Personal Views on Success Factors for D&B Projects

Please rate the following that you consider the factors for determining the success of a D&B project.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. Project Characteristics	❑	❑	❑	❑	❑	❑	❑
2. Project Procedures	❑	❑	❑	❑	❑	❑	❑
3. Project Environments	❑	❑	❑	❑	❑	❑	❑
4. Project-related Participants	❑	❑	❑	❑	❑	❑	❑
5. Project Management Strategies	❑	❑	❑	❑	❑	❑	❑
6. Project Work Atmosphere	❑	❑	❑	❑	❑	❑	❑
7. Others; please specify: ______________________________________	❑	❑	❑	❑	❑	❑	❑

11. About The Personal Views on Success Criteria for D&B Projects

Please prioritize the success criteria for a D&B project.	Highly Unimportant	Unimportant	Slightly Unimportant	Neutral	Slightly Important	Important	Highly Important
1. The Project should be completed on schedule	❑	❑	❑	❑	❑	❑	❑
2. The Project should be completed on budget	❑	❑	❑	❑	❑	❑	❑
3. The Project should be completed to the specified quality standard	❑	❑	❑	❑	❑	❑	❑
4. The Project should achieve its fundamental functions	❑	❑	❑	❑	❑	❑	❑
5. The Project should be completed with a low accident rate	❑	❑	❑	❑	❑	❑	❑
6. The Project should be completed with minimal claims and disputes	❑	❑	❑	❑	❑	❑	❑
7. The Project should be completed with environmental consciousness	❑	❑	❑	❑	❑	❑	❑
8. The Project should serve the aesthetic purpose	❑	❑	❑	❑	❑	❑	❑
9. The Project should create learning value	❑	❑	❑	❑	❑	❑	❑
10. The Project should satisfy the expectations of the project participants	❑	❑	❑	❑	❑	❑	❑
11. The Project should provide the participants with a professional image	❑	❑	❑	❑	❑	❑	❑
12. Others; please specify: ______________________________________	❑	❑	❑	❑	❑	❑	❑

12. About The Level of Satisfaction (Project Level)

Please indicate the level of your satisfaction with the performance of the D&B project.	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Satisfaction with time	❑	❑	❑	❑	❑	❑	❑
2. Satisfaction with cost	❑	❑	❑	❑	❑	❑	❑
3. Satisfaction with quality of design	❑	❑	❑	❑	❑	❑	❑
4. Satisfaction with quality of workmanship	❑	❑	❑	❑	❑	❑	❑
5. Satisfaction with achieving functionality	❑	❑	❑	❑	❑	❑	❑
6. Satisfaction with health issues	❑	❑	❑	❑	❑	❑	❑
7. Satisfaction with safety records	❑	❑	❑	❑	❑	❑	❑
8. Satisfaction with aesthetics aspects	❑	❑	❑	❑	❑	❑	❑
9. Satisfaction with buildability issues	❑	❑	❑	❑	❑	❑	❑
10. Satisfaction with achieving environmental friendliness	❑	❑	❑	❑	❑	❑	❑
11. Satisfaction with learning purposes	❑	❑	❑	❑	❑	❑	❑
12. Satisfaction with the overall performance	❑	❑	❑	❑	❑	❑	❑

13. About The Project Performance

Please indicate the performance of the D&B project.

1. Time performance: ❑ On schedule
❑ ahead / ❑ behind schedule by: ❑ below 1% ❑ 1% to 5% ❑ 6% to 10% ❑ more than 10%

2. Cost performance: ❑ On budget
❑ underrun / ❑ overrun budget by: ❑ below 1% ❑ 1% to 5% ❑ 6% to 10% ❑ more than 10%

3. Claim and Dispute occurrence: ❑ Claim- and Dispute-free ❑ Indifferent to an average project
❑ above / ❑ below an average project by: ❑ below 1% ❑ 1% to 5% ❑ 6% to 10% ❑ more than 10%

4. Accident occurrence: ❑ Accident-free ❑ Indifferent to an average project
❑ above / ❑ below an average project by: ❑ below 1% ❑ 1% to 5% ❑ 6% to 10% ❑ more than 10%

5. Pollution occurrence: ❑ Pollution-free ❑ Indifferent to an average project
❑ above / ❑ below an average project by: ❑ below 1% ❑ 1% to 5% ❑ 6% to 10% ❑ more than 10%

6. Quality performance:
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

7. Functionality performance:
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

8. Aesthetic value
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

9. Learning value
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

10. Expectation achievement
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

11. Professional image establishment
❑ far below average ❑ below average ❑ average ❑ above average ❑ well above average

12. Overall performance:
❑ very unsuccessful ❑ unsuccessful ❑ average ❑ successful ❑ very successful

13. About The Reasons for the Increasing Use of D&B in the Public Sector of Hong Kong

Please rate the following reasons that account for the increasing adoption of D&B in the Public Sector of Hong Kong.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. D&B enables the government to maximize the use of resources and design expertise from the private sector	❑	❑	❑	❑	❑	❑	❑
2. The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	❑	❑	❑	❑	❑	❑	❑
3. D&B reduces disputes and arbitration	❑	❑	❑	❑	❑	❑	❑
4. The project size in the public sector makes D&B feasible to apply	❑	❑	❑	❑	❑	❑	❑
5. The public sector is more willing to try new procurement systems	❑	❑	❑	❑	❑	❑	❑
6. The D&B contractor bears all risks related to the project, including management, financial and design matters	❑	❑	❑	❑	❑	❑	❑
7. The buildability of project design in D&B projects ensures a higher success rate in public sector projects	❑	❑	❑	❑	❑	❑	❑
8. D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	❑	❑	❑	❑	❑	❑	❑
9. The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	❑	❑	❑	❑	❑	❑	❑
10. The good track record of past D&B projects in the public sector enhances its further adoption	❑	❑	❑	❑	❑	❑	❑
11. D&B secures a reasonable and competitive price for government projects	❑	❑	❑	❑	❑	❑	❑
12. D&B gives rise to a win-win situation for all players	❑	❑	❑	❑	❑	❑	❑
13. D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	❑	❑	❑	❑	❑	❑	❑
14. D&B provides the public sector client with a guaranteed cost	❑	❑	❑	❑	❑	❑	❑
15. D&B provides the public sector client with a guaranteed completion date	❑	❑	❑	❑	❑	❑	❑
16. D&B provides the public sector with a more innovative and efficient image because of the simplified structure	❑	❑	❑	❑	❑	❑	❑
17. Others; please specify: ______________________________	❑	❑	❑	❑	❑	❑	❑

★ *End of the questionnaire* ★

※ *Thank you for your contribution* ※

Return Slip (Optional)

Those who wish to receive a summary of the research findings please enter the details below:

Name:
Organization:
Address:
Telephone Number:
Fax Number:
Email:

APPENDIX D

SAMPLE OF ACKNOWLEDGEMENT LETTER

Receiver's Address

Date

Dear,

Acknowledgement for Interview

I am writing to express my sincere thanks for your generous help in conducting an interview with me on the topic of '*A Conceptual Model of Success for Design and Build Projects in the Public Sector of Hong Kong*' on 9-8-2001. It is my pleasure to have the chance to meet with you and your valuable comments and work experience are of vital importance for reaching a representative conclusion for my research study.

After the face-to-face interview, I will carry out a questionnaire survey in order to investigate this topic in more detail and your valuable responses form the basic data source for my research study. I strongly believe that your experience and expertise is highly valuable to my project and I would like to invite you to participate in my questionnaire survey in the near future.

Your information and comment to the research project is always welcome and your help is highly appreciated. If you have any problems, please contact me at 9313-: or e-mail to edmond.lam@

Thank you very much for your help.

Yours truly,

Mr. Edmond W.M. Lam
PhD Student
The Hong Kong Polytechnic University

APPENDIX E

SAMPLE OF INVITATION LETTER FOR QUESTIONNAIRE SURVEY

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學	A Conceptual Model of Success for Design and Build Projects in the Public Sector of Hong Kong - EMPIRICAL SURVEY 2003

Date

Dear Sir/Madam,

Re: Invitation of Participating in a Research Survey

I am a PhD candidate at the Department of Building and Real Estate of The Hong Kong Polytechnic University under the joint supervision of Dr. Albert Chan and Professor David Scott. My research topic is entitled '*A Conceptual Model of Success for Design and Build Projects in the Public Sector of Hong Kong*'. The main objectives of this project are to formulate a framework to measure project success for design-build projects in Hong Kong, to identify those factors that are essential in running a successful design-build project in the Public Sector, and to study how these factors affect the performance level of the project. The ultimate goal is to develop a conceptual model to link the critical success factors to the project performance of design-build projects.

As an active participant in the local building construction industry, you are cordially invited to express your opinions by completing the enclosed questionnaire. I strongly believe that your experience and expertise is highly valuable to the academics and practitioners and your responses would be of great significance in drawing a representative conclusion for my research study. All the information you provide will be kept in strictest confidentiality and is used for academic purposes only.

Please kindly complete the questionnaire with reference to the D&B project list attached and return it using the enclosed self-addressed prepaid envelope or by fax to Mr. Edmond Lam at 2764-5131 within **2 weeks** upon the receipt of this questionnaire. If you have experience for more than one D&B projects, please kindly photocopy the questionnaire and complete one questionnaire for each project. Other participants of the same D&B project are also welcome to complete the questionnaire.

Your prompt response to the research is highly appreciated. Should you have further enquiries, please contact me at your earliest convenience at 2766- / 9313- or by e-mail to edmond.lam@ Thank you in advance for your generous assistance with my research.

Yours faithfully,

....

Mr. Edmond W.M. Lam
PhD Candidate
Department of Building and Real Estate
The Hong Kong Polytechnic University

....

Dr. Albert P.C. Chan
Associate Professor (Supervisor)
Department of Building and Real Estate
The Hong Kong Polytechnic University

ENCL.

APPENDIX F

SAMPLE OF REMINDER LETTER FOR QUESTIONNAIRE SURVEY

THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

Date

建築及房地產學系
香港 九龍 紅磡
Department of Building and Real Estate
Hung Hom Kowloon Hong Kong
Tel (852) 2766 5814 Fax (852) 2764 5131
E-Mail bsachan@polyu.edu.hk
Homepage
http://home.bre.polyu.edu.hk/~bsachan

副教授
陳炳泉*博士*
Associate Professor
Dr. Albert PC Chan
MSc, PhD, FCIOB, FAIB, FHKICM, MHKIE, MAIPM

Dear Respondent,

<u>Re: Reminder for the Reply of Design-Build Questionnaire Survey at PhD Level</u>

I am Edmond W.M. Lam, a PhD candidate at the Department of Building and Real Estate of The Hong Kong Polytechnic University.

You may kindly recall that a set of the research questionnaire on "A Conceptual Model of Success for Design and Build Projects in the Public Sector of Hong Kong" has been sent to you early this year between January and February. To be frank, the response rate is not satisfactory and more valid questionnaires are expected for drawing a representative conclusion to the research. This letter serves as a gentle reminder for those who have not yet replied and I would like to request for your help again to complete and return the questionnaires at your earliest convenience. You are also welcome to nominate your colleagues who have participated in the design-build project to complete the questionnaire. Please fax the questionnaire to Mr. Edmond Lam at 2764-5131 upon completion or send it by post with the above address on or before **25 April 2003**, beyond which the responses received would be used for testing purposes.

Please be assured that the information you provided will be kept to strictest confidentiality and your participation is of great significance to the success of my research study. Should you require another set of the questionnaire, or have any queries, you are most welcome to contact me at 9313- / 2766- or e-mail me at edmond.lam@

Thank you for your kind attention and favourable consideration.

Yours faithfully,

Mr. Edmond W.M. Lam
PhD Candidate
Department of Building and Real Estate
The Hong Kong Polytechnic University

APPENDIX G

DATA OF RESPONDENTS

Ref.	Post	Professional	Qualification	Years of experience	Organization of works
1	Design Director	Builder	Bachelor's Degree	20 years or more	Main contractor
2	Project Quantity Surveyor	Quantity Surveyor	Bachelor's Degree	15 to 19 years	Main contractor
3	Assistant Quantity Surveyor	Quantity Surveyor	Bachelor's Degree	less than 5 years	Main contractor
4	Project Manager	Engineer	Diploma/Certificate	15 to 19 years	Main contractor
5	Project Manager	Engineer	Bachelor's Degree	15 to 19 years	Main contractor
6	Senior Project Planning Engineer	Engineer	Postgrad Diploma	20 years or more	Main contractor
7	Project Management - Manager	Builder	Master's Degree	20 years or more	Main contractor
8	Director	Builder	Master's Degree	20 years or more	Main contractor
9	Senior Engineer	Builder	Master's Degree	10 to 14 years	Main contractor
10	Contracts Manager	Building Surveyor	Master's Degree	20 years or more	Main contractor
11	Quantity Surveying Manager	Quantity Surveyor	Bachelor's Degree	15 to 19 years	Main contractor
12	Project Manager	Builder	Bachelor's Degree	10 to 14 years	Main contractor
13	Senior Manager - Estimating & Procurement	Manager	Bachelor's Degree	20 years or more	Main contractor
14	Project Quantity Surveyor	Builder	Bachelor's Degree	5 to 9 years	Main contractor
15	Project Manager	Engineer	Master's Degree	20 years or more	Main contractor
16	Assistant Project Manager	Builder	Master's Degree	10 to 14 years	Main contractor
17	Site Agent	Builder	Master's Degree	10 to 14 years	Main contractor
18	Assistant Project Manager	Builder	Bachelor's Degree	10 to 14 years	Main contractor
19	Project Manager	Builder	Registered Architect	20 years or more	Main contractor
20	Senior Site Agent	Builder	Diploma/Certificate	20 years or more	Main contractor
21	D&B Manager	Builder	Bachelor's Degree	20 years or more	Main contractor
22	Contracts Manager	Builder	Master's Degree	15 to 19 years	Main contractor
23	Contracts Manager	Building Surveyor	Bachelor's Degree	20 years or more	Main contractor
24	Senior Managing QS	Quantity Surveyor	Diploma/Certificate	20 years or more	Main contractor
25	Assistant Building Engineer	Builder	Bachelor's Degree	10 to 14 years	Main contractor
26	Division Manager	Manager	Diploma/Certificate	15 to 19 years	Main contractor
27	Production Manager	Builder	Postgrad Diploma	15 to 19 years	Main contractor
28	Contracts Manager	Builder	.	.	Main contractor
29	Project Coordinator	Builder	Bachelor's Degree	15 to 19 years	Main contractor
30	Senior Quantity Surveyor	Quantity Surveyor	Diploma/Certificate	20 years or more	Main contractor
31	Contracts Manager	Builder	Diploma/Certificate	20 years or more	Main contractor
32	Senior Project Manager	Project Manager	.	15 to 19 years	Main contractor

Ref.	Post	Professional	Qualification	Years of experience	Organization of works
33	Assistant Building Services Manager	Engineer	Postgrad Diploma	20 years or more	Main contractor
34	Building Services Engineer	Engineer	Diploma/Certificate	15 to 19 years	Main contractor
35	Project Coordinator	Builder	Diploma/Certificate	5 to 9 years	Main contractor
36	Deputy General Manager	Builder	Postgrad Diploma	20 years or more	Main contractor
37	Production Manager	Builder	Postgrad Diploma	15 to 19 years	Main contractor
38	Senior Project Manager	Engineer	Master's Degree	20 years or more	Project management consultant
39	Deputy Director	Architect	Master's Degree	15 to 19 years	Architectural firm
40	Associate Director	Architect	Master's Degree	10 to 14 years	Architectural firm
41	Assistant Quantity Surveyor	Quantity Surveyor	Bachelor's Degree	less than 5 years	Q.S. consultant
42	Quantity Surveyor	Quantity Surveyor	Bachelor's Degree	less than 5 years	Q.S. consultant
43	Engineer	Engineer	Bachelor's Degree	10 to 14 years	Main Contractor
44	Quantity Surveyor	Quantity Surveyor	Bachelor's Degree	less than 5 years	Q.S. consultant
45	Team Leader	Quantity Surveyor	Bachelor's Degree	5 to 9 years	Q.S. consultant
46	Associate Director	Quantity Surveyor	Postgrad Diploma	15 to 19 years	Q.S. consultant
47	Project Architect	Architect	Master's Degree	5 to 9 years	Architectural firm
48	Architect	Architect	Master's Degree	5 to 9 years	Architectural firm
49	Architect	Architect	Master's Degree	5 to 9 years	Architectural firm
50	Associate Director	Architect	Bachelor's Degree	20 years or more	Architectural firm
51	General Manager	Quantity Surveyor	Diploma/Certificate	20 years or more	Q.S. consultant
52	Executive Director	Architect	Bachelor's Degree	20 years or more	Architectural firm
53	Monitoring Surveyor	Quantity Surveyor	Others	20 years or more	Q.S. consultant
54	Project Engineer	Engineer	Diploma/Certificate	10 to 14 years	Engineering consultant
55	Engineer	Engineer	Master's Degree	10 to 14 years	Engineering consultant
56	Associates	Engineer	Postgrad Diploma	15 to 19 years	Engineering consultant
57	Department Director	Building Surveyor	Bachelor's Degree	10 to 14 years	Project management consultant
58	Assistant Director	Quantity Surveyor	Diploma/Certificate	10 to 14 years	Q.S. consultant
59	Associate	Engineer	Master's Degree	15 to 19 years	Engineering consultant
60	Senior Engineer	Engineer	Bachelor's Degree	20 years or more	Engineering consultant
61	Engineer	Engineer	Bachelor's Degree	5 to 9 years	Engineering consultant
62	Senior Project Manager	Engineer	Master's Degree	20 years or more	Main Contractor
63	BS consultant, associate	Engineer	Master's Degree	10 to 14 years	Engineering consultant
64	Associate Director	Architect	Bachelor's Degree	20 years or more	Architectural firm

Ref.	Post	Professional	Qualification	Years of experience	Organization of works
65	Quantity Surveyor	Quantity Surveyor	Postgrad Diploma	10 to 14 years	Main Contractor
66	Senior Quantity Surveyor	Quantity Surveyor	Postgrad Diploma	20 years or more	Q.S. consultant
67	Director	Architect	Master's Degree	20 years or more	Architectural firm
68	Director	Engineer	Bachelor's Degree	20 years or more	Engineering consultant
69	Director QS Services	Quantity Surveyor	Postgrad Diploma	15 to 19 years	Engineering consultant
70	Executive Director	Architect	Bachelor's Degree	20 years or more	Architectural firm
71	Project Engineer	Engineer	Bachelor's Degree	5 to 9 years	Client organization
72	Architect	Architect	Bachelor's Degree	10 to 14 years	Client organization
73	Property Services Manager	Architect	Bachelor's Degree	20 years or more	Client organization
74	Project Architect	Architect	Master's Degree	15 to 19 years	Client organization
75	Project Engineer	Engineer	Master's Degree	5 to 9 years	Client organization
76	Architect	Architect	Bachelor's Degree	20 years or more	Client organization
77	Senior Engineer	Engineer	Bachelor's Degree	20 years or more	Client organization
78	Architect	Architect	Master's Degree	15 to 19 years	Client organization
79	Project Architect	Architect	Master's Degree	15 to 19 years	Client organization
80	Architect	Architect	Postgrad Diploma	10 to 14 years	Client organization
81	Architect	Architect	Registered Architect	10 to 14 years	Client organization
82	Associate Director	Architect	Doctorate Degree	20 years or more	Client organization
83	Associate Director	Architect	Doctorate Degree	20 years or more	Client organization
84	Property Services Manager	Architect	Bachelor's Degree	15 to 19 years	Client organization
85	Associate Director	Architect	Doctorate Degree	20 years or more	Client organization
86	Project Manager	Architect	Postgrad Diploma	20 years or more	Client organization
87	Assistant Secretary	Engineer	Bachelor's Degree	20 years or more	Client organization
88	Senior Quantity Surveyor	Quantity Surveyor	Master's Degree	20 years or more	Client organization
89	Project Manager	Building Surveyor	Diploma/Certificate	20 years or more	Client organization
90	Senior Property Services Manager	Architect	Master's Degree	15 to 19 years	Client organization
91	Chief Project Manager	Quantity Surveyor	Postgrad Diploma	20 years or more	Client organization
92	Executive Manager	Building Surveyor	Master's Degree	15 to 19 years	Client organization

APPENDIX H

RESULTS OF THE REASONS FOR A WIDER ADOPTION OF D&B IN THE PUBLIC SECTOR OF HONG KONG

Reliability

Case Processing Summary

		N	%
Cases	Valid	83	90.2
	Excluded (a)	9	9.8
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.890	16

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The D&B contractor bears all risks related to the project, including management, financial and design matters	88	2.00	7.00	5.4545	1.02732
D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	88	2.00	7.00	5.4545	.84294
The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	89	2.00	7.00	5.3258	.93875
D&B enables the government to maximize the use of resources and design expertise from the private sector	89	1.00	7.00	5.1011	1.23440
The project size in the public sector makes D&B feasible to apply	89	2.00	7.00	4.9775	1.01105
The buildability of project design in D&B projects ensures a higher success rate in public sector projects	89	2.00	7.00	4.9326	1.05311
The good track record of past D&B projects in the public sector enhances its further adoption	88	1.00	7.00	4.9205	1.10611
D&B requires variations to be kept to minimum, which is considered important in the public sector environment	89	2.00	7.00	4.8989	1.20647
D&B provides the public sector client with a guaranteed cost	87	1.00	7.00	4.8966	1.21075
D&B secures a reasonable and competitive price for government projects	89	2.00	7.00	4.8315	1.22693
The public sector is more willing to try new procurement systems	88	2.00	7.00	4.7273	1.26607
The tendering procedures and contractual arrangement for D&B projects in the public sector are well-organized	88	2.00	7.00	4.5341	1.19336
D&B reduces disputes and arbitration	89	2.00	6.00	4.5056	1.25339
D&B gives rise to a win-win situation for all players	89	1.00	7.00	4.4494	1.14823
D&B provides the public sector with a more innovative and efficient image because of the simplified structure	89	1.00	7.00	4.3596	1.18942

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
D&B provides the public sector client with a guaranteed completion date	89	1.00	7.00	4.3371	1.40570
Valid N (listwise)	83				

Kendall's W Test

Ranks

	Mean Rank
N14.1RSN D&B enables the government to maximize the use of resources and design expertise from the private sector	9.84
N14.2RSN The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	10.54
N14.3RSN D&B reduces disputes and arbitration	6.71
N14.4RSN The project size in the public sector makes D&B feasible to apply	9.40
N14.5RSN The public sector is more willing to try new procurement systems	7.77
N14.6RSN The D&B contractor bears all risks related to the project, including management, financial and design matters	10.79
N14.7RSN The buildability of project design in D&B projects ensures a higher success rate in public sector projects	8.54
N14.8RSN D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	8.45
N14.9RSN The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	7.21
N.10RESN The good track record of past D&B projects in the public sector enhances its further adoption	8.81
N.11RESN D&B secures a reasonable and competitive price for government projects	8.36
N.12RESN D&B gives rise to a win-win situation for all players	6.62
N.13RESN D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	10.99
N.14RESN D&B provides the public sector client with a guaranteed cost	8.88
N.15RESN D&B provides the public sector client with a guaranteed completion date	6.84
N.16RESN D&B provides the public sector with a more innovative and efficient image because of the simplified structure	6.25

Test Statistics

N	83
Kendall's W[a]	.133
Chi-Square	165.168
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
N14.1RSN D&B enables the government to maximize the use of resources and design expertise from the private sector	10.65
N14.2RSN The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	11.23
N14.3RSN D&B reduces disputes and arbitration	5.47
N14.4RSN The project size in the public sector makes D&B feasible to apply	9.82
N14.5RSN The public sector is more willing to try new procurement systems	6.57
N14.6RSN The D&B contractor bears all risks related to the project, including management, financial and design matters	10.32
N14.7RSN The buildability of project design in D&B projects ensures a higher success rate in public sector projects	6.88
N14.8RSN D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	8.73
N14.9RSN The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	9.80
N.10RESN The good track record of past D&B projects in the public sector enhances its further adoption	8.10
N.11RESN D&B secures a reasonable and competitive price for government projects	7.90
N.12RESN D&B gives rise to a win-win situation for all players	6.30
N.13RESN D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	11.27
N.14RESN D&B provides the public sector client with a guaranteed cost	9.65
N.15RESN D&B provides the public sector client with a guaranteed completion date	6.25
N.16RESN D&B provides the public sector with a more innovative and efficient image because of the simplified structure	7.05

Test Statistics

N	20
Kendall's W[a]	.199
Chi-Square	59.791
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
N14.1RSN D&B enables the government to maximize the use of resources and design expertise from the private sector	9.11
N14.2RSN The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	10.20
N14.3RSN D&B reduces disputes and arbitration	7.72
N14.4RSN The project size in the public sector makes D&B feasible to apply	9.27
N14.5RSN The public sector is more willing to try new procurement systems	7.74
N14.6RSN The D&B contractor bears all risks related to the project, including management, financial and design matters	10.84
N14.7RSN The buildability of project design in D&B projects ensures a higher success rate in public sector projects	9.41
N14.8RSN D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	8.50
N14.9RSN The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	5.97
N.10RESN The good track record of past D&B projects in the public sector enhances its further adoption	8.19
N.11RESN D&B secures a reasonable and competitive price for government projects	8.05
N.12RESN D&B gives rise to a win-win situation for all players	7.07
N.13RESN D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	10.49
N.14RESN D&B provides the public sector client with a guaranteed cost	9.43
N.15RESN D&B provides the public sector client with a guaranteed completion date	7.19
N.16RESN D&B provides the public sector with a more innovative and efficient image because of the simplified structure	6.82

Test Statistics

N	37
Kendall's W[a]	.118
Chi-Square	65.729
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
N14.1RSN D&B enables the government to maximize the use of resources and design expertise from the private sector	10.27
N14.2RSN The one-off arrangement of D&B makes the contractor responsible for the communication with the various project team members	10.50
N14.3RSN D&B reduces disputes and arbitration	6.23
N14.4RSN The project size in the public sector makes D&B feasible to apply	9.27
N14.5RSN The public sector is more willing to try new procurement systems	8.73
N14.6RSN The D&B contractor bears all risks related to the project, including management, financial and design matters	11.08
N14.7RSN The buildability of project design in D&B projects ensures a higher success rate in public sector projects	8.60
N14.8RSN D&B requires variations to be kept to a minimum, which is considered important in the public sector environment	8.15
N14.9RSN The tendering procedures and contractual arrangements for D&B projects in the public sector are well-organized	6.98
N.10RESN The good track record of past D&B projects in the public sector enhances its further adoption	10.23
N.11RESN D&B secures a reasonable and competitive price for government projects	9.13
N.12RESN D&B gives rise to a win-win situation for all players	6.23
N.13RESN D&B enables the contractors' expertise in construction methods to be introduced at an early stage in the design	11.50
N.14RESN D&B provides the public sector client with a guaranteed cost	7.50
N.15RESN D&B provides the public sector client with a guaranteed completion date	6.79
N.16RESN D&B provides the public sector with a more innovative and efficient image because of the simplified structure	4.81

Test Statistics

N	26
Kendall's W[a]	.204
Chi-Square	79.604
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Correlations

			CLT	COT
Spearman's rho	CLT	Correlation Coefficient	1.000	.774(**)
		Sig. (2-tailed)	.	.000
		N	16	16
	COT	Correlation Coefficient	.774(**)	1.000
		Sig. (2-tailed)	.000	.
		N	16	16

** Correlation is significant at the .01 level (2-tailed).

Correlations

			CTR	COT
Spearman's rho	CTR	Correlation Coefficient	1.000	.798(**)
		Sig. (2-tailed)	.	.000
		N	16	16
	COT	Correlation Coefficient	.798(**)	1.000
		Sig. (2-tailed)	.000	.
		N	16	16

** Correlation is significant at the 0.01 level (2-tailed).

Correlations

			CTR	CLT
Spearman's rho	CTR	Correlation Coefficient	1.000	.668(**)
		Sig. (2-tailed)	.	.005
		N	16	16
	CLT	Correlation Coefficient	.668(**)	1.000
		Sig. (2-tailed)	.005	.
		N	16	16

** Correlation is significant at the .01 level (2-tailed).

APPENDIX I

RESULTS OF THE PROBLEMS OF RUNNING PUBLIC-SECTOR D&B PROJECTS IN HONG KONG

Reliability

Case Processing Summary

		N	%
Cases	Valid	84	91.3
	Excluded (a)	8	8.7
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.808	16

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
consensus on the client's requirements	90	1.00	6.00	3.7000	1.58256
hard to understand the client's requirements	91	1.00	7.00	2.9121	1.33040
a conflict of interest between the design team members and the contractor	89	1.00	7.00	4.3820	1.66860
D&B contractors were not competent with design issues	91	1.00	7.00	3.2088	1.54572
difficult to control design quality in that project	91	1.00	6.00	3.0440	1.36554
difficult to control workmanship in that project	91	1.00	7.00	3.1429	1.52440
Frequent changes were introduced by various clients	90	1.00	7.00	4.2000	1.64351
Frequent changes were introduced by various end-users	91	1.00	7.00	4.4615	1.68198
The schedule was tight	90	2.00	7.00	5.7333	1.01450
no room for innovation	90	2.00	7.00	3.6222	1.42669
difficult to compare the contractor's proposal with the client's brief	91	1.00	6.00	3.3187	1.37339
Stress was placed on the project by the client	89	2.00	7.00	4.5618	1.24275
ambiguity in allocating the responsibilities in the contract	91	1.00	7.00	3.4396	1.44690
The provision of various service was poorly coordinated	90	1.00	6.00	2.9667	1.36941
The project participants were unclear about their roles in D&B	91	1.00	6.00	3.0989	1.37481
The scope of the D&B project was ill-defined	91	1.00	6.00	2.5385	1.14802
Valid N (listwise)	84				

Kendall's W Test

Ranks

	Mean Rank
B2.1PROB consensus on the client's requirements	8.76
B2.2PROB hard to understand the client's requirements	6.32
B2.3PROB a conflict of interest between the design team members and the contractor	10.43
B2.4PROB D&B contractors were not competent with design issues	7.49
B2.5PROB difficult to control design quality in that project	6.88
B2.6PROB difficult to control workmanship in that project	7.13
B2.7PROB Frequent changes were introduced by various clients	10.29
B2.8PROB Frequent changes were introduced by various end-users	11.11
B2.9PROB The schedule was tight	14.13
B2.10PRB no room for innovation	8.80
B2.11PRB difficult to compare the contractor's proposal with the client's brief	7.35
B2.12PRB Stress was placed on the project by the client	11.10
B2.13PRB ambiguity in allocating the responsibilities in the contract	7.88
B2.14PRB The provision of various services was poorly coordinated	6.52
B2.15PRB The project participants were unclear about their roles in D&B	6.83
B2.16PRB The scope of the D&B project was ill-defined	4.96

Test Statistics

N	84
Kendall's W[a]	.284
Chi-Square	357.621
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
B2.1PROB consensus on the client's requirements	6.76
B2.2PROB hard to understand the client's requirements	5.50
B2.3PROB a conflict of interest between the design team members and the contractor	11.71
B2.4PROB D&B contractors were not competent with design issues	8.74
B2.5PROB difficult to control design quality in that project	7.39
B2.6PROB difficult to control workmanship in that project	9.79
B2.7PROB Frequent changes were introduced by various clients	9.45
B2.8PROB Frequent changes were introduced by various end-users	9.50
B2.9PROB The schedule was tight	14.66
B2.10PRB no room for innovation	9.13
B2.11PRB difficult to compare the contractor's proposal with the client's brief	5.74
B2.12PRB Stress was placed on the project by the client	10.18
B2.13PRB ambiguity in allocating the responsibilities in the contract	7.84
B2.14PRB The provision of various services was poorly coordinated	8.61
B2.15PRB The project participants were unclear about their roles in D&B	6.95
B2.16PRB The scope of the D&B project was ill-defined	4.05

Test Statistics

N	19
Kendall's W[a]	.348
Chi-Square	99.098
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
B2.1PROB consensus on the client's requirements	9.80
B2.2PROB hard to understand the client's requirements	7.36
B2.3PROB a conflict of interest between the design team members and the contractor	9.12
B2.4PROB D&B contractors were not competent with design issues	6.53
B2.5PROB difficult to control design quality in that project	6.09
B2.6PROB difficult to control workmanship in that project	5.66
B2.7PROB Frequent changes were introduced by various clients	11.26
B2.8PROB Frequent changes were introduced by various end-users	11.95
B2.9PROB The schedule was tight	14.46
B2.10PRB no room for innovation	8.35
B2.11PRB difficult to compare the contractor's proposal with the client's brief	6.85
B2.12PRB Stress was placed on the project by the client	11.86
B2.13PRB ambiguity in allocating the responsibilities in the contract	8.04
B2.14PRB The provision of various services was poorly coordinated	5.77
B2.15PRB The project participants were unclear about their roles in D&B	6.88
B2.16PRB The scope of the D&B project was ill-defined	6.01

Test Statistics

N	37
Kendall's W[a]	.360
Chi-Square	199.769
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
B2.1PROB consensus on the client's requirements	8.73
B2.2PROB hard to understand the client's requirements	5.50
B2.3PROB a conflict of interest between the design team members and the contractor	11.30
B2.4PROB D&B contractors were not competent with design issues	7.93
B2.5PROB difficult to control design quality in that project	7.57
B2.6PROB difficult to control workmanship in that project	7.27
B2.7PROB Frequent changes were introduced by various clients	9.59
B2.8PROB Frequent changes were introduced by various end-users	11.11
B2.9PROB The schedule was tight	13.34
B2.10PRB no room for innovation	9.16
B2.11PRB difficult to compare the contractor's proposal with the client's brief	9.11
B2.12PRB Stress was placed on the project by the client	10.71
B2.13PRB ambiguity in allocating the responsibilities in the contract	7.70
B2.14PRB The provision of various services was poorly coordinated	6.11
B2.15PRB The project participants were unclear about their roles in D&B	6.70
B2.16PRB The scope of the D&B project was ill-defined	4.18

Test Statistics

N	28
Kendall's W[a]	.284
Chi-Square	119.142
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Correlations

			CLT	COT
Spearman's rho	CLT	Correlation Coefficient	1.000	.747(**)
		Sig. (2-tailed)	.	.001
		N	16	16
	COT	Correlation Coefficient	.747(**)	1.000
		Sig. (2-tailed)	.001	.
		N	16	16

** Correlation is significant at the .01 level (2-tailed).

Correlations

			COT	CTR
Spearman's rho	COT	Correlation Coefficient	1.000	.812(**)
		Sig. (2-tailed)	.	.000
		N	16	16
	CTR	Correlation Coefficient	.812(**)	1.000
		Sig. (2-tailed)	.000	.
		N	16	16

** Correlation is significant at the .01 level (2-tailed).

Correlations

			CTR	CLT
Spearman's rho	CTR	Correlation Coefficient	1.000	.485
		Sig. (2-tailed)	.	.057
		N	16	16
	CLT	Correlation Coefficient	.485	1.000
		Sig. (2-tailed)	.057	.
		N	16	16

APPENDIX J

RESULTS OF THE BARRIERS TO APPLYING THE D&B PROCUREMENT SYSTEM IN HONG KONG

Reliability

Case Processing Summary

		N	%
Cases	Valid	85	92.4
	Excluded (a)	7	7.6
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.800	16

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
D&B contractors carry a high degree of risk and liability	91	2.00	7.00	5.3956	1.28131
A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	90	1.00	7.00	4.9556	1.68210
It takes more effort to develop the client's requirements for D&B projects	91	1.00	7.00	4.7802	1.50408
D&B contractors do not have in-house architects and engineers	92	1.00	7.00	4.7717	1.64486
There is a lack of promotion of D&B within the industry	90	2.00	7.00	4.7111	1.30034
There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	88	2.00	7.00	4.5114	1.09328
There is a lack of capable and experienced D&B contractors	92	1.00	7.00	4.3370	1.58480
There is a restriction on design flexibility in D&B projects	92	1.00	7.00	4.2826	1.55009
Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	91	1.00	7.00	4.1648	1.46260
There is a lack of D&B knowledge and experience in Hong Kong	91	1.00	7.00	4.1209	1.52633
There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	90	2.00	7.00	4.0778	1.38392
Clients prefer traditional practice to the D&B method	90	1.00	7.00	4.0778	1.35934
D&B contractors do not have sufficient design management expertise	92	1.00	7.00	4.0652	1.62943
Clients are not aware of the benefits of the D&B method	91	1.00	7.00	3.7582	1.47076
There is a negative impact on the image of the design team in the D&B method	91	1.00	6.00	3.5714	1.43095
Project participants do not have confidence in managing D&B projects successfully	91	1.00	7.00	3.4066	1.35792
Valid N (listwise)	85				

Kendall's W Test

Ranks

	Mean Rank
C3.1BARR A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	10.99
C3.2BARR It takes more effort to develop the client's requirements for D&B projects	9.85
C3.3BARR There is a lack of capable and experienced D&B contractors	8.71
C3.4BARR There is a negative impact on the image of the design team in the D&B method	5.97
C3.5BARR There is a restriction on design flexibility in D&B projects	8.08
C3.6BARR D&B contractors carry a high degree of risk and liability	11.79
C3.7BARR There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	7.81
C3.8BARR Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	7.95
C3.9BARR Clients are not aware of the benefits of the D&B method	6.98
C3.10BAR Clients prefer traditional practice to the D&B method	7.89
C3.11BAR Project participants do not have confidence in managing D&B projects successfully	5.70
C3.12BAR There is a lack of promotion of D&B within the industry	9.85
C3.13BAR There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	8.59
C3.14BAR D&B contractors do not have sufficient design management expertise	7.72
C3.15BAR There is a lack of D&B knowledge and experience in Hong Kong	7.94
C3.16BAR D&B contractors do not have in-house architects and engineers	10.18

Test Statistics

N	85
Kendall's W[a]	.138
Chi-Square	176.263
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
C3.1BARR A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	8.30
C3.2BARR It takes more efforts to develop the client's requirements for D&B projects	10.38
C3.3BARR There is a lack of capable and experienced D&B contractors	9.75
C3.4BARR There is a negative impact on the image of the design team in the D&B method	8.13
C3.5BARR There is a restriction on design flexibility in D&B projects	8.02
C3.6BARR D&B contractors carry a high degree of risk and liability	9.65
C3.7BARR There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	9.55
C3.8BARR Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	7.82
C3.9BARR Clients are not aware of the benefits of the D&B method	5.68
C3.10BAR Clients prefer traditional practice to the D&B method	6.63
C3.11BAR Project participants do not have confidence in managing D&B projects successfully	5.07
C3.12BAR There is a lack of promotion of D&B within the industry	10.57
C3.13BAR There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	7.43
C3.14BAR D&B contractors do not have sufficient design management expertise	9.73
C3.15BAR There is a lack of D&B knowledge and experience in Hong Kong	8.02
C3.16BAR D&B contractors do not have in-house architects and engineers	11.27

Test Statistics

N	20
Kendall's W[a]	.150
Chi-Square	44.912
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
C3.1BARR A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	12.58
C3.2BARR It takes more effort to develop the client's requirements for D&B projects	9.99
C3.3BARR There is a lack of capable and experienced D&B contractors	7.75
C3.4BARR There is a negative impact on the image of the design team in the D&B method	5.18
C3.5BARR There is a restriction on design flexibility in D&B projects	8.05
C3.6BARR D&B contractors carry a high degree of risk and liability	12.50
C3.7BARR There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	6.75
C3.8BARR Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	8.29
C3.9BARR Clients are not aware of the benefits of the D&B method	7.42
C3.10BAR Clients prefer traditional practice to the D&B method	7.74
C3.11BAR Project participants do not have confidence in managing D&B projects successfully	6.04
C3.12BAR There is a lack of promotion of D&B within the industry	10.71
C3.13BAR There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	9.42
C3.14BAR D&B contractors do not have sufficient design management expertise	6.17
C3.15BAR There is a lack of D&B knowledge and experience in Hong Kong	7.45
C3.16BAR D&B contractors do not have in-house architects and engineers	9.96

Test Statistics

N	38
Kendall's W[a]	.236
Chi-Square	134.645
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Kendall's W Test

Ranks

	Mean Rank
C3.1BARR A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	10.76
C3.2BARR It takes more effort to develop the client's requirements for D&B projects	9.28
C3.3BARR There is a lack of capable and experienced D&B contractors	9.28
C3.4BARR There is a negative impact on the image of the design team in the D&B method	5.48
C3.5BARR There is a restriction on design flexibility in D&B projects	8.17
C3.6BARR D&B contractors carry a high degree of risk and liability	12.39
C3.7BARR There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	8.00
C3.8BARR Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	7.56
C3.9BARR Clients are not aware of the benefits of the D&B method	7.31
C3.10BAR Clients prefer traditional practice to the D&B method	9.04
C3.11BAR Project participants do not have confidence in managing D&B projects successfully	5.69
C3.12BAR There is a lack of promotion of D&B within the industry	8.11
C3.13BAR There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	8.28
C3.14BAR D&B contractors do not have sufficient design management expertise	8.43
C3.15BAR There is a lack of D&B knowledge and experience in Hong Kong	8.57
C3.16BAR D&B contractors do not have in-house architects and engineers	9.67

Test Statistics

N	27
Kendall's W[a]	.140
Chi-Square	56.680
df	15
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

Correlations

			CLT	COT
Spearman's rho	CLT	Correlation Coefficient	1.000	.518(*)
		Sig. (2-tailed)	.	.040
		N	16	16
	COT	Correlation Coefficient	.518(*)	1.000
		Sig. (2-tailed)	.040	.
		N	16	16

* Correlation is significant at the .05 level (2-tailed).

Correlations

			CTR	COT
Spearman's rho	CTR	Correlation Coefficient	1.000	.687(**)
		Sig. (2-tailed)	.	.003
		N	16	16
	COT	Correlation Coefficient	.687(**)	1.000
		Sig. (2-tailed)	.003	.
		N	16	16

** Correlation is significant at the .01 level (2-tailed).

Correlations

			CLT	CTR
Spearman's rho	CLT	Correlation Coefficient	1.000	.398
		Sig. (2-tailed)	.	.127
		N	16	16
	CTR	Correlation Coefficient	.398	1.000
		Sig. (2-tailed)	.127	.
		N	16	16

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
C3.1BARR A contractor tendering for a D&B project will suffer greatly if the contract is not awarded to him	Equal variances assumed	2.410	.126	-3.618	58	.001	-1.5500	.42836	-2.40745	-.69255
	Equal variances not assumed			-3.348	31.299	.002	-1.5500	.46301	-2.49394	-.60606
C3.2BARR It takes more effort to develop the client's requirements for D&B projects	Equal variances assumed	.062	.805	-.554	59	.582	-.2333	.42139	-1.07653	.60986
	Equal variances not assumed			-.566	43.232	.575	-.2333	.41255	-1.06519	.59852
C3.3BARR There is a lack of capable and experienced D&B contractors	Equal variances assumed	5.653	.021	1.393	60	.169	.6068	.43554	-.26439	1.47803
	Equal variances not assumed			1.505	53.514	.138	.6068	.40327	-.20185	1.41549
C3.4BARR There is a negative impact on the image of the design team in the D&B method	Equal variances assumed	2.769	.101	2.693	59	.009	1.0478	.38905	.26930	1.82627
	Equal variances not assumed			2.881	52.691	.006	1.0478	.36363	.31834	1.77723
C3.5BARR There is a restriction on design flexibility in D&B projects	Equal variances assumed	4.387	.040	-.660	60	.512	-.2750	.41684	-1.10881	.55881
	Equal variances not assumed			-.697	50.588	.489	-.2750	.39471	-1.06757	.51757

Independent Samples Test (Cont'd)

C3.6BARR D&B contractors carry a high degree of risk and liability	Equal variances assumed	.629	.431	-2.598	59	.012	-.9607	.36973	-1.70053	-.22090
	Equal variances not assumed			-2.466	35.338	.019	-.9607	.38952	-1.75121	-.17021
C3.7BARR There is a heavy burden on the client to commit himself at an early stage to contractual and financial arrangements	Equal variances assumed	1.315	.256	2.371	59	.021	.8738	.36852	.13640	1.61122
	Equal variances not assumed			2.437	43.984	.019	.8738	.35855	.15118	1.59644
C3.8BARR Contractors do not have sufficient incentive to promote the advantages of the D&B method to clients	Equal variances assumed	2.953	.091	-.268	59	.790	-.1071	.40012	-.90778	.69350
	Equal variances not assumed			-.290	50.516	.773	-.1071	.36956	-.84923	.63494
C3.9BARR Clients are not aware of the benefits of the D&B method	Equal variances assumed	3.760	.057	-.551	59	.583	-.2262	.41025	-1.04709	.59471
	Equal variances not assumed			-.593	49.684	.556	-.2262	.38142	-.99242	.54004
C3.10BAR Clients prefer traditional practice to the D&B method	Equal variances assumed	4.832	.032	-.651	58	.518	-.2418	.37128	-.98496	.50144
	Equal variances not assumed			-.741	56.186	.462	-.2418	.32629	-.89535	.41183

Independent Samples Test (Cont'd)

C3.11BAR Project participants do not have confidence of managing D&B projects successfully	Equal variances assumed	5.603	.021	-.896	59	.374	-.3345	.37329	-1.08148	.41243
	Equal variances not assumed			-.980	51.771	.332	-.3345	.34130	-1.01946	.35041
C3.12BAR There is a lack of promotion of D&B within the industry	Equal variances assumed	4.951	.030	-.471	58	.640	-.1500	.31871	-.78796	.48796
	Equal variances not assumed			-.520	49.441	.606	-.1500	.28861	-.72985	.42985
C3.13BAR There are inadequate local legal precedents regarding D&B projects to follow in case of disputes	Equal variances assumed	.335	.565	-1.991	58	.051	-.5750	.28886	-1.15321	.00321
	Equal variances not assumed			-2.005	38.830	.052	-.5750	.28682	-1.15524	.00524
C3.14BAR D&B contractors do not have sufficient design management expertise	Equal variances assumed	.001	.974	1.909	60	.061	.8295	.43457	-.03973	1.69882
	Equal variances not assumed			1.870	40.881	.069	.8295	.44353	-.06626	1.72536
C3.15BAR There is a lack of D&B knowledge and experience in Hong Kong	Equal variances assumed	.111	.740	.562	59	.576	.2381	.42364	-.60960	1.08579
	Equal variances not assumed			.561	40.543	.578	.2381	.42442	-.61933	1.09552
C3.16BAR D&B contractors do not have in-house architects and engineers	Equal variances assumed	5.430	.023	.686	60	.496	.3159	.46075	-.60574	1.23756
	Equal variances not assumed			.739	53.288	.463	.3159	.42737	-.54119	1.17301

APPENDIX K

CALCULATION OF PRINCIPAL COMPONENTS ANALYSIS ON PROJECT SUCCESS INDEX FOR D&B PROJECTS (PSI-D&B)

K.1	**Cronbach's alpha coefficients of ranking the success criteria for D&B projects**
K.2	**Mean values of success criteria for D&B projects**
K.3	**Formulation of PSI-D&B equation**
K.4	**Cronbach's alpha coefficients of the perceptions of D&B project participants on project performance**
K.5	**Results of PSI-D&B in Hong Kong**

Reliability

Case Processing Summary

		N	%
Cases	Valid	90	97.8
	Excluded (a)	2	2.2
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.840	11

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The Project should be completed on schedule	92	3.00	7.00	6.0870	.87269
The Project should be completed on budget	91	1.00	7.00	6.0440	1.04256
The Project should be completed to the specified quality standard	92	3.00	7.00	5.8587	.83313
The Project should achieve its fundamental functions	92	3.00	7.00	5.9239	.86740
The Project should be completed with a low accident rate	92	2.00	7.00	5.4891	1.14349
The Project should be completed with minimal claims and disputes	91	2.00	7.00	5.3846	1.16208
The Project should be completed with environmental consciousness	92	2.00	7.00	5.2065	1.10482
The Project should serve the aesthetic purpose	92	2.00	7.00	4.9674	1.20850
The Project should create learning value	92	2.00	7.00	4.5978	1.15844
The Project should satisfy the expectations of the project participants	92	2.00	7.00	5.1196	1.32468
The Project should provide the participants with a professional image	92	1.00	7.00	4.8478	1.08875
Valid N (listwise)	90				

The SAS System

The PRINCOMP Procedure

Observations	90
Variables	4

Simple Statistics

	a	b	c	d
Mean	6.088888889	6.044444444	5.855555556	5.922222222
StD	0.882341681	1.048392146	0.842162960	0.877019695

Correlation Matrix

	a	b	c	d
a	1.0000	0.6394	0.3653	0.2704
b	0.6394	1.0000	0.3764	0.3215
c	0.3653	0.3764	1.0000	0.3801
d	0.2704	0.3215	0.3801	1.0000

Eigenvalues of the Correlation Matrix

	Eigenvalue	Difference	Proportion	Cumulative
1	2.19139521	1.34910789	0.5478	0.5478
2	0.84228732	0.23379456	0.2106	0.7584
3	0.60849275	0.25066804	0.1521	0.9105
4	0.35782472		0.0895	1.0000

Eigenvectors

	Prin1	Prin2	Prin3	Prin4
a	0.538379	-.475133	0.073182	0.692127
b	0.553083	-.393396	0.158649	-.717056
c	0.474740	0.386152	-.790623	-.020600
d	0.422929	0.685839	0.586848	0.079786

The SAS System

The CORR Procedure

6 Variables: a b c d Prin1 Prin2

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
a	90	6.08889	0.88234	548.00000	3.00000	7.00000
b	90	6.04444	1.04839	544.00000	1.00000	7.00000
c	90	5.85556	0.84216	527.00000	3.00000	7.00000
d	90	5.92222	0.87702	533.00000	3.00000	7.00000
Prin1	90	0	1.48034	0	-4.32610	2.22492
Prin2	90	0	0.91776	0	-3.20320	2.55755

Pearson Correlation Coefficients, N = 90
Prob > |r| under H0: Rho=0

	a	b	c	d	Prin1	Prin2
a	1.00000	0.63944	0.36525	0.27039	0.79698	-0.43606
		<.0001	0.0004	0.0100	<.0001	<.0001
b	0.63944	1.00000	0.37641	0.32153	0.81875	-0.36104
	<.0001		0.0003	0.0020	<.0001	0.0005
c	0.36525	0.37641	1.00000	0.38015	0.70278	0.35440
	0.0004	0.0003		0.0002	<.0001	0.0006
d	0.27039	0.32153	0.38015	1.00000	0.62608	0.62944
	0.0100	0.0020	0.0002		<.0001	<.0001
Prin1	0.79698	0.81875	0.70278	0.62608	1.00000	0.00000
	<.0001	<.0001	<.0001	<.0001		1.0000
Prin2	-0.43606	-0.36104	0.35440	0.62944	0.00000	1.00000
	<.0001	0.0005	0.0006	<.0001	1.0000	

Reliability

Case Processing Summary

		N	%
Cases	Valid	85	92.4
	Excluded (a)	7	7.6
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.897	12

Project Success Indices for Public-sector Design-build Projects in Hong Kong (PSI-D&B)
No. of cases: 92
No. of cases without PSI-D&B: 6

PSI-D&B = 0.54 x Time + 0.55 x Cost + 0.47 x Quality + 0.42 x Functionality

Max.: 13.86

Project name	Time	Cost	Quality	Functionality	PSI-D&B	Mean
Project 1	6	5	5	6	10.86	
	4	6	5	5	9.91	
	3	5	4.5	6	9.005	
	5	5	5	4	9.48	
	4	4	4	5	8.34	9.52
Project 2	6	2	6	6	9.68	
	5	6	6.5	5	11.155	
	3	3	3	4	6.36	
	5	5	6	6	10.79	
	5	4	6	5	9.82	
	4	4	3.5	5	8.105	9.32
Project 3	6	6	6	6	11.88	
	6	6	6	6	11.88	
	3	2	4	4	6.28	
	5	6	5.5	5	10.685	
	6	6	4	5	10.52	10.25
Project 4	5	5	4	6	9.85	
	5	5	6	6	10.79	
	2	2	4.5	4	5.975	
	2	2	5	5	6.63	
	6	5	5	6	10.86	
	5	3	4	5	8.33	
	5	6	5.5	6	11.105	
	2	2	4.5	5	6.395	
	2	6	6	6	9.72	8.85

Project Success Indices for Public-sector Design-build Projects in Hong Kong (PSI-D&B)
No. of cases: 92
No. of cases without PSI-D&B: 6

PSI-D&B = 0.54 x Time + 0.55 x Cost + 0.47 x Quality + 0.42 x Functionality

Max.: 13.86

Project name	Time	Cost	Quality	Functionality	PSI-D&B	Mean
Project 5	6	6	6	6	11.88	
	6	6	4	5	10.52	
	4	4	5	6	9.23	
	6	6	6	6	11.88	
	6	6	5.5	7	12.065	
	7	7	6	7	13.39	11.49
Project 6	6	6	6	6	11.88	
	7	7	4	6	12.03	
	3	5	5.5	6	9.475	
	6	6	5.5	7	12.065	
	6	7	5	5	11.54	11.40
Project 7	6	6	6	6	11.88	
	6	5	5.5	7	11.515	
	3	5	4	4	7.93	
	6	6	5	6	11.41	
	6	6	5	6	11.41	10.83
Project 8	6	6	6	6	11.88	
	5	5	5	5	9.9	
	4	4	4	5	8.34	
	5	6	5.5	6	11.105	10.31
Project 9	4	4	4.5	4	8.155	
	6	6	5	6	11.41	9.78
Project 10	6	6	5	5	10.99	10.99

Project Success Indices for Public-sector Design-build Projects in Hong Kong (PSI-D&B)
No. of cases: 92
No. of cases without PSI-D&B: 6

PSI-D&B = 0.54 x Time + 0.55 x Cost + 0.47 x Quality + 0.42 x Functionality

Max.: 13.86

Project name	Time	Cost	Quality	Functionality	PSI-D&B	Mean
Project 11	5	6	5	3	9.61	
	7	4	7	7	12.21	10.91
Project 12	6	6	6	6	11.88	11.88
Project 13	3	3	3	6	7.2	7.20
Project 14	3	5	5	5	8.82	8.82
Project 15	3	6	4	5	8.9	
	3	4	4.5	6	8.455	8.68
Project 16	3	6	4	5	8.9	8.90
Project 17	3	6	4	5	8.9	8.90
Project 18	4	4	5	7	9.65	
	4	4	3.5	6	8.525	
	6	6	6	6	11.88	
	6	4	5	5	9.89	9.99
Project 19	6	5	5	4	10.02	10.02
Project 20	7	4	7	6	11.79	
	4	4	5	5	8.81	
	5	4	5.5	6	10.005	10.20
Project 21	7	7	6	7	13.39	13.39
Project 22	3	6	3.5	4	8.245	8.25

Project Success Indices for Public-sector Design-build Projects in Hong Kong (PSI-D&B)
No. of cases: 92
No. of cases without PSI-D&B: 6

PSI-D&B = 0.54 x Time + 0.55 x Cost + 0.47 x Quality + 0.42 x Functionality

Max.: 13.86

Project name	Time	Cost	Quality	Functionality	PSI-D&B	Mean
Project 23	7	7	6.5	4	12.365	12.37
Project 24	4	4	4.5	5	8.575	8.58
Project 25	1	1	1	4	3.24	3.24
Project 26	3	2	5	6	7.59	7.59
Project 27	4	5	4.5	5	9.125	
	4	4	2	4	6.98	8.05
Project 28	3	4	4	3	6.96	6.96
Project 29	6	6	7	7	12.77	12.77
Project 30	6	6	5	6	11.41	11.41
Project 31	6	5	4.5	6	10.625	10.63
Project 32	4	4	3.5	5	8.105	8.11
Project 33	6	6	4	5	10.52	10.52
Project 34	5	6	5.5	5	10.685	10.69
Project 35	4	5	3.5	4	8.235	8.24
Project 36	6	6	5.5	6	11.645	11.65
Project 37	6	6	6	6	11.88	11.88

Project Success Indices for Public-sector Design-build Projects in Hong Kong (PSI-D&B)
No. of cases: 92
No. of cases without PSI-D&B: 6

PSI-D&B = 0.54 x Time + 0.55 x Cost + 0.47 x Quality + 0.42 x Functionality

Max.: 13.86

Project name	Time	Cost	Quality	Functionality	PSI-D&B	Mean
Project 38	7	7	6	6	12.97	12.97
Project 39	6	6	4.5	5	10.755	10.76
Project 40	4	4	5	5	8.81	8.81

APPENDIX L

CALCULATION OF FACTOR ANALYSIS ON CRITICAL SUCCESS FACTORS FOR D&B PROJECTS (CSF-D&B)

Original Factors	Transformation	New Factor Label	Variable
Contractor's input		Contractor's input to the project	**ctrskill**
Contractor's special skills			
Project with various types of building services		Complexity of the project	**prjcompl**
Project with a heavy use of new technology			
A flexible project		Attractiveness of the project	**prjattrc**
A unique project			
An innovative project			
An attractive project			
Competitive tender price		Client’s emphasis on cost	**cltcosto**
Certainty of cost without fluctuation			
Timely completion		Client’s emphasis on time	**clttimeo**
Certainty of time			
Client’s ability to quickly make authoritative decisions		Decision-making power of client	**cltprdmk**
Client’s ability to define the roles of the participants			
Client’s ability to contribute ideas to design		Client's involvement in the project	**cltinvpj**
Client’s ability to contribute ideas to construction			
Planning skills (client’s representative)		Project management skills of client's representative	**cltpmski**
Organization skills (client’s representative)			
Coordinating skills (client’s representative)			
Leadership skills (client’s representative)			
Controlling skills (client’s representative)			
Commitment to targets (client’s representative)		Commitment and adaptability of client's representative	**cltcomad**
Continued involvement (client’s representative)			
Adaptability to changes (client’s representative)			

Original Factors	Transformation	New Factor Label	Variable
Planning skills (consultants)		Project management skills of contractor's design consultants	**cotpmski**
Organization skills (consultants)			
Coordinating skills (consultants)			
Leadership skills (consultants)			
Controlling skills (consultants)			
Commitment to targets (consultants)		Commitment and adaptability of contractor's design consultants	**cotcomad**
Continued involvement (consultants)			
Adaptability to changes (consultants)			
Planning skills (contractor)		Project management skills of the construction team leader	**ctrpmski**
Organization skills (contractor)			
Coordinating skills (contractor)			
Leadership skills (contractor)			
Controlling skills (contractor)			
Commitment to targets (contractor)		Commitment and adaptability of the construction team leader	**ctrcomad**
Continued involvement (contractor)			
Adaptability to changes (contractor)			
End users' ability to brief the D&B team		End users' involvement in the design-build process	**endstreq**
End users' ability to contribute ideas to design			
End users' ability to contribute ideas to construction			
Channels of communication systems		Effectiveness of communication	**commwppt**
Feedback channels			
Reporting system			
Regular meetings with the project participants			
Control mechanism, such as monitoring and updating		Effectiveness of control systems	**pmctrsys**
Development of standard procedures			

Original Factors	Transformation	New Factor Label	Variable
Quality system, like quality controls and assurance Safety system Risk management system Conflict management system Control of subcontractors	→	Effectiveness of management systems	**pjmgtsys**
Delegation of power from the client to the contractor Delegation of power from the client to the consultants	→	Delegation of decision-making authority from the client	**cltddeci**
Confidence level of contractor on design Confidence level of contractor on construction	→	Confidence level of the construction team leader	**cfdlvctr**
Working relationships of team members Satisfaction, expectations and values from project Respect and mutual trust of team members	→	Harmonious working relationships among project team members	**dbtmwkat**

Note: The convergence of the arrows means taking the average of the scores of the similar factors to form a new factor item.

Descriptive Statistics

	N	Mean	Std. Deviation
Contractor's input to the project	92	5.0272	.84958
Complexity of the project	92	4.5109	1.27309
Scope of the project	92	5.4783	1.15291
Clarity of client's requirements	90	5.3444	1.25565
Attractiveness of the project	91	4.3131	.92495
Adoption of innovative management approaches	89	1.3258	.73508
Physical environment	90	4.1000	1.66288
Economic environment	90	4.6556	1.13337
Political environment	90	4.0333	1.64522
Social environment	90	4.8000	1.06212
Client's emphasis on time	89	5.6067	1.03757
Client's emphasis on cost	90	5.0389	1.05263
Client's emphasis on transfer of risk	88	4.9318	1.25758
Client's emphasis on single point of responsibility	88	5.3636	1.27019
Client's ability to brief the design team	90	4.8111	1.18885
Decision-making power of client	90	4.5500	1.27652
Client's involvement in the project	89	4.2809	1.37542
Technical skills of client's representative	88	4.8864	1.20756
Project management skills of client's representative	87	4.6954	1.08702
Experience and capabilities of client's representative	87	5.0575	1.17490
Commitment and adaptability of client's representative	87	4.8848	1.06865
Technical skills of contractor's design consultants	90	5.07778	.950787
Project management skills of contractor's design consultants	91	4.6484	.99436
Experience and capabilities of contractor's design consultants	90	5.1222	1.10999
Commitment and adaptability of contractor's design consultants	91	5.0041	.98072
Support from the parent company of contractor's design consultants	88	4.6477	1.23213
Technical skills of the construction team leader	91	5.0110	1.15945
Project management skills of the construction team leader	90	4.8533	1.13526
Experience and capabilities of the construction team leader	90	4.9444	1.28396

Descriptive Statistics

	N	Mean	Std. Deviation
Commitment and adaptability of the construction team leader	90	4.8558	1.24131
Support from the parent company of the construction team leader	90	4.8000	1.30857
End users' involvement in the design-build process	86	3.6049	1.26904
Effectiveness of communication	88	4.8239	.81664
Up-front planning efforts	90	4.7333	1.05788
Effectiveness of control systems	91	4.8297	.87946
Effectiveness of management systems	90	4.7283	.83033
Effectiveness of organizational structure	90	4.9111	1.00162
Delegation of decision-making authority from the client	91	4.4560	1.14418
Delegation of decision-making authority from the construction team leader	89	4.4045	1.18436
Confidence level of the construction team leader	91	4.9505	1.01120
Cohesiveness of the D&B team	90	4.7778	1.17825
Harmonious working relationships among project team members	91	4.7951	1.09199
Valid N (listwise)	68		

Reliability

Case Processing Summary

		N	%
Cases	Valid	68	73.9
	Excluded (a)	24	26.1
	Total	92	100.0

a Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.899	42

\- - - - - - - - - - - FACTOR ANALYSIS - - - - - - - - - -
\-

Factor Analysis

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.635
Bartlett's Test of Sphericity	Approx. Chi-Square	2291.829
	df	861
	Sig.	.000

Communalities

	Initial
Contractor's input to the project	1.000
Complexity of the project	1.000
Scope of the project	1.000
Clarity of client's requirements	1.000
Attractiveness of the project	1.000
Adoption of innovative management approaches	1.000
Physical environment	1.000
Economic environment	1.000
Political environment	1.000
Social environment	1.000
Client's emphasis on time	1.000
Client's emphasis on cost	1.000
Client's emphasis on transfer of risk	1.000
Client's emphasis on single point of responsibility	1.000
Client's ability to brief the design team	1.000
Decision-making power of client	1.000
Client's involvement in the project	1.000
Technical skills of client's representative	1.000
Project management skills of client's representative	1.000
Experience and capabilities of client's representative	1.000
Commitment and adaptability of client's representative	1.000
Technical skills of contractor's design consultants	1.000

Extraction Method: Principal Component Analysis.

Communalities

	Initial
Project management skills of contractor's design consultants	1.000
Experience and capabilities of contractor's design consultants	1.000
Commitment and adaptability of contractor's design consultants	1.000
Support from the parent company of contractor's design consultants	1.000
Technical skills of the construction team leader	1.000
Project management skills of the construction team leader	1.000
Experience and capabilities of the construction team leader	1.000
Commitment and adaptability of the construction team leader	1.000
Support from the parent company of the construction team leader	1.000
End users' involvement in the design-build process	1.000
Up-front planning efforts	1.000
Effectiveness of communication	1.000
Effectiveness of control systems	1.000
Effectiveness of management systems	1.000
Effectiveness of organizational structure	1.000
Delegation of decision-making authority from the client	1.000
Delegation of decision-making authority from the construction team leader	1.000
Confidence level of the construction team leader	1.000
Cohesiveness of the D&B team	1.000
Harmonious working relationships among project team members	1.000

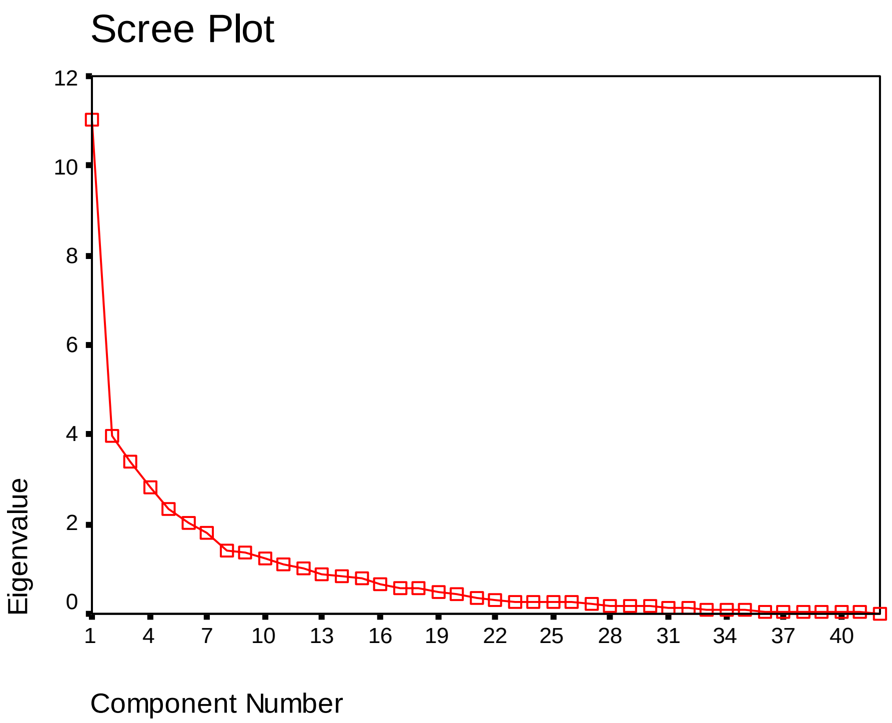
Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Rotation
	Total	% of Variance	Cumulative %	Total
1	11.033	26.268	26.268	6.931
2	3.962	9.434	35.702	6.009
3	3.385	8.059	43.761	6.924
4	2.817	6.707	50.468	6.328
5	2.344	5.581	56.050	6.335
6	2.024	4.818	60.868	2.841
7	1.823	4.340	65.208	2.989
8	1.411	3.361	68.569	2.660
9	1.389	3.308	71.877	2.264
10	1.238	2.947	74.824	1.841
11	1.097	2.611	77.435	1.775
12	1.014	2.414	79.849	1.695
13	.886	2.110	81.959	
14	.820	1.951	83.910	
15	.792	1.886	85.796	
16	.679	1.616	87.412	
17	.593	1.411	88.823	
18	.569	1.354	90.177	
19	.463	1.103	91.280	
20	.450	1.070	92.351	
21	.371	.884	93.235	
22	.320	.762	93.997	
23	.278	.661	94.658	
24	.268	.638	95.296	
25	.247	.588	95.883	
26	.243	.579	96.462	
27	.201	.478	96.940	
28	.178	.423	97.364	
29	.172	.409	97.772	
30	.160	.380	98.152	
31	.137	.327	98.479	
32	.111	.263	98.742	
33	9.512E-02	.226	98.969	
34	7.978E-02	.190	99.159	
35	7.683E-02	.183	99.342	
36	6.272E-02	.149	99.491	
37	5.935E-02	.141	99.632	
38	4.811E-02	.115	99.747	
39	3.643E-02	8.675E-02	99.834	
40	3.229E-02	7.688E-02	99.911	
41	2.424E-02	5.771E-02	99.968	
42	1.331E-02	3.170E-02	100.000	

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.



Component Matrix[a]

a. 12 components extracted.

Structure Matrix

	Component				
	1	2	3	4	5
Project management skills of client's representative	.807	.452	.426	.418	.251
Client's involvement in the project	.802	.332	.375	.263	.330
End users' involvement in the design-build process	.788	.036	.265	.211	.304
Commitment and adaptability of client's representative	.771	.392	.402	.413	.377
Decision-making power of client	.762	.366	.293	.388	.348
Delegation of decision-making authority from the client	.760	.050	.144	.330	.513
Experience and capabilities of client's representative	.680	.455	.424	.298	.080
Technical skills of client's representative	.667	.535	.246	.287	.086
Project management skills of the construction team leader	.336	.937	.315	.288	.241
Experience and capabilities of the construction team leader	.156	.910	.296	.348	.151
Commitment and adaptability of the construction team leader	.298	.871	.428	.175	.307
Technical skills of the construction team leader	.188	.853	.113	.315	.059
Support from the parent company of the construction team leader	.315	.677	.504	-.032	.292
Up-front planning efforts	.315	.379	.805	.439	.590
Effectiveness of communication	.263	.339	.796	.417	.539
Effectiveness of control systems	.148	.308	.791	.246	.376
Effectiveness of management systems	.331	.359	.781	.500	.592
Effectiveness of organizational structure	.253	.106	.726	.112	.169
Experience and capabilities of contractor's design consultants	.112	.336	.241	.870	.287
Technical skills of contractor's design consultants	.388	.172	.212	.846	.379
Commitment and adaptability of contractor's design consultants	.274	.276	.359	.828	.454
Project management skills of contractor's design consultants	.441	.236	.191	.767	.505
Support from the parent company of contractor's design consultants	.356	.012	.390	.623	.486
Harmonious working relationships among project team members	.333	.285	.573	.527	.831

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Structure Matrix

	Component				
	1	2	3	4	5
Confidence level of the construction team leader	.248	.271	.475	.552	.827
Cohesiveness of the D&B team	.192	.272	.524	.545	.813
Delegation of decision-making authority from the construction team leader	.422	-.004	.113	.203	.753
Scope of the project	.102	.132	.405	.168	.185
Client's ability to brief the design team	.461	.391	.133	.410	.311
Clarity of client's requirements	.251	-.016	.340	.149	.142
Contractor's input to the project	.045	.123	.310	.115	.207
Attractiveness of the project	-.019	.152	.345	.157	.313
Complexity of the project	-.298	.019	.048	.046	.115
Client's emphasis on time	.018	.122	.359	.049	.312
Client's emphasis on cost	-.067	.166	.091	.156	.018
Political environment	.336	-.022	.574	.203	.318
Adoption of innovative management approaches	-.040	.035	.085	.124	.059
Client's emphasis on single point of responsibility	-.176	-.036	-.161	-.001	-.162
Client's emphasis on transfer of risk	-.285	-.018	-.083	-.010	-.047
Physical environment	.089	.054	-.047	-.057	-.080
Social environment	-.257	.085	.154	.001	.094
Economic environment	.033	.016	.175	.112	.170

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Structure Matrix

	Component				
	6	7	8	9	10
Project management skills of client's representative	.283	-.156	-.079	.090	-.253
Client's involvement in the project	.101	.023	-.053	-.009	.019
End users' involvement in the design-build process	-.014	.125	.140	.248	-.158
Commitment and adaptability of client's representative	.217	-.020	.115	.128	-.183
Decision-making power of client	.333	-.094	.186	-.077	-.136
Delegation of decision-making authority from the client	.081	.137	-.042	.004	-.112
Experience and capabilities of client's representative	.260	-.164	-.238	.007	-.146
Technical skills of client's representative	.185	-.301	-.344	-.057	-.110
Project management skills of the construction team leader	.071	.035	.054	.085	-.012
Experience and capabilities of the construction team leader	.323	.038	-.119	-.073	-.155
Commitment and adaptability of the construction team leader	-.022	.059	.137	.199	.127
Technical skills of the construction team leader	.223	-.039	.011	-.028	-.210
Support from the parent company of the construction team leader	-.287	-.025	.340	.306	.302
Up-front planning efforts	.107	.356	.295	.465	.003
Effectiveness of communication	.400	.397	.205	.196	-.241
Effectiveness of control systems	.425	.331	.154	.104	-.235
Effectiveness of management systems	.022	.301	.282	.274	-.026
Effectiveness of organizational structure	.121	.066	.143	-.095	.011
Experience and capabilities of contractor's design consultants	.320	.089	-.003	.110	-.169
Technical skills of contractor's design consultants	.043	.133	.032	.187	.005
Commitment and adaptability of contractor's design consultants	.118	.087	.180	.093	.090
Project management skills of contractor's design consultants	-.008	.112	.078	.276	-.098
Support from the parent company of contractor's design consultants	-.356	.002	.359	.159	.336
Harmonious working relationships among project team members	.166	.433	.228	.195	-.073

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Structure Matrix

	Component				
	6	7	8	9	10
Confidence level of the construction team leader	.242	.133	.194	.147	.033
Cohesiveness of the D&B team	.258	.411	.074	-.073	-.211
Delegation of decision-making authority from the construction team leader	-.150	.053	.154	.102	-.077
Scope of the project	.692	.217	.160	.064	.089
Client's ability to brief the design team	.655	-.091	-.051	-.115	-.298
Clarity of client's requirements	.626	.054	.166	.075	.082
Contractor's input to the project	.000	.792	.103	.067	.054
Attractiveness of the project	.163	.770	.061	.370	-.088
Complexity of the project	.110	.619	-.170	.352	-.297
Client's emphasis on time	-.003	.025	.826	.199	.125
Client's emphasis on cost	.132	.003	.649	-.173	.181
Political environment	-.068	.258	.583	.311	.047
Adoption of innovative management approaches	-.012	.172	.093	.836	.091
Client's emphasis on single point of responsibility	.102	-.017	-.009	-.008	.721
Client's emphasis on transfer of risk	-.080	-.333	.319	.059	.581
Physical environment	.032	.003	-.089	.039	-.134
Social environment	.206	-.115	.214	-.525	.072
Economic environment	.183	.026	.086	-.079	-.083

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Structure Matrix

	Component	
	11	12
Project management skills of client's representative	.021	-.112
Client's involvement in the project	.177	-.178
End users' involvement in the design-build process	.027	.203
Commitment and adaptability of client's representative	.118	-.364
Decision-making power of client	-.015	-.078
Delegation of decision-making authority from the client	-.062	.151
Experience and capabilities of client's representative	-.035	-.360
Technical skills of client's representative	.088	-.362
Project management skills of the construction team leader	.102	-.156
Experience and capabilities of the construction team leader	.192	-.175
Commitment and adaptability of the construction team leader	.186	-.274
Technical skills of the construction team leader	-.033	-.017
Support from the parent company of the construction team leader	.159	-.159
Up-front planning efforts	.184	.054
Effectiveness of communication	.112	.175
Effectiveness of control systems	.034	.037
Effectiveness of management systems	.302	.031
Effectiveness of organizational structure	.129	-.023
Experience and capabilities of contractor's design consultants	.100	-.044
Technical skills of contractor's design consultants	-.088	.065
Commitment and adaptability of contractor's design consultants	.081	-.015
Project management skills of contractor's design consultants	-.212	.345
Support from the parent company of contractor's design consultants	-.077	-.050
Harmonious working relationships among project team members	.155	.133

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Structure Matrix

	Component	
	11	12
Confidence level of the construction team leader	.115	-.004
Cohesiveness of the D&B team	.218	.125
Delegation of decision-making authority from the construction team leader	-.125	.119
Scope of the project	.107	.107
Client's ability to brief the design team	.052	-.109
Clarity of client's requirements	.052	.064
Contractor's input to the project	.026	-.043
Attractiveness of the project	.159	-.017
Complexity of the project	.322	.137
Client's emphasis on time	.098	-.121
Client's emphasis on cost	-.021	.311
Political environment	.315	.067
Adoption of innovative management approaches	.047	-.016
Client's emphasis on single point of responsibility	-.062	-.067
Client's emphasis on transfer of risk	-.311	.345
Physical environment	.738	-.017
Social environment	.604	.020
Economic environment	.094	.729

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

APPENDIX M

CALCULATION OF MULTIPLE LINEAR REGRESSION

M.1 **Regression plots for PSI-D&B**

M.2 **Regression plots for time performance**

M.3 **Regression plots for cost performance**

M.4 **Regression plots for quality performance**

M.5 **Regression plots for functionality performance**

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Project Success Index for Design-Build Projects	10.2689	1.64682	58
REGR factor score 1 for analysis 1	-.0127189	1.04296172	58
REGR factor score 2 for analysis 1	-.0382091	1.00445880	58
REGR factor score 3 for analysis 1	-.0136118	1.01439969	58
REGR factor score 4 for analysis 1	.0407976	1.01399107	58
REGR factor score 5 for analysis 1	.0367002	1.02950356	58
REGR factor score 6 for analysis 1	-.0015427	.99698594	58
REGR factor score 7 for analysis 1	-.0269032	1.03424157	58
REGR factor score 8 for analysis 1	.0430250	.99763475	58
REGR factor score 9 for analysis 1	.0088457	1.02731703	58
REGR factor score 10 for analysis 1	-.0032412	.99637410	58
REGR factor score 11 for analysis 1	-.0779813	.98729641	58
REGR factor score 12 for analysis 1	.1326273	.99568914	58

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	REGR factor score 7 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	REGR factor score 3 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	REGR factor score 9 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Project Success Index for Design-Build Projects

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.577[a]	.333	.321	1.35680
2	.711[b]	.506	.488	1.17883
3	.757[c]	.573	.549	1.10565

a. Predictors: (Constant), REGR factor score 7 for analysis 1

b. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 3 for analysis 1

c. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 3 for analysis 1 , REGR factor score 9 for analysis 1

d. Dependent Variable: Project Success Index for Design-Build Projects

Coefficients[a]

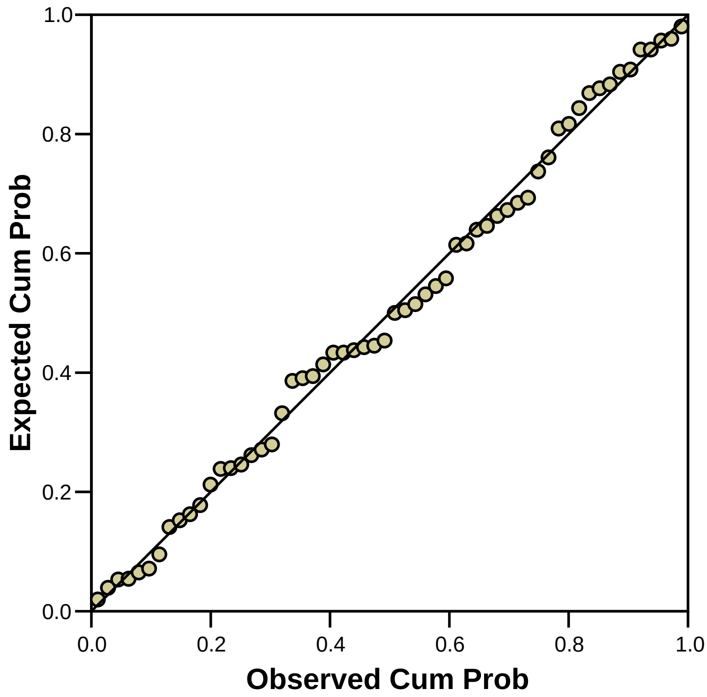
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	10.294	.178		57.758	.000
	REGR factor score 7 for analysis 1	.919	.174	.577	5.289	.000
2	(Constant)	10.299	.155		66.510	.000
	REGR factor score 7 for analysis 1	.759	.155	.477	4.886	.000
	REGR factor score 3 for analysis 1	.694	.158	.427	4.380	.000
3	(Constant)	10.291	.145		70.847	.000
	REGR factor score 7 for analysis 1	.664	.149	.417	4.444	.000
	REGR factor score 3 for analysis 1	.602	.152	.371	3.962	.000
	REGR factor score 9 for analysis 1	.441	.151	.275	2.919	.005

a. Dependent Variable: Project Success Index for Design-Build Projects

Charts

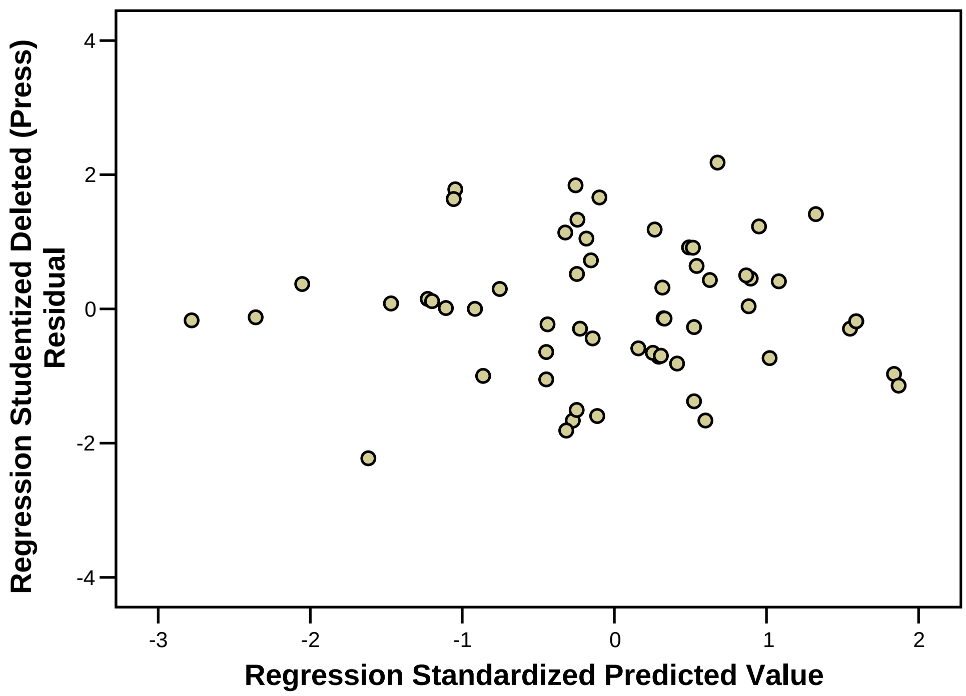
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Project Success Index (PSI-D&B)



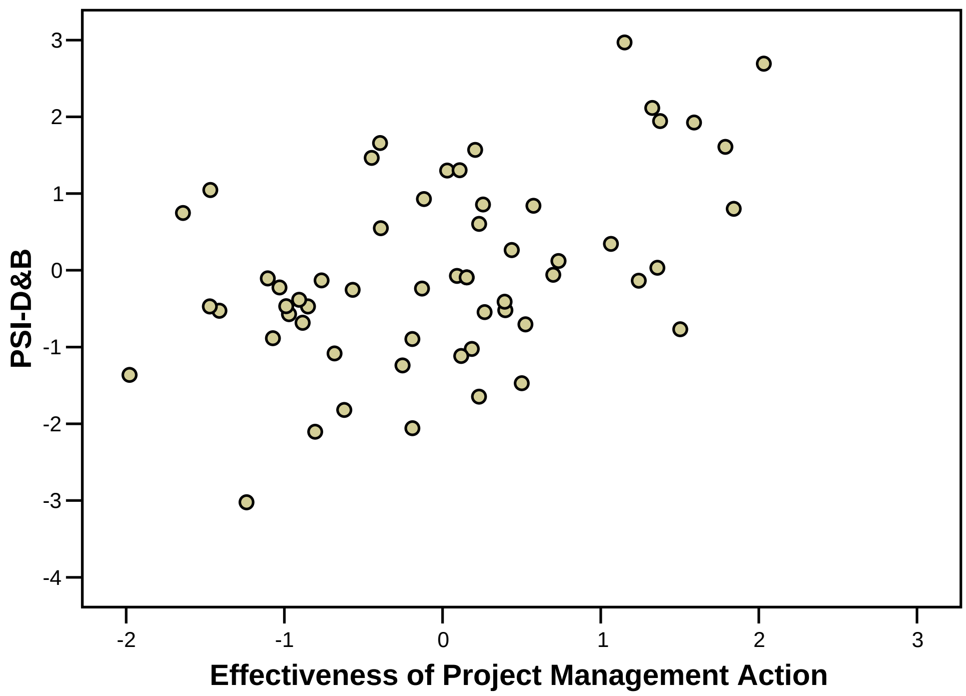
Scatterplot

Dependent Variable: Project Success Index (PSI-D&B)



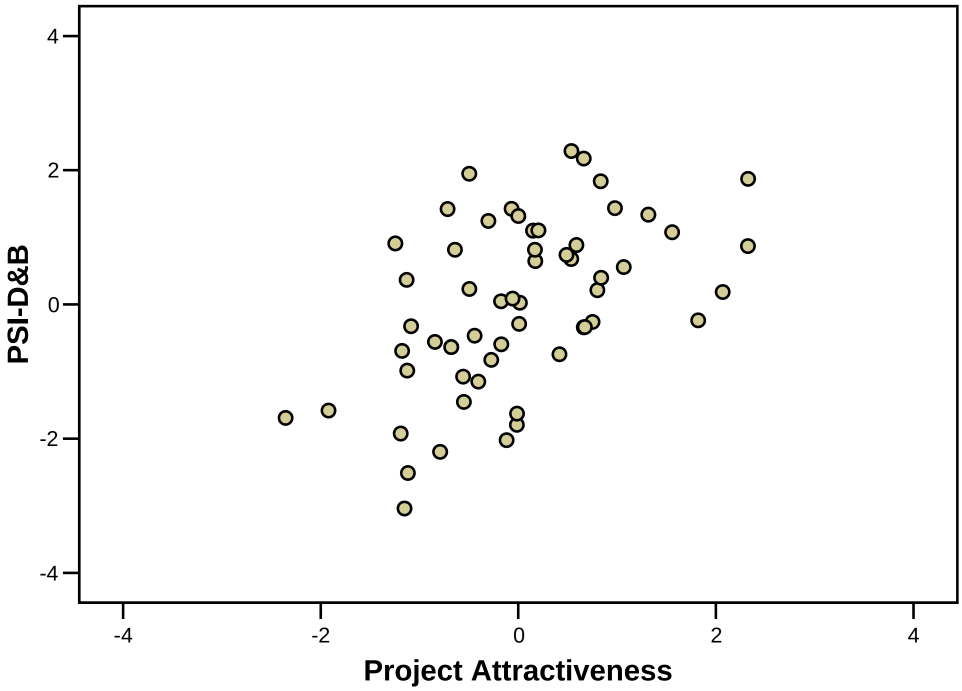
Partial Regression Plot

Dependent Variable: Project Success Index for Design-Build Projects



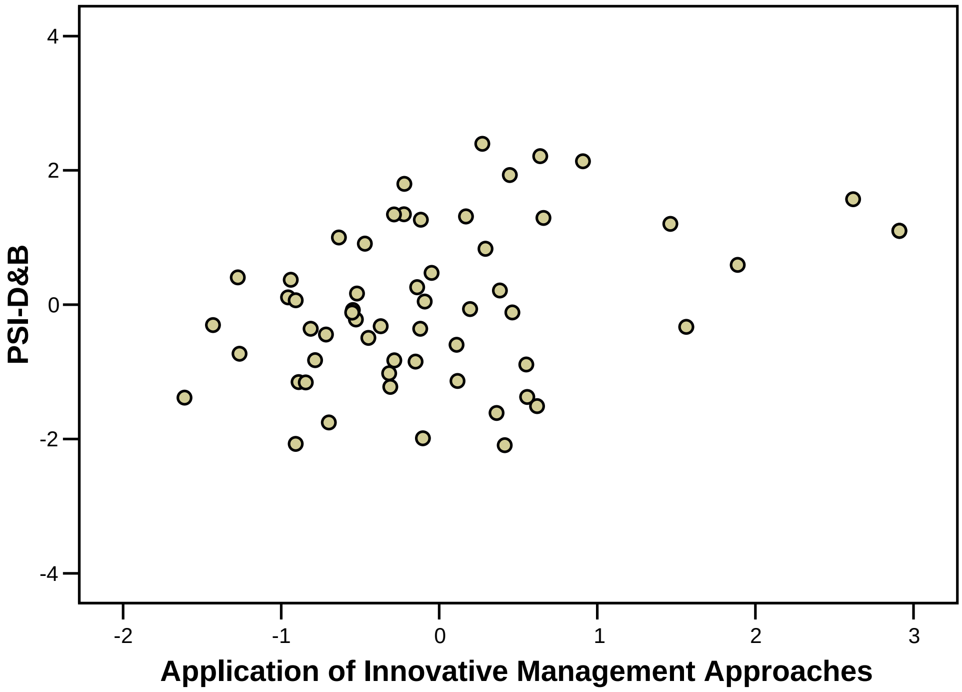
Partial Regression Plot

Dependent Variable: Project Success Index (PSI-D&B)



Partial Regression Plot

Dependent Variable: Project Success Index (PSI-D&B)



Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Time	4.9333	1.32597	60
REGR factor score 1 for analysis 1	-.0328960	1.03417341	60
REGR factor score 2 for analysis 1	-.0517612	.99263913	60
REGR factor score 3 for analysis 1	-.0167884	1.01579963	60
REGR factor score 4 for analysis 1	.0264717	1.00225384	60
REGR factor score 5 for analysis 1	.0242944	1.03417061	60
REGR factor score 6 for analysis 1	.0142364	1.01367817	60
REGR factor score 7 for analysis 1	-.0196340	1.00146859	60
REGR factor score 8 for analysis 1	-.0140120	.99145001	60
REGR factor score 9 for analysis 1	-.0190063	1.02237151	60
REGR factor score 10 for analysis 1	-.0229442	1.01232391	60
REGR factor score 11 for analysis 1	-.0244321	.95482064	60
REGR factor score 12 for analysis 1	.0445034	.98130469	60

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	REGR factor score 7 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	REGR factor score 3 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	REGR factor score 9 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Time

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.542[a]	.294	.281	1.12403
2	.673[b]	.453	.434	.99736
3	.742[c]	.550	.526	.91255

a. Predictors: (Constant), REGR factor score 7 for analysis 1

b. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 3 for analysis 1

c. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 3 for analysis 1 , REGR factor score 9 for analysis 1

d. Dependent Variable: Time

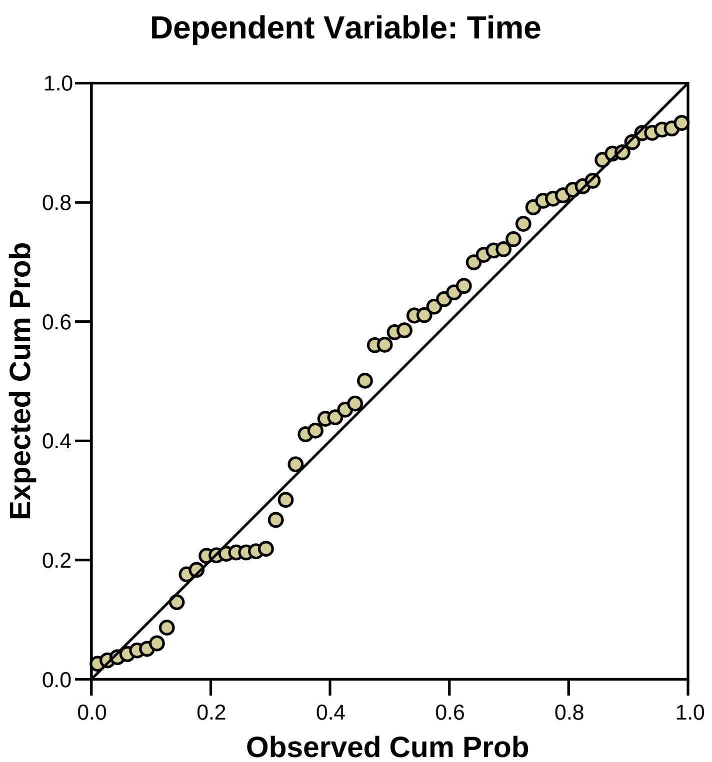
Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.947	.145		34.087	.000
	REGR factor score 7 for analysis 1	.717	.146	.542	4.910	.000
2	(Constant)	4.954	.129		38.463	.000
	REGR factor score 7 for analysis 1	.575	.134	.434	4.279	.000
	REGR factor score 3 for analysis 1	.541	.132	.414	4.083	.000
3	(Constant)	4.959	.118		42.076	.000
	REGR factor score 7 for analysis 1	.487	.125	.368	3.886	.000
	REGR factor score 3 for analysis 1	.456	.124	.349	3.691	.001
	REGR factor score 9 for analysis 1	.426	.122	.328	3.477	.001

a. Dependent Variable: Time

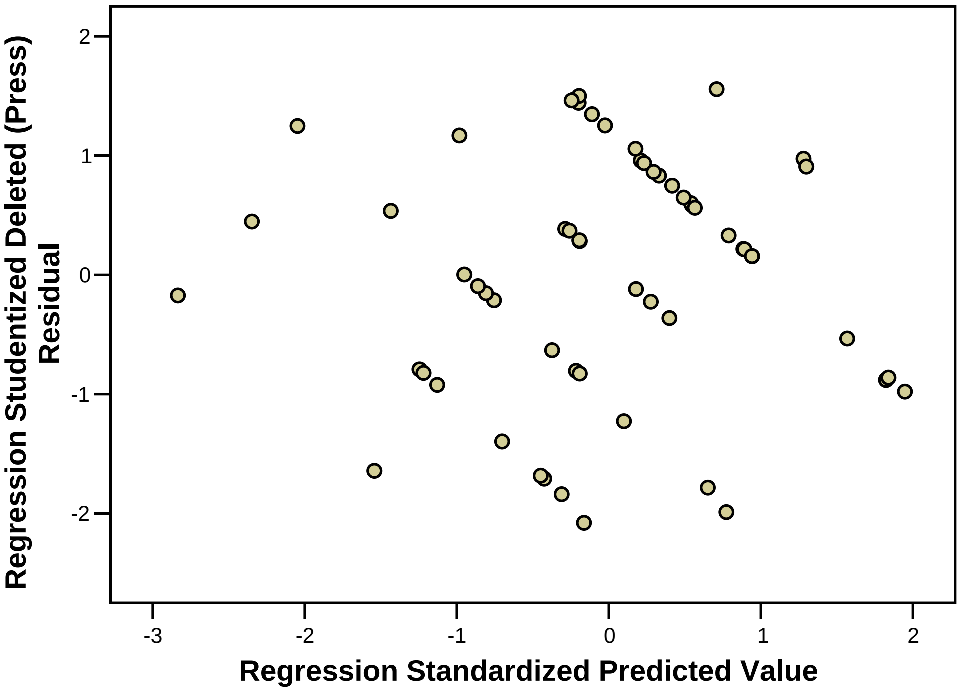
Charts

Normal P-P Plot of Regression Standardized Residual



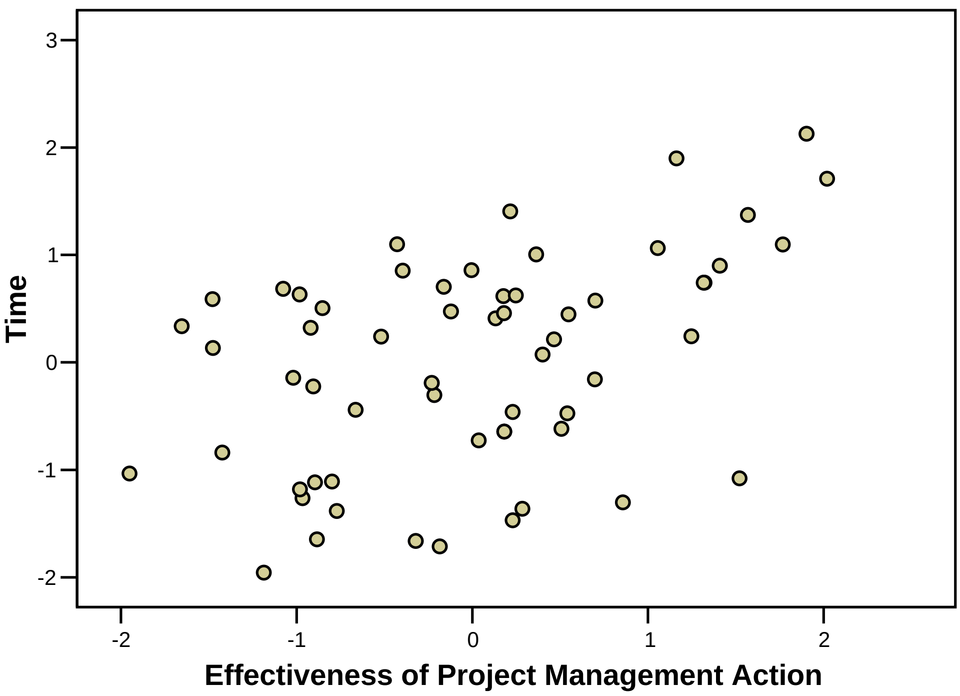
Scatterplot

Dependent Variable: Time



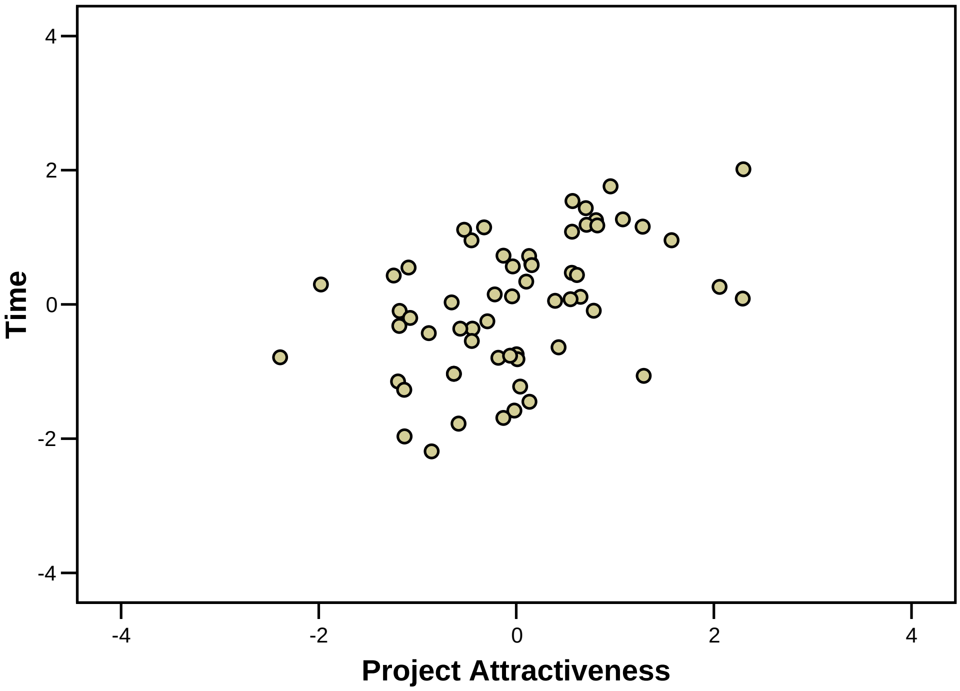
Partial Regression Plot

Dependent Variable: Time



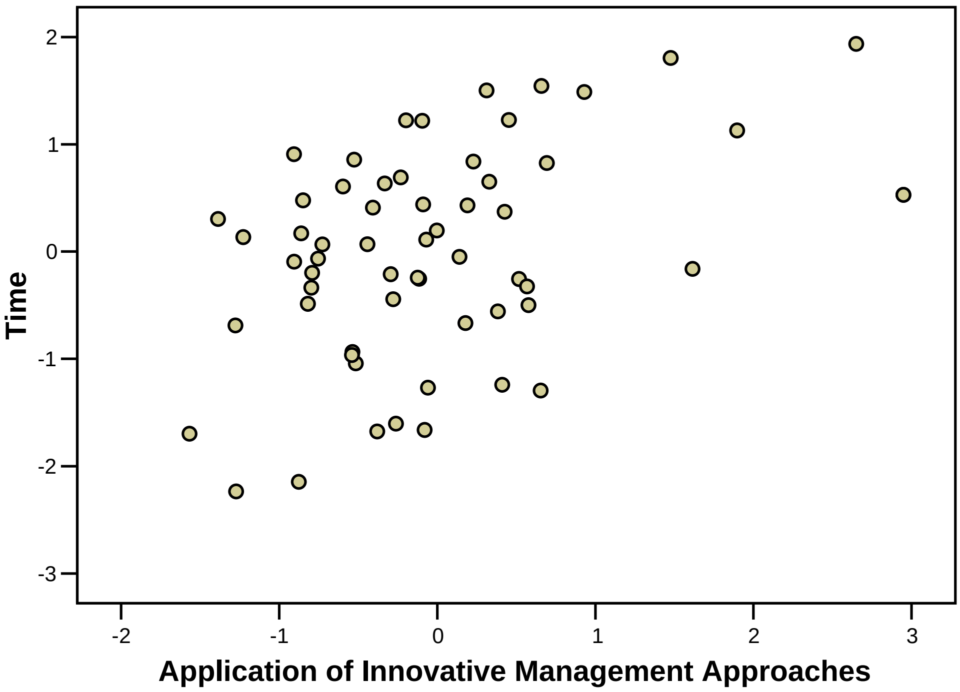
Partial Regression Plot

Dependent Variable: Time



Partial Regression Plot

Dependent Variable: Time



Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Cost	5.4630	.90518	54
REGR factor score 1 for analysis 1	-.0324887	1.01749831	54
REGR factor score 2 for analysis 1	-.0420226	.97683855	54
REGR factor score 3 for analysis 1	.0336449	.93426363	54
REGR factor score 4 for analysis 1	-.0480837	1.02192730	54
REGR factor score 5 for analysis 1	.0153447	1.01076470	54
REGR factor score 6 for analysis 1	-.1058525	.99783445	54
REGR factor score 7 for analysis 1	.1046432	.92243598	54
REGR factor score 8 for analysis 1	.0794074	.98363366	54
REGR factor score 9 for analysis 1	.0594059	.99953727	54
REGR factor score 10 for analysis 1	.0296798	1.04452150	54
REGR factor score 11 for analysis 1	-.0042281	.95156174	54
REGR factor score 12 for analysis 1	.0930046	1.02646911	54

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	REGR factor score 7 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	REGR factor score 6 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	REGR factor score 9 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Cost

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.408[a]	.166	.150	.83444
2	.525[b]	.275	.247	.78555
3	.658[c]	.432	.398	.70216

a. Predictors: (Constant), REGR factor score 7 for analysis 1

b. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 6 for analysis 1

c. Predictors: (Constant), REGR factor score 7 for analysis 1 , REGR factor score 6 for analysis 1 , REGR factor score 9 for analysis 1

d. Dependent Variable: Cost

Coefficients[a]

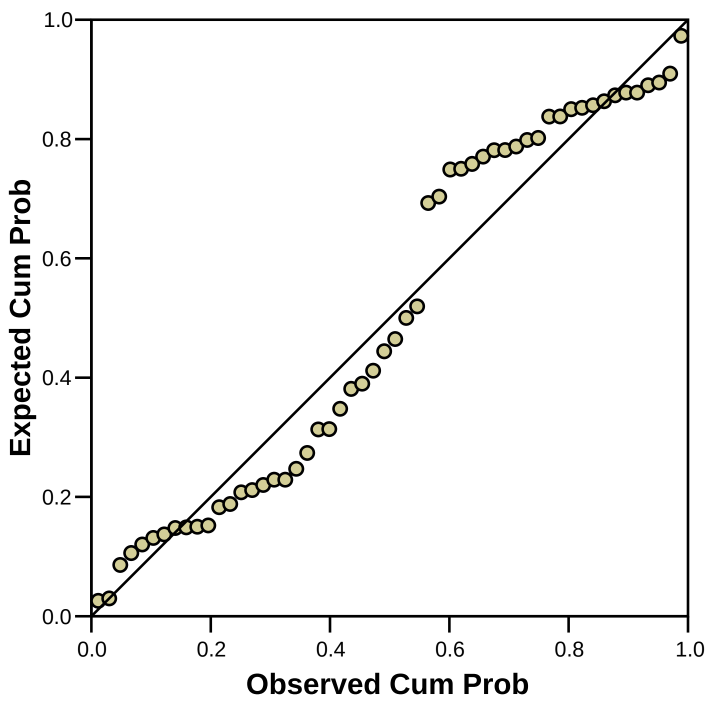
Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	5.421	.114		47.431	.000
	REGR factor score 7 for analysis 1	.400	.124	.408	3.220	.002
2	(Constant)	5.460	.109		50.315	.000
	REGR factor score 7 for analysis 1	.335	.119	.342	2.811	.007
	REGR factor score 6 for analysis 1	.306	.110	.337	2.770	.008
3	(Constant)	5.457	.097		56.258	.000
	REGR factor score 7 for analysis 1	.249	.109	.254	2.280	.027
	REGR factor score 6 for analysis 1	.403	.102	.445	3.953	.000
	REGR factor score 9 for analysis 1	.376	.101	.416	3.719	.001

a. Dependent Variable: Cost

Charts

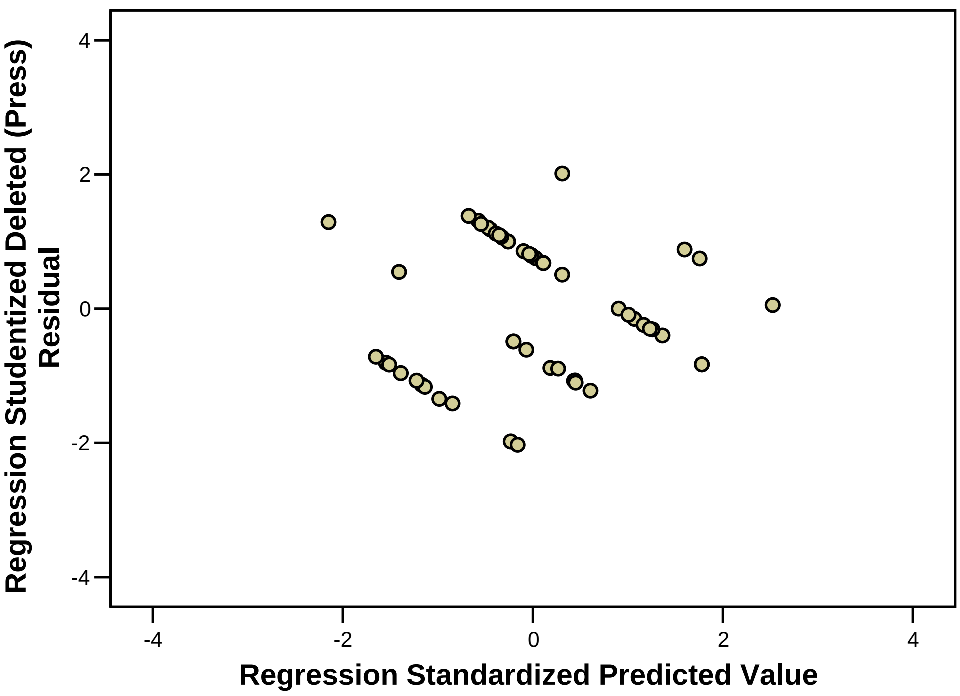
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: Cost



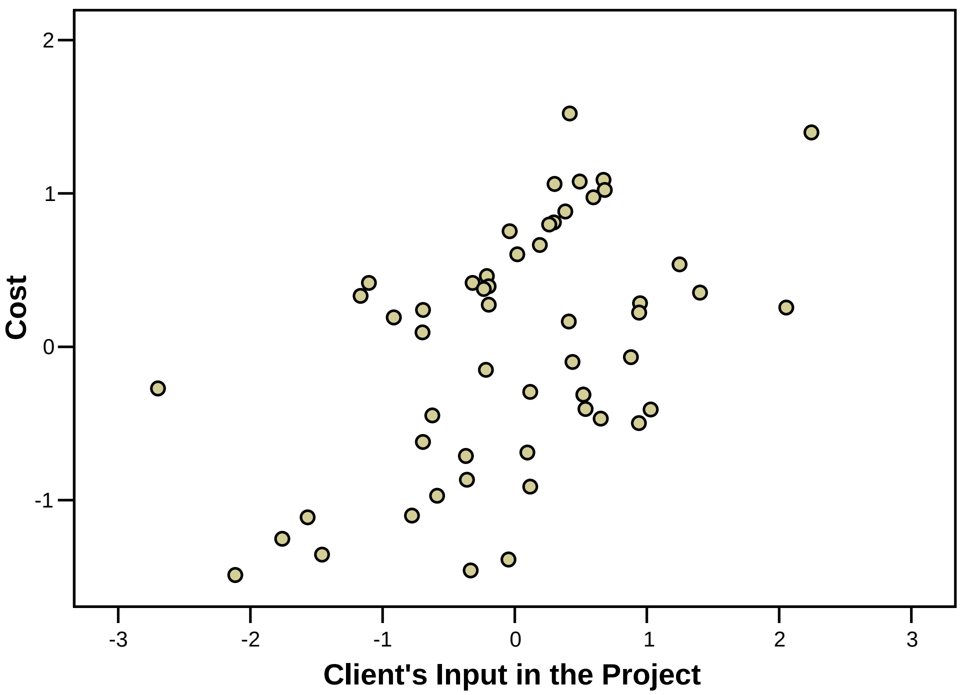
Scatterplot

Dependent Variable: Cost



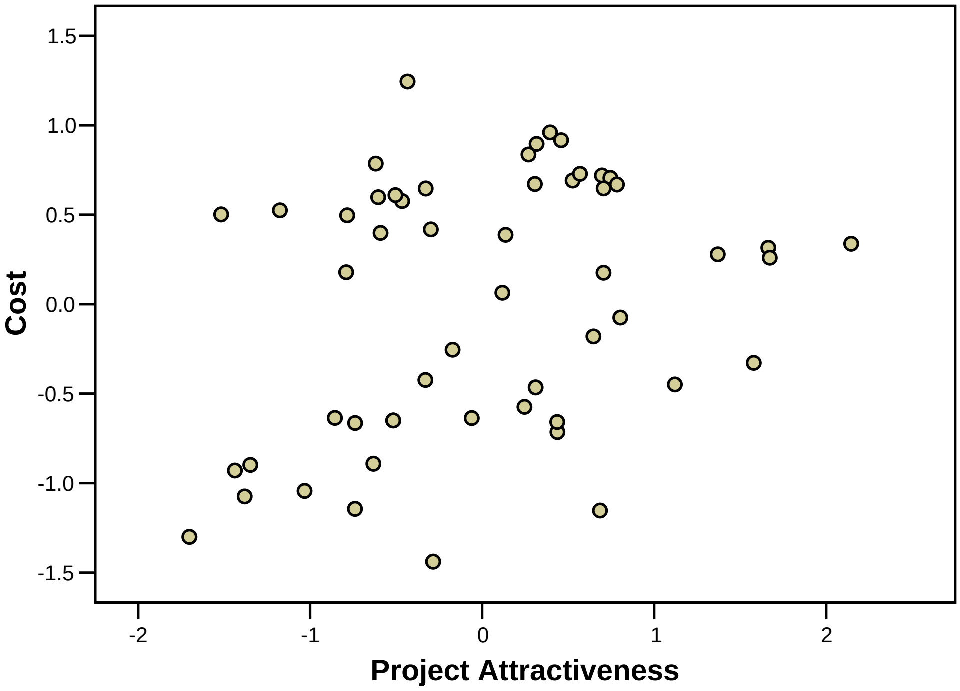
Partial Regression Plot

Dependent Variable: Cost



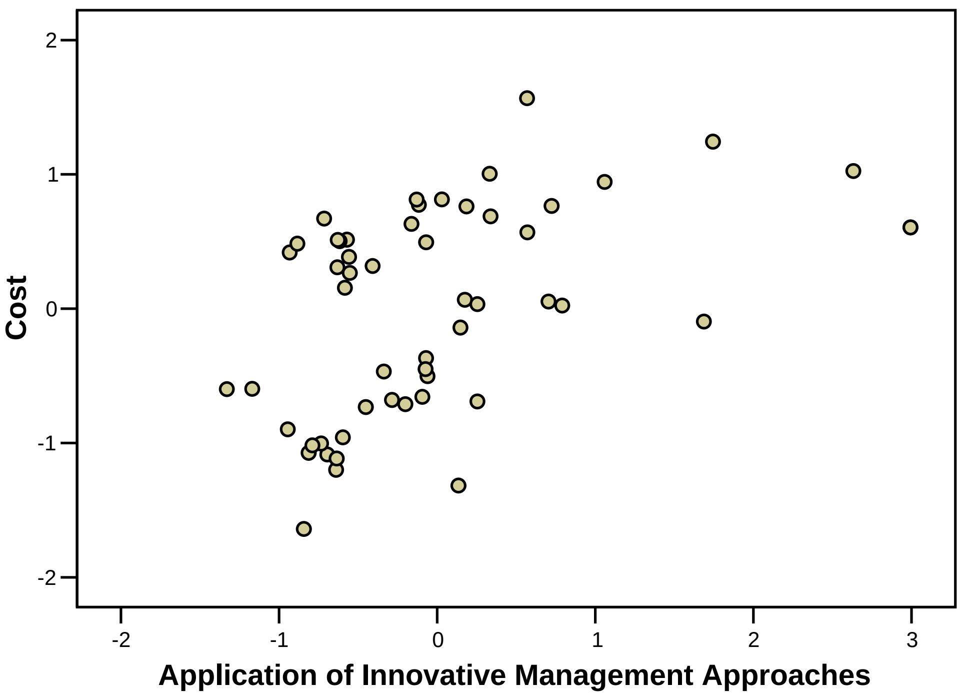
Partial Regression Plot

Dependent Variable: Cost



Partial Regression Plot

Dependent Variable: Cost



Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Quality	4.7984	.84669	62
REGR factor score 1 for analysis 1	.0244466	.98286277	62
REGR factor score 2 for analysis 1	-.0194669	.97395707	62
REGR factor score 3 for analysis 1	-.0196495	.96473395	62
REGR factor score 4 for analysis 1	.0391886	.98480227	62
REGR factor score 5 for analysis 1	.0207204	1.02156357	62
REGR factor score 6 for analysis 1	.0697243	.99312884	62
REGR factor score 7 for analysis 1	.0051097	1.02876380	62
REGR factor score 8 for analysis 1	.0027647	.97438059	62
REGR factor score 9 for analysis 1	-.0184201	1.02856159	62
REGR factor score 10 for analysis 1	-.0216840	.98120002	62
REGR factor score 11 for analysis 1	-.0537349	.97203006	62
REGR factor score 12 for analysis 1	.0354471	1.00737908	62

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	REGR factor score 3 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	REGR factor score 5 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Quality

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.563[a]	.317	.305	.70574
2	.638[b]	.406	.386	.66327

a. Predictors: (Constant), REGR factor score 3 for analysis 1

b. Predictors: (Constant), REGR factor score 3 for analysis 1 , REGR factor score 5 for analysis 1

c. Dependent Variable: Quality

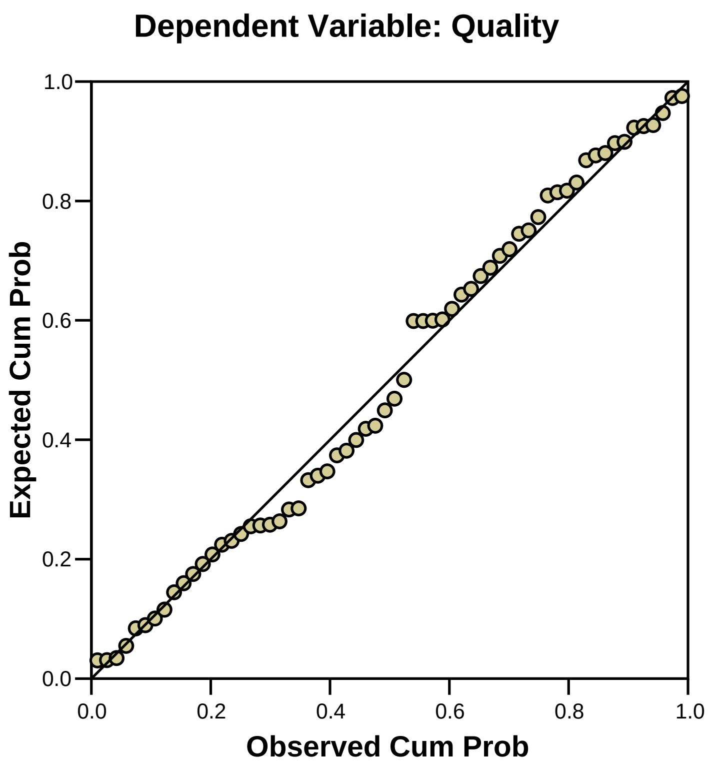
Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.808	.090		53.633	.000
	REGR factor score 3 for analysis 1	.494	.094	.563	5.273	.000
2	(Constant)	4.799	.084		56.926	.000
	REGR factor score 3 for analysis 1	.342	.102	.390	3.372	.001
	REGR factor score 5 for analysis 1	.287	.096	.346	2.988	.004

a. Dependent Variable: Quality

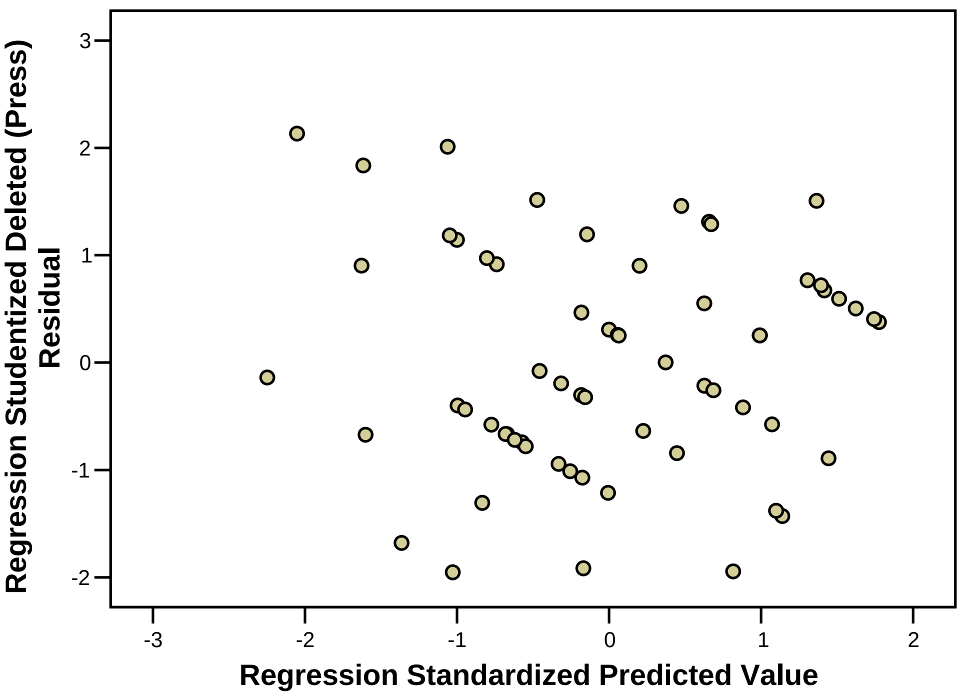
Charts

Normal P-P Plot of Regression Standardized Residual



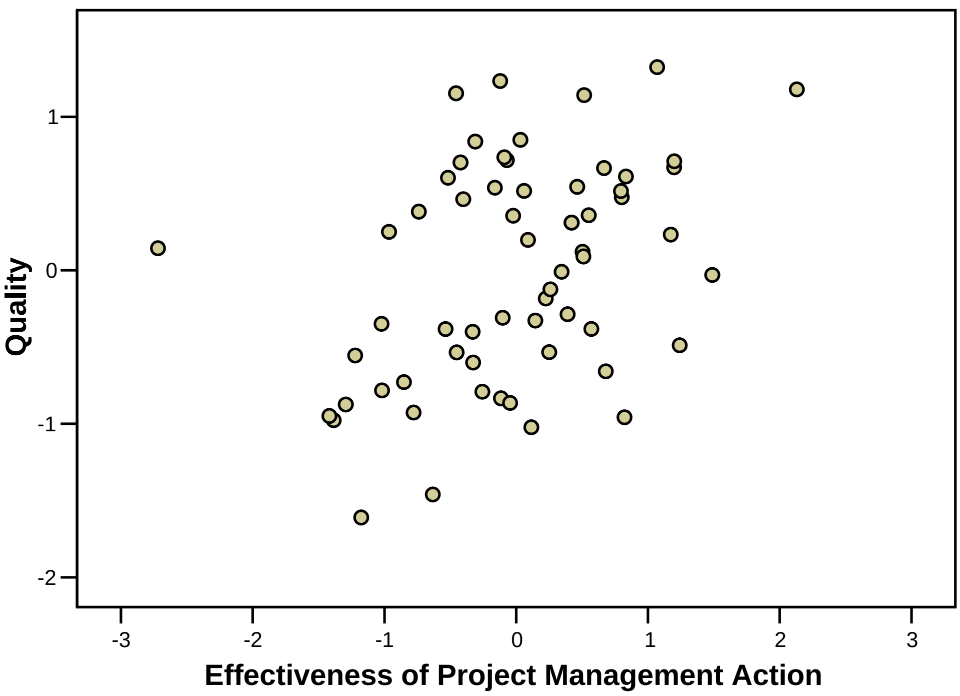
Scatterplot

Dependent Variable: Quality



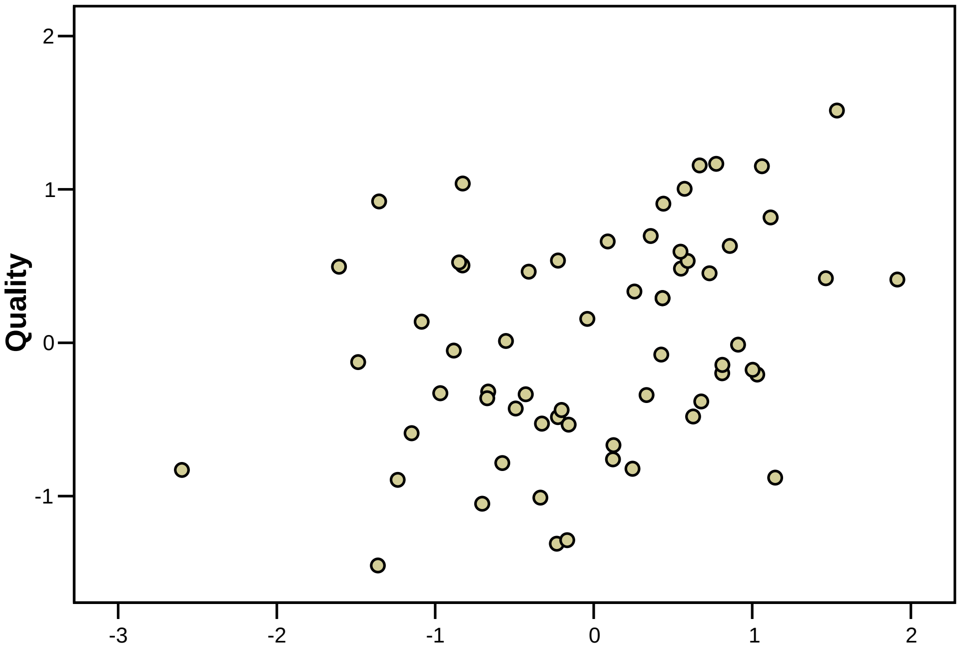
Partial Regression Plot

Dependent Variable: Quality



Partial Regression Plot

Dependent Variable: Quality



Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Functionality	5.5082	.80876	61
REGR factor score 1 for analysis 1	-.0352849	1.01546074	61
REGR factor score 2 for analysis 1	-.0385684	.99824904	61
REGR factor score 3 for analysis 1	-.0237078	.99774623	61
REGR factor score 4 for analysis 1	-.0114996	1.01288929	61
REGR factor score 5 for analysis 1	.0633222	.98431711	61
REGR factor score 6 for analysis 1	.0909434	.95707827	61
REGR factor score 7 for analysis 1	.0448914	1.03127067	61
REGR factor score 8 for analysis 1	.0438728	.94511244	61
REGR factor score 9 for analysis 1	.0281106	1.03585239	61
REGR factor score 10 for analysis 1	-.0671981	.97918771	61
REGR factor score 11 for analysis 1	-.0571921	.98391307	61
REGR factor score 12 for analysis 1	.1092700	.98058882	61

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	REGR factor score 3 for analysis 1	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Functionality

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.467[a]	.218	.205	.72113

a. Predictors: (Constant), REGR factor score 3 for analysis 1

b. Dependent Variable: Functionality

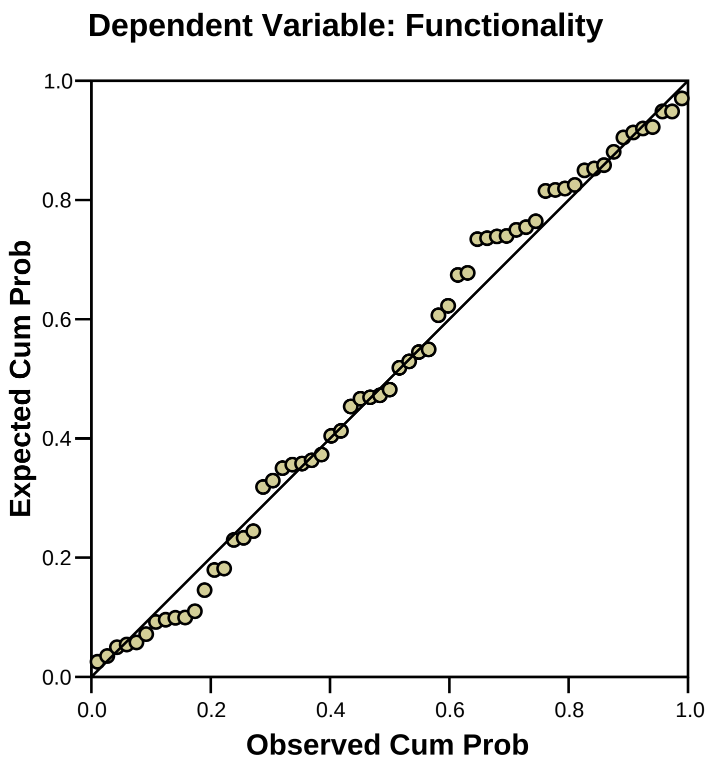
Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	5.517	.092		59.737	.000
	REGR factor score 3 for analysis 1	.379	.093	.467	4.058	.000

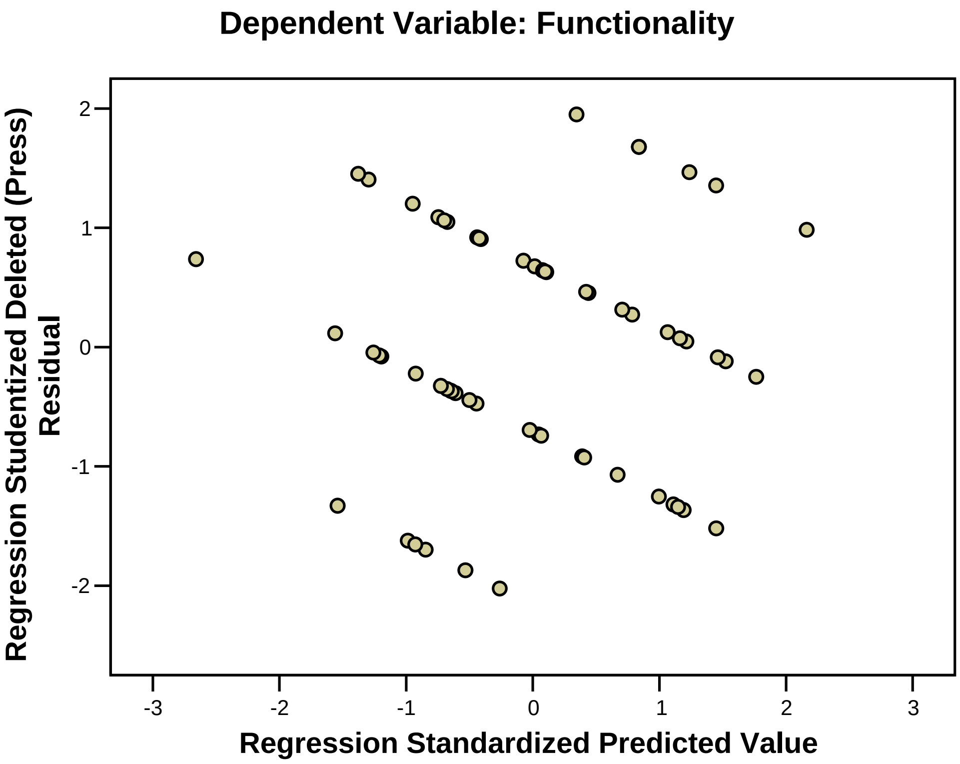
a. Dependent Variable: Functionality

Charts

Normal P-P Plot of Regression Standardized Residual



Scatterplot



APPENDIX N

SAMPLE OF QUESTIONNAIRE FOR TESTING OF MODEL

Instruction

This questionnaire intends to collect responses from practitioners in D&B projects in Hong Kong for validation purposes. Please answer all questions with reference to a *D&B project* you have involved in. Kindly show your perceptions to all items by ticking *ONE* appropriate box for your answer.

1. About The Respondent

1. Your Position: ______________________

2. Years of experience in the construction industry:
   - ❑ less than 5 years ❑ 5 to 9 years ❑ 10 to 14 years ❑ 15 to 19 years
   - ❑ 20 years or more

3. Type of organization in which you are working:
   - ❑ Client organization ❑ Main Contractor ❑ Architectural firm
   - ❑ Engineering consultant ❑ Project management consultant ❑ Q.S. consultant
   - ❑ Sub-contractor ❑ Others; please specify:______________

4. Please indicate your experience in running design-build projects.
   - ❑ Experience for one D&B project.
   - ❑ Experience for two D&B projects.
   - ❑ Experience for three or more D&B projects.
   - ❑ Others; please specify: ______________________________

2. About The Project

2.1 Project scope details (Optional)

1. Name of project (Contract No.; if appropriate): ______________________
2. Type of project: ❑ Building work ❑ Civil work ❑ Foundation work ❑ E&M work ❑ Others; please specify: ______________
3. Type of D&B used: ❑ Traditional D&B ❑ Enhanced D&B ❑ Novated D&B ❑ Others; please specify: ______________
4. Classification of project: ❑ Residential ❑ Office Building ❑ Maintenance Depot ❑ Godown ❑ Hospital ❑ Slaughterhouse ❑ Services Facilities ❑ Roadworks ❑ Quarry ❑ Others; please specify: ______________
5. Nature of project: ❑ New work ❑ Refurbishment ❑ Redevelopment ❑ Extension ❑ Fitting-out ❑ Others; please specify: ______________
6. Progress of project: ❑ Completed ❑ On-going
7. Maximum number of floors below ground level (if applicable): ______________
8. Maximum number of floors above ground level (if applicable): ______________
9. Gross floor area (if applicable): ______________ m^2
10. Original contract sum at tender award: HK $______________ Million
11. Final contract sum at completion: HK $______________ Million
12. Total amount of V.O.: HK $______________ Million
13. Project commencement date: ______________
14. Practical completion date: ______________
15. Total agreed E.O.T.: ______________ working days
16. Original construction period at tender stage: ______________ (calendar days / working days)*
17. Number of claims and disputes that arose during the construction period: ______________
18. Number of reported accidents that arose during the construction period: ______________
19. Number of environmental complaints that arose during the construction period: ______________

* Please delete as appropriate

2. About The Project (Cont'd)

2.2 Project features

Please rate the following statements to reflect the special features of the D&B project.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The contractor's input could achieve the buildability of design	❑	❑	❑	❑	❑	❑	❑
2. This project was housed with various types of building services	❑	❑	❑	❑	❑	❑	❑
3. This project required a heavy use of new technology	❑	❑	❑	❑	❑	❑	❑
4. This project had a well defined scope	❑	❑	❑	❑	❑	❑	❑
5. The client's requirements of this D&B project were clear	❑	❑	❑	❑	❑	❑	❑
6. The project enabled the contractor to utilize special skills	❑	❑	❑	❑	❑	❑	❑
7. The project was flexible enough to allow alternative solutions	❑	❑	❑	❑	❑	❑	❑
8. This project was unique to other D&B projects	❑	❑	❑	❑	❑	❑	❑
9. This project could be considered innovative	❑	❑	❑	❑	❑	❑	❑
10. This project was attractive to tenderers	❑	❑	❑	❑	❑	❑	❑

3. About The Project Management Approaches

1. Was there any innovative management approach adopted?

❑ No ❑ Partnering ❑ Value management

❑ Partnering & Value management ❑ Others; please specify: ______________

4. About The Project Environments

Please rate the following statements to indicate the project environment under which the D&B project was subjected to.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The disturbance of the physical environment (e.g., weather, ground conditions) to the project was minimal	❑	❑	❑	❑	❑	❑	❑
2. The prevailing economic environment was positive	❑	❑	❑	❑	❑	❑	❑
3. The government provided resources to the D&B project	❑	❑	❑	❑	❑	❑	❑
4. The society did not act against the D&B project	❑	❑	❑	❑	❑	❑	❑

5. About The Project-related Participants

5.1 Client objectives

Please rate the following statements that best describe the emphasis of the client's project objectives.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Competitive tender price	❑	❑	❑	❑	❑	❑	❑
2. Timely completion	❑	❑	❑	❑	❑	❑	❑
3. Certainty of time	❑	❑	❑	❑	❑	❑	❑
4. Certainty of cost without fluctuation	❑	❑	❑	❑	❑	❑	❑
5. Transfer of risk	❑	❑	❑	❑	❑	❑	❑
6. Single point of responsibility	❑	❑	❑	❑	❑	❑	❑

5.2 Competency measures of the client

Please rate the following statements that best describe the competency of the client.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Ability to effectively brief the design team	❑	❑	❑	❑	❑	❑	❑
2. Ability to quickly make authoritative decisions	❑	❑	❑	❑	❑	❑	❑
3. Ability to effectively define the roles of the participants	❑	❑	❑	❑	❑	❑	❑
4. Ability to contribute ideas to the design process	❑	❑	❑	❑	❑	❑	❑
5. Ability to contribute ideas to the construction process	❑	❑	❑	❑	❑	❑	❑

5.3 Competency measures of the client's representative

Please rate the following statements that best describe the competency of the client's representative.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Technical skills	❑	❑	❑	❑	❑	❑	❑
2. Planning skills	❑	❑	❑	❑	❑	❑	❑
3. Organization skills	❑	❑	❑	❑	❑	❑	❑
4. Coordinating skills	❑	❑	❑	❑	❑	❑	❑
5. Leadership skills	❑	❑	❑	❑	❑	❑	❑
6. Controlling skills	❑	❑	❑	❑	❑	❑	❑
7. Experience and capabilities	❑	❑	❑	❑	❑	❑	❑
8. Commitment to meeting the targets of time, cost and quality	❑	❑	❑	❑	❑	❑	❑
9. Early and continued involvement in the project	❑	❑	❑	❑	❑	❑	❑
10. Adaptability to changes in the project plan	❑	❑	❑	❑	❑	❑	❑

5. About The Project-related Participants (Cont'd)

5.4 Competency measures of the contractor's consultants

Please rate the following statements that best describe the competency of the contractor's consultants.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Technical skills	☐	☐	☐	☐	☐	☐	☐
2. Planning skills	☐	☐	☐	☐	☐	☐	☐
3. Organization skills	☐	☐	☐	☐	☐	☐	☐
4. Coordinating skills	☐	☐	☐	☐	☐	☐	☐
5. Leadership skills	☐	☐	☐	☐	☐	☐	☐
6. Controlling skills	☐	☐	☐	☐	☐	☐	☐
7. Experience and capabilities	☐	☐	☐	☐	☐	☐	☐
8. Commitment to meeting the targets of time, cost and quality	☐	☐	☐	☐	☐	☐	☐
9. Early and continued involvement in the project	☐	☐	☐	☐	☐	☐	☐
10. Adaptability to changes in the project plan	☐	☐	☐	☐	☐	☐	☐
11. Support by parent company	☐	☐	☐	☐	☐	☐	☐

5.5 Competency measures of the construction team leader

Please rate the following statements that best describe the competency of the construction team leader.	Very Low	Low	Slightly Low	Average	Slightly High	High	Very High
1. Technical skills	☐	☐	☐	☐	☐	☐	☐
2. Planning skills	☐	☐	☐	☐	☐	☐	☐
3. Organization skills	☐	☐	☐	☐	☐	☐	☐
4. Coordinating skills	☐	☐	☐	☐	☐	☐	☐
5. Leadership skills	☐	☐	☐	☐	☐	☐	☐
6. Controlling skills	☐	☐	☐	☐	☐	☐	☐
7. Experience and capabilities	☐	☐	☐	☐	☐	☐	☐
8. Commitment to meeting the targets of time, cost and quality	☐	☐	☐	☐	☐	☐	☐
9. Early and continued involvement in the project	☐	☐	☐	☐	☐	☐	☐
10. Adaptability to changes in the project plan	☐	☐	☐	☐	☐	☐	☐
11. Support by parent company	☐	☐	☐	☐	☐	☐	☐

5.6 Competency measures of the end users

Please rate the following statements that best describe the competency of the end users.	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Ability to effectively brief the needs to the D&B team	☐	☐	☐	☐	☐	☐	☐
2. Ability to contribute ideas to the design process	☐	☐	☐	☐	☐	☐	☐
3. Ability to contribute ideas to the construction process	☐	☐	☐	☐	☐	☐	☐

6. About The Project Management Action

Please rate the following statements that best describe the level of effectiveness of managerial strategies in the D&B project.	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Channels of communication systems	❑	❑	❑	❑	❑	❑	❑
2. Control mechanism, such as monitoring and updating	❑	❑	❑	❑	❑	❑	❑
3. Feedback channels	❑	❑	❑	❑	❑	❑	❑
4. Up-front planning efforts	❑	❑	❑	❑	❑	❑	❑
5. Quality system, like quality controls and assurance	❑	❑	❑	❑	❑	❑	❑
6. Safety system	❑	❑	❑	❑	❑	❑	❑
7. Risk management system	❑	❑	❑	❑	❑	❑	❑
8. Conflict management system	❑	❑	❑	❑	❑	❑	❑
9. Control of subcontractors	❑	❑	❑	❑	❑	❑	❑
10. Reporting system	❑	❑	❑	❑	❑	❑	❑
11. Development of standard procedures	❑	❑	❑	❑	❑	❑	❑
12. Regular meetings with the project participants	❑	❑	❑	❑	❑	❑	❑
13. Organizational structure	❑	❑	❑	❑	❑	❑	❑

7. About The Project Work Atmosphere

Please rate the following statements that best described the effects of human-related factors on the D&B project.	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. The client delegated adequate decision-making authority to the construction team leader	❑	❑	❑	❑	❑	❑	❑
2. The client delegated adequate decision-making authority to the contractor's consultants	❑	❑	❑	❑	❑	❑	❑
3. The construction team leader delegated adequate decision-making authority to the contractor's consultants	❑	❑	❑	❑	❑	❑	❑
4. The construction team leader was confident of the design of the D&B project	❑	❑	❑	❑	❑	❑	❑
5. The construction team leader was confident of the construction of the D&B project	❑	❑	❑	❑	❑	❑	❑
6. The D&B team was cohesive and well-integrated	❑	❑	❑	❑	❑	❑	❑
7. The team members enjoyed working relationships with one another	❑	❑	❑	❑	❑	❑	❑
8. The team members established satisfaction, expectations and values from the project	❑	❑	❑	❑	❑	❑	❑
9. The team members developed respect and mutual trust with one another	❑	❑	❑	❑	❑	❑	❑

8. About The Level of Satisfaction (Project Level)

Please indicate the level of your satisfaction with the performance of the D&B project.

	Very low	Low	Slightly low	Average	Slightly high	High	Very high
1. Satisfaction with time	☐	☐	☐	☐	☐	☐	☐
2. Satisfaction with cost	☐	☐	☐	☐	☐	☐	☐
3. Satisfaction with quality of design	☐	☐	☐	☐	☐	☐	☐
4. Satisfaction with quality of workmanship	☐	☐	☐	☐	☐	☐	☐
5. Satisfaction with achieving functionality	☐	☐	☐	☐	☐	☐	☐

★ *End of the questionnaire* ★

※ *Thank you for your contribution* ※

Return Slip (Optional)

Those who wish to receive a summary of the research findings please enter the details below:

Name:
Organization:
Address:
Telephone Number:
Fax Number:
Email:

APPENDIX O

RESULTS OF TESTING OF MODEL

O.1 **Calculation of factor scores**

O.2 **Paired-samples *t* tests of the performance measures**

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-0.5	-0.77067	-1.33888	-1.5	-0.77246	-0.44721	-0.13484	-0.22019	0.44721	-1.58251	-1.63299	-1.09545	-0.70711
FSC1	0.039	-0.088	-0.021	0.026	-0.019	-0.012	0.023	-0.001	0.085	-0.104	-0.019	0.001	-0.04
FSC2	-0.01	0.017	0	-0.046	0.008	0.002	-0.004	0	-0.085	0.021	0.003	0.029	0.027
FSC3	0.006	-0.039	0.033	0.032	0.003	0.007	-0.014	0.004	0.112	0.062	0.027	-0.078	0.017
FSC4	0	0.02	-0.017	-0.018	-0.009	0.003	-0.005	-0.004	-0.002	0.024	-0.036	0.055	-0.011
FSC5	-0.039	0.03	-0.008	-0.02	0.031	0.007	-0.015	0	-0.033	0.068	0.067	-0.092	0.03
FSC6	-0.059	-0.07	0.258	0.234	0.045	0.009	-0.015	0.003	-0.119	-0.067	0.01	0.032	-0.055
Sub-score	0.315407	-0.072641	-0.088262	0.008954	-0.140174	-0.610091	(From F1 to F6)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	0.39563	0.67082	1.17279	-0.15339	0	-0.35082	-0.39522	-0.44721	0.65738	-0.44721	0.44721	-0.7303
FSC1	0.007	0.008	0.129	0.166	0.095	0.124	0.102	0.116	0.042	0.054	-0.076	-0.01	0.066
FSC2	-0.005	0.065	0.02	0	0.082	0.038	0.048	0.015	-0.024	0.008	0.04	0.03	-0.073
FSC3	-0.005	-0.113	-0.059	0.043	0.058	0.04	0.103	0.007	-0.026	-0.069	-0.02	0.027	0.111
FSC4	0.003	0.057	0.021	-0.034	0.017	0.031	0.019	0.028	0.233	0.168	0.277	0.218	0.139
FSC5	-0.006	0.05	-0.002	0.019	-0.032	-0.058	-0.09	0.013	-0.029	0.03	-0.045	0.016	0.056
FSC6	0.01	0.302	0.092	-0.066	0.018	0.046	0.043	0.051	-0.031	-0.055	0.137	-0.002	-0.239
Sub-score	0.183084	0.070855	-0.173192	-0.146575	0.093824	0.151404	(From F1 to F6)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	0.35082	0.25646	0.30779	0.30779	-0.5	0.5113	-0.15482	0	-0.52623	-0.37347	-0.61357	0.83666	1.09545
FSC1	-0.019	0.02	-0.055	0.016	0.063	0.203	-0.028	0.004	-0.051	0.006	0.028	0.163	0.053
FSC2	0.211	0.207	0.213	0.186	0.133	-0.068	0.025	0.023	0.031	0.011	-0.035	-0.053	-0.025
FSC3	-0.095	-0.013	-0.007	0.057	0.132	0.029	0.132	0.167	0.173	0.174	0.253	-0.08	-0.059
FSC4	0.06	-0.004	0.054	-0.06	-0.14	-0.036	-0.02	0.006	-0.011	0.048	-0.021	-0.014	-0.066
FSC5	-0.071	0.06	-0.022	0.063	0.072	-0.027	0.03	0.068	-0.003	0.062	-0.063	0.105	0.302
FSC6	0.087	-0.029	0.107	-0.078	-0.227	-0.098	0.094	-0.054	0.124	-0.1	-0.06	-0.034	-0.07
Sub-score	0.26494	0.074104	-0.5357	-0.0104	0.384403	-0.01537	(From F1 to F6)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.58132	0.44721	0.04925
FSC1	-0.058	-0.067	-0.008
FSC2	0.024	0.022	0.011
FSC3	0.045	0.038	0.038
FSC4	0.042	0.064	0.027
FSC5	0.268	0.217	0.202
FSC6	0.077	0.067	0.006

Factor	Sub-score
F1	-0.064074
F2	0.024332
F3	0.045025
F4	0.054367
F5	0.262787
F6	0.07502

Case 1	
Factor	Score
1	0.699358
2	0.09665
3	-0.75213
4	-0.093654
5	0.60084
6	-0.399036

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-0.5	-0.77067	-1.33888	-1.5	-0.77246	-0.44721	-0.13484	-0.22019	0.44721	-1.58251	-1.63299	-1.09545	-0.70711
FSC7	0.406	0.235	0.044	-0.023	0.311	-0.019	0.012	-0.001	0.059	-0.076	-0.057	0.06	-0.169
FSC8	0.042	-0.107	0.004	0.027	-0.012	0.012	-0.014	-0.007	0.253	0.065	0.381	0.335	0.108
FSC9	-0.117	0.159	0.01	0.04	0.096	0.485	0.063	-0.002	0.108	-0.296	0.065	-0.134	0.083
FSC10	0.082	-0.171	0.069	0.064	-0.027	0.013	-0.01	-0.005	0.045	0.066	-0.032	0.025	0.298
FSC11	-0.073	0.17	0.008	0.001	0.023	0.049	0.532	0.01	0.161	0.412	0.015	-0.076	-0.17
FSC12	-0.002	0.081	0.035	0.002	-0.017	-0.011	0.016	0.524	0.018	-0.071	-0.161	0.219	0.222
Sub-score	-0.348143	-1.032294	0.062145	-0.350277	-0.621367	-0.224334	(From F7 to F12)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	0.39563	0.67082	1.17279	-0.15339	0	-0.35082	-0.39522	-0.44721	0.65738	-0.44721	0.44721	-0.7303
FSC7	0.038	-0.053	-0.015	0.031	-0.141	-0.092	-0.095	-0.032	0.043	0.029	-0.023	-0.016	-0.054
FSC8	-0.025	-0.034	0.103	-0.032	-0.174	-0.052	-0.134	0.057	-0.015	0.003	-0.051	0.025	0.118
FSC9	-0.017	-0.072	-0.079	-0.048	-0.023	0.042	-0.017	0.017	0.014	0.099	-0.014	-0.044	-0.009
FSC10	0.469	-0.183	-0.05	0.145	0.031	-0.085	-0.01	-0.071	0.018	-0.049	-0.138	0.062	0.23
FSC11	0.037	-0.005	-0.059	0.103	0.061	-0.036	-0.061	0.046	-0.048	-0.163	0.057	0.059	-0.012
FSC12	-0.046	-0.075	-0.004	-0.044	-0.153	0.005	-0.169	-0.218	0.041	0.266	-0.073	-0.053	-0.085
Sub-score	0.098335	0.036959	-0.075422	-0.237603	-0.019472	0.333076	(From F7 to F12)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	0.35082	0.25646	0.30779	0.30779	-0.5	0.5113	-0.15482	0	-0.52623	-0.37347	-0.61357	0.83666	1.09545
FSC7	0.017	0.022	0.005	-0.009	-0.062	0.088	0.054	0.017	0.022	0.011	-0.054	0.101	-0.026
FSC8	0.02	0.011	-0.089	0.026	0.118	0.093	-0.015	0.025	-0.037	0.03	-0.016	-0.015	0.038
FSC9	-0.039	0.001	-0.081	0.063	0.148	0.121	0.032	0.181	-0.01	0.063	-0.099	-0.037	0.034
FSC10	-0.16	0.022	-0.073	0.119	0.235	-0.016	-0.113	0.049	-0.125	0.048	0.081	0.035	-0.012
FSC11	-0.116	-0.012	0.046	0.059	0.054	-0.021	-0.057	0.038	-0.115	0.133	0.015	-0.054	-0.081
FSC12	0.112	0.022	-0.03	-0.09	-0.013	0.222	0.09	0.02	-0.013	-0.004	-0.036	0.148	0.038
Sub-score	0.151478	0.028481	0.012713	-0.130226	-0.172637	0.30995	(From F7 to F12)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.58132	0.44721	0.04925
FSC7	-0.079	0.085	0.095
FSC8	-0.027	-0.072	0.009
FSC9	0.02	-0.143	0.009
FSC10	0.047	-0.068	0.011
FSC11	0.062	0.079	0.038
FSC12	-0.104	0.004	0.039

Factor	Sub-score
F7	-0.003233
F8	-0.047452
F9	-0.051881
F10	-0.002546
F11	0.073243
F12	-0.056748

Case 1	
Factor	Score
7	-0.101563
8	-1.014305
9	-0.052446
10	-0.720652
11	-0.740233
12	0.361945

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-0.5	-1.32116	0.48686	0.5	-1.17902	-0.44721	1.21356	-1.32116	-1.0435	0.39563	0.8165	0.7303	-0.70711
FSC1	0.039	-0.088	-0.021	0.026	-0.019	-0.012	0.023	-0.001	0.085	-0.104	-0.019	0.001	-0.04
FSC2	-0.01	0.017	0	-0.046	0.008	0.002	-0.004	0	-0.085	0.021	0.003	0.029	0.027
FSC3	0.006	-0.039	0.033	0.032	0.003	0.007	-0.014	0.004	0.112	0.062	0.027	-0.078	0.017
FSC4	0	0.02	-0.017	-0.018	-0.009	0.003	-0.005	-0.004	-0.002	0.024	-0.036	0.055	-0.011
FSC5	-0.039	0.03	-0.008	-0.02	0.031	0.007	-0.015	0	-0.033	0.068	0.067	-0.092	0.03
FSC6	-0.059	-0.07	0.258	0.234	0.045	0.009	-0.015	0.003	-0.119	-0.067	0.01	0.032	-0.055
Sub-score	0.040197	0.045901	-0.087632	-0.005081	-0.06427	0.453438	(From F1 to F6)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	-0.26375	-0.44721	-0.08377	-0.92036	-1.17318	-1.22788	-0.78338	-0.44721	-1.73308	-0.44721	0.44721	-0.7303
FSC1	0.007	0.008	0.129	0.166	0.095	0.124	0.102	0.116	0.042	0.054	-0.076	-0.01	0.066
FSC2	-0.005	0.065	0.02	0	0.082	0.038	0.048	0.015	-0.024	0.008	0.04	0.03	-0.073
FSC3	-0.005	-0.113	-0.059	0.043	0.058	0.04	0.103	0.007	-0.026	-0.069	-0.02	0.027	0.111
FSC4	0.003	0.057	0.021	-0.034	0.017	0.031	0.019	0.028	0.233	0.168	0.277	0.218	0.139
FSC5	-0.006	0.05	-0.002	0.019	-0.032	-0.058	-0.09	0.013	-0.029	0.03	-0.045	0.016	0.056
FSC6	0.01	0.302	0.092	-0.066	0.018	0.046	0.043	0.051	-0.031	-0.055	0.137	-0.002	-0.239
Sub-score	-0.656914	-0.168883	-0.106275	-0.643452	0.133979	-0.061461	(From F1 to F6)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	-1.40329	-1.5754	-1.74416	-1.74416	-1.5	-0.44619	-0.92894	-0.8165	-0.08771	-0.54323	-0.61357	-1.5538	-0.7303
FSC1	-0.019	0.02	-0.055	0.016	0.063	0.203	-0.028	0.004	-0.051	0.006	0.028	0.163	0.053
FSC2	0.211	0.207	0.213	0.186	0.133	-0.068	0.025	0.023	0.031	0.011	-0.035	-0.053	-0.025
FSC3	-0.095	-0.013	-0.007	0.057	0.132	0.029	0.132	0.167	0.173	0.174	0.253	-0.08	-0.059
FSC4	0.06	-0.004	0.054	-0.06	-0.14	-0.036	-0.02	0.006	-0.011	0.048	-0.021	-0.014	-0.066
FSC5	-0.071	0.06	-0.022	0.063	0.072	-0.027	0.03	0.068	-0.003	0.062	-0.063	0.105	0.302
FSC6	0.087	-0.029	0.107	-0.078	-0.227	-0.098	0.094	-0.054	0.124	-0.1	-0.06	-0.034	-0.07
Sub-score	-0.407097	-1.415895	-0.500868	0.23004	-0.624206	0.398228	(From F1 to F6)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	-1.07959	-1.0435	-0.9742
FSC1	-0.058	-0.067	-0.008
FSC2	0.024	0.022	0.011
FSC3	0.045	0.038	0.038
FSC4	0.042	0.064	0.027
FSC5	0.268	0.217	0.202
FSC6	0.077	0.067	0.006

Factor	Sub-score
FS1	0.140324
FS2	-0.059583
FS3	-0.125254
FS4	-0.13843
FS5	-0.712558
FS6	-0.158888

Case 2	
Factor	Score
1	-0.883489
2	-1.59846
3	-0.820029
4	-0.556923
5	-1.267055
6	0.631318

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-0.5	-1.32116	0.48686	0.5	-1.17902	-0.44721	1.21356	-1.32116	-1.0435	0.39563	0.8165	0.7303	-0.70711
FSC7	0.406	0.235	0.044	-0.023	0.311	-0.019	0.012	-0.001	0.059	-0.076	-0.057	0.06	-0.169
FSC8	0.042	-0.107	0.004	0.027	-0.012	0.012	-0.014	-0.007	0.253	0.065	0.381	0.335	0.108
FSC9	-0.117	0.159	0.01	0.04	0.096	0.485	0.063	-0.002	0.108	-0.296	0.065	-0.134	0.083
FSC10	0.082	-0.171	0.069	0.064	-0.027	0.013	-0.01	-0.005	0.045	0.066	-0.032	0.025	0.298
FSC11	-0.073	0.17	0.008	0.001	0.023	0.049	0.532	0.01	0.161	0.412	0.015	-0.076	-0.17
FSC12	-0.002	0.081	0.035	0.002	-0.017	-0.011	0.016	0.524	0.018	-0.071	-0.161	0.219	0.222
Sub-score	-0.8207	0.377931	-0.710964	0.031567	0.471619	-0.911254	(From F7 to F12)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	-0.26375	-0.44721	-0.08377	-0.92036	-1.17318	-1.22788	-0.78338	-0.44721	-1.73308	-0.44721	0.44721	-0.7303
FSC7	0.038	-0.053	-0.015	0.031	-0.141	-0.092	-0.095	-0.032	0.043	0.029	-0.023	-0.016	-0.054
FSC8	-0.025	-0.034	0.103	-0.032	-0.174	-0.052	-0.134	0.057	-0.015	0.003	-0.051	0.025	0.118
FSC9	-0.017	-0.072	-0.079	-0.048	-0.023	0.042	-0.017	0.017	0.014	0.099	-0.014	-0.044	-0.009
FSC10	0.469	-0.183	-0.05	0.145	0.031	-0.085	-0.01	-0.071	0.018	-0.049	-0.138	0.062	0.23
FSC11	0.037	-0.005	-0.059	0.103	0.061	-0.036	-0.061	0.046	-0.048	-0.163	0.057	0.059	-0.012
FSC12	-0.046	-0.075	-0.004	-0.044	-0.153	0.005	-0.169	-0.218	0.041	0.266	-0.073	-0.053	-0.085
Sub-score	0.353593	0.267118	-0.139285	-0.013829	0.341103	0.15075	(From F7 to F12)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	-1.40329	-1.5754	-1.74416	-1.74416	-1.5	-0.44619	-0.92894	-0.8165	-0.08771	-0.54323	-0.61357	-1.5538	-0.7303
FSC7	0.017	0.022	0.005	-0.009	-0.062	0.088	0.054	0.017	0.022	0.011	-0.054	0.101	-0.026
FSC8	0.02	0.011	-0.089	0.026	0.118	0.093	-0.015	0.025	-0.037	0.03	-0.016	-0.015	0.038
FSC9	-0.039	0.001	-0.081	0.063	0.148	0.121	0.032	0.181	-0.01	0.063	-0.099	-0.037	0.034
FSC10	-0.16	0.022	-0.073	0.119	0.235	-0.016	-0.113	0.049	-0.125	0.048	0.081	0.035	-0.012
FSC11	-0.116	-0.012	0.046	0.059	0.054	-0.021	-0.057	0.038	-0.115	0.133	0.015	-0.054	-0.081
FSC12	0.112	0.022	-0.03	-0.09	-0.013	0.222	0.09	0.02	-0.013	-0.004	-0.036	0.148	0.038
Sub-score	-0.174564	-0.168166	-0.308896	-0.281193	0.020535	-0.394329	(From F7 to F12)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	-1.07959	-1.0435	-0.9742
FSC7	-0.079	0.085	0.095
FSC8	-0.027	-0.072	0.009
FSC9	0.02	-0.143	0.009
FSC10	0.047	-0.068	0.011
FSC11	0.062	0.079	0.038
FSC12	-0.104	0.004	0.039

Factor	Sub-score
FS7	-0.095959
FS8	0.095513
FS9	0.118861
FS10	0.009501
FS11	-0.186391
FS12	0.07011

Case 2	
Factor	Score
7	-0.73763
8	0.572397
9	-1.040285
10	-0.253955
11	0.646866
12	-1.084723

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-1	0.33029	-0.7303	-0.5	0.04066	-0.44721	0.53936	0.33029	-1.0435	-0.26375	0	-1.09545	-0.70711
FSC1	0.039	-0.088	-0.021	0.026	-0.019	-0.012	0.023	-0.001	0.085	-0.104	-0.019	0.001	-0.04
FSC2	-0.01	0.017	0	-0.046	0.008	0.002	-0.004	0	-0.085	0.021	0.003	0.029	0.027
FSC3	0.006	-0.039	0.033	0.032	0.003	0.007	-0.014	0.004	0.112	0.062	0.027	-0.078	0.017
FSC4	0	0.02	-0.017	-0.018	-0.009	0.003	-0.005	-0.004	-0.002	0.024	-0.036	0.055	-0.011
FSC5	-0.039	0.03	-0.008	-0.02	0.031	0.007	-0.015	0	-0.033	0.068	0.067	-0.092	0.03
FSC6	-0.059	-0.07	0.258	0.234	0.045	0.009	-0.015	0.003	-0.119	-0.067	0.01	0.032	-0.055
Sub-score	-0.083139	0.068187	-0.12802	-0.034419	0.150859	-0.133148	(From F1 to F6)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	-1.58251	-0.81989	-1.34033	-0.92036	-0.73324	-0.35082	-0.78338	-0.44721	0.05976	-0.44721	-1.78885	1.09545
FSC1	0.007	0.008	0.129	0.166	0.095	0.124	0.102	0.116	0.042	0.054	-0.076	-0.01	0.066
FSC2	-0.005	0.065	0.02	0	0.082	0.038	0.048	0.015	-0.024	0.008	0.04	0.03	-0.073
FSC3	-0.005	-0.113	-0.059	0.043	0.058	0.04	0.103	0.007	-0.026	-0.069	-0.02	0.027	0.111
FSC4	0.003	0.057	0.021	-0.034	0.017	0.031	0.019	0.028	0.233	0.168	0.277	0.218	0.139
FSC5	-0.006	0.05	-0.002	0.019	-0.032	-0.058	-0.09	0.013	-0.029	0.03	-0.045	0.016	0.056
FSC6	0.01	0.302	0.092	-0.066	0.018	0.046	0.043	0.051	-0.031	-0.055	0.137	-0.002	-0.239
Sub-score	-0.540442	-0.389258	0.137215	-0.585907	0.060711	-0.883617	(From F1 to F6)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	-0.52623	-0.10991	0.30779	0.30779	0.5	-1.0877	0.23223	0	-0.08771	0.13581	0.15339	0.83666	1.09545
FSC1	-0.019	0.02	-0.055	0.016	0.063	0.203	-0.028	0.004	-0.051	0.006	0.028	0.163	0.053
FSC2	0.211	0.207	0.213	0.186	0.133	-0.068	0.025	0.023	0.031	0.011	-0.035	-0.053	-0.025
FSC3	-0.095	-0.013	-0.007	0.057	0.132	0.029	0.132	0.167	0.173	0.174	0.253	-0.08	-0.059
FSC4	0.06	-0.004	0.054	-0.06	-0.14	-0.036	-0.02	0.006	-0.011	0.048	-0.021	-0.014	-0.066
FSC5	-0.071	0.06	-0.022	0.063	0.072	-0.027	0.03	0.068	-0.003	0.062	-0.063	0.105	0.302
FSC6	0.087	-0.029	0.107	-0.078	-0.227	-0.098	0.094	-0.054	0.124	-0.1	-0.06	-0.034	-0.07
Sub-score	0.004008	0.056969	0.047622	-0.148219	0.533417	-0.157533	(From F1 to F6)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.58132	0.44721	0.56482
FSC1	-0.058	-0.067	-0.008
FSC2	0.024	0.022	0.011
FSC3	0.045	0.038	0.038
FSC4	0.042	0.064	0.027
FSC5	0.268	0.217	0.202
FSC6	0.077	0.067	0.006

Factor	Sub-score
FS1	-0.068198
FS2	0.030003
FS3	0.064617
FS4	0.068287
FS5	0.366932
FS6	0.078114

Case 3	
Factor	Score
1	-0.687771
2	-0.234099
3	0.121433
4	-0.700258
5	1.111919
6	-1.096185

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	-1	0.33029	-0.7303	-0.5	0.04066	-0.44721	0.53936	0.33029	-1.0435	-0.26375	0	-1.09545	-0.70711
FSC7	0.406	0.235	0.044	-0.023	0.311	-0.019	0.012	-0.001	0.059	-0.076	-0.057	0.06	-0.169
FSC8	0.042	-0.107	0.004	0.027	-0.012	0.012	-0.014	-0.007	0.253	0.065	0.381	0.335	0.108
FSC9	-0.117	0.159	0.01	0.04	0.096	0.485	0.063	-0.002	0.108	-0.296	0.065	-0.134	0.083
FSC10	0.082	-0.171	0.069	0.064	-0.027	0.013	-0.01	-0.005	0.045	0.066	-0.032	0.025	0.298
FSC11	-0.073	0.17	0.008	0.001	0.023	0.049	0.532	0.01	0.161	0.412	0.015	-0.076	-0.17
FSC12	-0.002	0.081	0.035	0.002	-0.017	-0.011	0.016	0.524	0.018	-0.071	-0.161	0.219	0.222
Sub-score	-0.309478	-0.833973	0.016011	-0.537297	0.318866	-0.208816	(From F7 to F12)						
Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	-1.58251	-0.81989	-1.34033	-0.92036	-0.73324	-0.35082	-0.78338	-0.44721	0.05976	-0.44721	-1.78885	1.09545
FSC7	0.038	-0.053	-0.015	0.031	-0.141	-0.092	-0.095	-0.032	0.043	0.029	-0.023	-0.016	-0.054
FSC8	-0.025	-0.034	0.103	-0.032	-0.174	-0.052	-0.134	0.057	-0.015	0.003	-0.051	0.025	0.118
FSC9	-0.017	-0.072	-0.079	-0.048	-0.023	0.042	-0.017	0.017	0.014	0.099	-0.014	-0.044	-0.009
FSC10	0.469	-0.183	-0.05	0.145	0.031	-0.085	-0.01	-0.071	0.018	-0.049	-0.138	0.062	0.23
FSC11	0.037	-0.005	-0.059	0.103	0.061	-0.036	-0.061	0.046	-0.048	-0.163	0.057	0.059	-0.012
FSC12	-0.046	-0.075	-0.004	-0.044	-0.153	0.005	-0.169	-0.218	0.041	0.266	-0.073	-0.053	-0.085
Sub-score	0.255508	0.338293	0.308436	0.211209	-0.275149	0.600631	(From F7 to F12)						
Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	-0.52623	-0.10991	0.30779	0.30779	0.5	-1.0877	0.23223	0	-0.08771	0.13581	0.15339	0.83666	1.09545
FSC7	0.017	0.022	0.005	-0.009	-0.062	0.088	0.054	0.017	0.022	0.011	-0.054	0.101	-0.026
FSC8	0.02	0.011	-0.089	0.026	0.118	0.093	-0.015	0.025	-0.037	0.03	-0.016	-0.015	0.038
FSC9	-0.039	0.001	-0.081	0.063	0.148	0.121	0.032	0.181	-0.01	0.063	-0.099	-0.037	0.034
FSC10	-0.16	0.022	-0.073	0.119	0.235	-0.016	-0.113	0.049	-0.125	0.048	0.081	0.035	-0.012
FSC11	-0.116	-0.012	0.046	0.059	0.054	-0.021	-0.057	0.038	-0.115	0.133	0.015	-0.054	-0.081
FSC12	0.112	0.022	-0.03	-0.09	-0.013	0.222	0.09	0.02	-0.013	-0.004	-0.036	0.148	0.038
Sub-score	-0.07947	-0.042821	-0.034771	0.250643	0.027823	-0.164832	(From F7 to F12)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.58132	0.44721	0.56482
FSC7	-0.079	0.085	0.095
FSC8	-0.027	-0.072	0.009
FSC9	0.02	-0.143	0.009
FSC10	0.047	-0.068	0.011
FSC11	0.062	0.079	0.038
FSC12	-0.104	0.004	0.039

Factor	Sub-score
FS7	0.045746
FS8	-0.042811
FS9	-0.047241
FS10	0.003125
FS11	0.092835
FS12	-0.03664

Case 3	
Factor	Score
7	-0.087693
8	-0.581313
9	0.242434
10	-0.07232
11	0.164375
12	0.190343

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	0.5	0.88077	0.48686	0.5	0.65049	-0.44721	-1.48324	-0.22019	0.44721	0.39563	0	0.7303	0.70711
FSC1	0.039	-0.088	-0.021	0.026	-0.019	-0.012	0.023	-0.001	0.085	-0.104	-0.019	0.001	-0.04
FSC2	-0.01	0.017	0	-0.046	0.008	0.002	-0.004	0	-0.085	0.021	0.003	0.029	0.027
FSC3	0.006	-0.039	0.033	0.032	0.003	0.007	-0.014	0.004	0.112	0.062	0.027	-0.078	0.017
FSC4	0	0.02	-0.017	-0.018	-0.009	0.003	-0.005	-0.004	-0.002	0.024	-0.036	0.055	-0.011
FSC5	-0.039	0.03	-0.008	-0.02	0.031	0.007	-0.015	0	-0.033	0.068	0.067	-0.092	0.03
FSC6	-0.059	-0.07	0.258	0.234	0.045	0.009	-0.015	0.003	-0.119	-0.067	0.01	0.032	-0.055
Sub-score	-0.126806	0.007782	0.049096	0.042429	-0.001518	0.103045	(From F1 to F6)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	0.39563	-0.81989	-0.50262	0.61357	0.58659	0.52623	0.39287	-0.44721	0.65738	-0.44721	0.44721	1.09545
FSC1	0.007	0.008	0.129	0.166	0.095	0.124	0.102	0.116	0.042	0.054	-0.076	-0.01	0.066
FSC2	-0.005	0.065	0.02	0	0.082	0.038	0.048	0.015	-0.024	0.008	0.04	0.03	-0.073
FSC3	-0.005	-0.113	-0.059	0.043	0.058	0.04	0.103	0.007	-0.026	-0.069	-0.02	0.027	0.111
FSC4	0.003	0.057	0.021	-0.034	0.017	0.031	0.019	0.028	0.233	0.168	0.277	0.218	0.139
FSC5	-0.006	0.05	-0.002	0.019	-0.032	-0.058	-0.09	0.013	-0.029	0.03	-0.045	0.016	0.056
FSC6	0.01	0.302	0.092	-0.066	0.018	0.046	0.043	0.051	-0.031	-0.055	0.137	-0.002	-0.239
Sub-score	0.15964	0.046862	0.209175	0.202816	0.03996	-0.192824	(From F1 to F6)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	0.35082	0.25646	0.30779	0.30779	0.5	1.46878	-0.73541	-0.8165	-0.96476	-0.88275	-0.61357	-0.35857	-0.7303
FSC1	-0.019	0.02	-0.055	0.016	0.063	0.203	-0.028	0.004	-0.051	0.006	0.028	0.163	0.053
FSC2	0.211	0.207	0.213	0.186	0.133	-0.068	0.025	0.023	0.031	0.011	-0.035	-0.053	-0.025
FSC3	-0.095	-0.013	-0.007	0.057	0.132	0.029	0.132	0.167	0.173	0.174	0.253	-0.08	-0.059
FSC4	0.06	-0.004	0.054	-0.06	-0.14	-0.036	-0.02	0.006	-0.011	0.048	-0.021	-0.014	-0.066
FSC5	-0.071	0.06	-0.022	0.063	0.072	-0.027	0.03	0.068	-0.003	0.062	-0.063	0.105	0.302
FSC6	0.087	-0.029	0.107	-0.078	-0.227	-0.098	0.094	-0.054	0.124	-0.1	-0.06	-0.034	-0.07
Sub-score	0.263021	0.198496	-0.550069	-0.060545	-0.349524	-0.181697	(From F1 to F6)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	-1.07959	-1.0435	-0.9742
FSC1	-0.058	-0.067	-0.008
FSC2	0.024	0.022	0.011
FSC3	0.045	0.038	0.038
FSC4	0.042	0.064	0.027
FSC5	0.268	0.217	0.202
FSC6	0.077	0.067	0.006

Factor	Sub-score
FS1	0.140324
FS2	-0.059583
FS3	-0.125254
FS4	-0.13843
FS5	-0.712558
FS6	-0.158888

Case 4	
Factor	Score
1	0.43618
2	0.193555
3	-0.417052
4	0.04627
5	-1.02364
6	-0.430365

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	0.5	0.88077	0.48686	0.5	0.65049	-0.44721	-1.48324	-0.22019	0.44721	0.39563	0	0.7303	0.70711
FSC7	0.406	0.235	0.044	-0.023	0.311	-0.019	0.012	-0.001	0.059	-0.076	-0.057	0.06	-0.169
FSC8	0.042	-0.107	0.004	0.027	-0.012	0.012	-0.014	-0.007	0.253	0.065	0.381	0.335	0.108
FSC9	-0.117	0.159	0.01	0.04	0.096	0.485	0.063	-0.002	0.108	-0.296	0.065	-0.134	0.083
FSC10	0.082	-0.171	0.069	0.064	-0.027	0.013	-0.01	-0.005	0.045	0.066	-0.032	0.025	0.298
FSC11	-0.073	0.17	0.008	0.001	0.023	0.049	0.532	0.01	0.161	0.412	0.015	-0.076	-0.17
FSC12	-0.002	0.081	0.035	0.002	-0.017	-0.011	0.016	0.524	0.018	-0.071	-0.161	0.219	0.222
Sub-score	0.533757	0.411218	-0.24902	0.22375	-0.621323	0.240006	(From F7 to F12)						
Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	-0.44721	0.39563	-0.81989	-0.50262	0.61357	0.58659	0.52623	0.39287	-0.44721	0.65738	-0.44721	0.44721	1.09545
FSC7	0.038	-0.053	-0.015	0.031	-0.141	-0.092	-0.095	-0.032	0.043	0.029	-0.023	-0.016	-0.054
FSC8	-0.025	-0.034	0.103	-0.032	-0.174	-0.052	-0.134	0.057	-0.015	0.003	-0.051	0.025	0.118
FSC9	-0.017	-0.072	-0.079	-0.048	-0.023	0.042	-0.017	0.017	0.014	0.099	-0.014	-0.044	-0.009
FSC10	0.469	-0.183	-0.05	0.145	0.031	-0.085	-0.01	-0.071	0.018	-0.049	-0.138	0.062	0.23
FSC11	0.037	-0.005	-0.059	0.103	0.061	-0.036	-0.061	0.046	-0.048	-0.163	0.057	0.059	-0.012
FSC12	-0.046	-0.075	-0.004	-0.044	-0.153	0.005	-0.169	-0.218	0.041	0.266	-0.073	-0.053	-0.085
Sub-score	-0.300478	-0.08409	0.111816	-0.076889	-0.117577	-0.176869	(From F7 to F12)						
Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	0.35082	0.25646	0.30779	0.30779	0.5	1.46878	-0.73541	-0.8165	-0.96476	-0.88275	-0.61357	-0.35857	-0.7303
FSC7	0.017	0.022	0.005	-0.009	-0.062	0.088	0.054	0.017	0.022	0.011	-0.054	0.101	-0.026
FSC8	0.02	0.011	-0.089	0.026	0.118	0.093	-0.015	0.025	-0.037	0.03	-0.016	-0.015	0.038
FSC9	-0.039	0.001	-0.081	0.063	0.148	0.121	0.032	0.181	-0.01	0.063	-0.099	-0.037	0.034
FSC10	-0.16	0.022	-0.073	0.119	0.235	-0.016	-0.113	0.049	-0.125	0.048	0.081	0.035	-0.012
FSC11	-0.116	-0.012	0.046	0.059	0.054	-0.021	-0.057	0.038	-0.115	0.133	0.015	-0.054	-0.081
FSC12	0.112	0.022	-0.03	-0.09	-0.013	0.222	0.09	0.02	-0.013	-0.004	-0.036	0.148	0.038
Sub-score	0.040005	0.17332	0.064652	0.125499	0.058447	0.202393	(From F7 to F12)						
Variable	cfdlvctr	chigdbtm	dbtmwkat										
SV	-1.07959	-1.0435	-0.9742										
FSC7	-0.079	0.085	0.095										
FSC8	-0.027	-0.072	0.009										
FSC9	0.02	-0.143	0.009										
FSC10	0.047	-0.068	0.011										
FSC11	0.062	0.079	0.038										
FSC12	-0.104	0.004	0.039										

Factor	Sub-score
FS7	-0.095959
FS8	0.095513
FS9	0.118861
FS10	0.009501
FS11	-0.186391
FS12	0.07011

Case 4	
Factor	Score
7	0.177325
8	0.595961
9	0.046308
10	0.281862
11	-0.866843
12	0.33564

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	1.5	0.88077	1.09545	1	1.26033	1.78885	-0.13484	1.43125	1.19257	1.05501	0.8165	0.7303	1.41421
FSC1	0.039	-0.088	-0.021	0.026	-0.019	-0.012	0.023	-0.001	0.085	-0.104	-0.019	0.001	-0.04
FSC2	-0.01	0.017	0	-0.046	0.008	0.002	-0.004	0	-0.085	0.021	0.003	0.029	0.027
FSC3	0.006	-0.039	0.033	0.032	0.003	0.007	-0.014	0.004	0.112	0.062	0.027	-0.078	0.017
FSC4	0	0.02	-0.017	-0.018	-0.009	0.003	-0.005	-0.004	-0.002	0.024	-0.036	0.055	-0.011
FSC5	-0.039	0.03	-0.008	-0.02	0.031	0.007	-0.015	0	-0.033	0.068	0.067	-0.092	0.03
FSC6	-0.059	-0.07	0.258	0.234	0.045	0.009	-0.015	0.003	-0.119	-0.067	0.01	0.032	-0.055
Sub-score	-0.145661	-0.049229	0.254818	-0.011883	0.055104	0.186755	(From F1 to F6)						

Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	1.78885	1.05501	1.41618	0.75394	1.38054	1.31982	1.40329	1.56911	1.78885	0.35857	1.78885	0.44721	-0.7303
FSC1	0.007	0.008	0.129	0.166	0.095	0.124	0.102	0.116	0.042	0.054	-0.076	-0.01	0.066
FSC2	-0.005	0.065	0.02	0	0.082	0.038	0.048	0.015	-0.024	0.008	0.04	0.03	-0.073
FSC3	-0.005	-0.113	-0.059	0.043	0.058	0.04	0.103	0.007	-0.026	-0.069	-0.02	0.027	0.111
FSC4	0.003	0.057	0.021	-0.034	0.017	0.031	0.019	0.028	0.233	0.168	0.277	0.218	0.139
FSC5	-0.006	0.05	-0.002	0.019	-0.032	-0.058	-0.09	0.013	-0.029	0.03	-0.045	0.016	0.056
FSC6	0.01	0.302	0.092	-0.066	0.018	0.046	0.043	0.051	-0.031	-0.055	0.137	-0.002	-0.239
Sub-score	0.854635	0.440425	-0.066926	1.173122	-0.328474	0.986502	(From F1 to F6)						

Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	1.22788	1.17239	0.82078	0.82078	1	-0.44619	1.58693	1.63299	1.66641	1.66365	1.68732	0.23905	-0.7303
FSC1	-0.019	0.02	-0.055	0.016	0.063	0.203	-0.028	0.004	-0.051	0.006	0.028	0.163	0.053
FSC2	0.211	0.207	0.213	0.186	0.133	-0.068	0.025	0.023	0.031	0.011	-0.035	-0.053	-0.025
FSC3	-0.095	-0.013	-0.007	0.057	0.132	0.029	0.132	0.167	0.173	0.174	0.253	-0.08	-0.059
FSC4	0.06	-0.004	0.054	-0.06	-0.14	-0.036	-0.02	0.006	-0.011	0.048	-0.021	-0.014	-0.066
FSC5	-0.071	0.06	-0.022	0.063	0.072	-0.027	0.03	0.068	-0.003	0.062	-0.063	0.105	0.302
FSC6	0.087	-0.029	0.107	-0.078	-0.227	-0.098	0.094	-0.054	0.124	-0.1	-0.06	-0.034	-0.07
Sub-score	-0.124872	1.086322	1.539014	-0.010875	0.05591	-0.043631	(From F1 to F6)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.99655	1.19257	1.33433
FSC1	-0.058	-0.067	-0.008
FSC2	0.024	0.022	0.011
FSC3	0.045	0.038	0.038
FSC4	0.042	0.064	0.027
FSC5	0.268	0.217	0.202
FSC6	0.077	0.067	0.006

Factor	Sub-score
FS1	-0.148377
FS2	0.064831
FS3	0.140867
FS4	0.154206
FS5	0.795398
FS6	0.164643

Case 5	
Factor	Score
1	0.435725
2	1.54235
3	1.867772
4	1.304571
5	0.577938
6	1.294268

Variable	ctrskill	prjcompl	scopprjt	cltreqrt	prjattrc	inmgtaph	phyenvir	econenvr	govtsupt	soclsupt	clttimeo	cltcosto	clttrsrk
SV	1.5	0.88077	1.09545	1	1.26033	1.78885	-0.13484	1.43125	1.19257	1.05501	0.8165	0.7303	1.41421
FSC7	0.406	0.235	0.044	-0.023	0.311	-0.019	0.012	-0.001	0.059	-0.076	-0.057	0.06	-0.169
FSC8	0.042	-0.107	0.004	0.027	-0.012	0.012	-0.014	-0.007	0.253	0.065	0.381	0.335	0.108
FSC9	-0.117	0.159	0.01	0.04	0.096	0.485	0.063	-0.002	0.108	-0.296	0.065	-0.134	0.083
FSC10	0.082	-0.171	0.069	0.064	-0.027	0.013	-0.01	-0.005	0.045	0.066	-0.032	0.025	0.298
FSC11	-0.073	0.17	0.008	0.001	0.023	0.049	0.532	0.01	0.161	0.412	0.015	-0.076	-0.17
FSC12	-0.002	0.081	0.035	0.002	-0.017	-0.011	0.016	0.524	0.018	-0.071	-0.161	0.219	0.222
Sub-score	0.944563	1.077118	0.88183	0.632253	0.45221	1.104392	(From F7 to F12)						
Variable	cltsptrp	cltbrfdt	cltprdmk	cltinvpj	clttcski	cltpmski	cltexpcp	cltcomad	cottcski	cotpmski	cotexpcp	cotcomad	cotsuppc
SV	1.78885	1.05501	1.41618	0.75394	1.38054	1.31982	1.40329	1.56911	1.78885	0.35857	1.78885	0.44721	-0.7303
FSC7	0.038	-0.053	-0.015	0.031	-0.141	-0.092	-0.095	-0.032	0.043	0.029	-0.023	-0.016	-0.054
FSC8	-0.025	-0.034	0.103	-0.032	-0.174	-0.052	-0.134	0.057	-0.015	0.003	-0.051	0.025	0.118
FSC9	-0.017	-0.072	-0.079	-0.048	-0.023	0.042	-0.017	0.017	0.014	0.099	-0.014	-0.044	-0.009
FSC10	0.469	-0.183	-0.05	0.145	0.031	-0.085	-0.01	-0.071	0.018	-0.049	-0.138	0.062	0.23
FSC11	0.037	-0.005	-0.059	0.103	0.061	-0.036	-0.061	0.046	-0.048	-0.163	0.057	0.059	-0.012
FSC12	-0.046	-0.075	-0.004	-0.044	-0.153	0.005	-0.169	-0.218	0.041	0.266	-0.073	-0.053	-0.085
Sub-score	-0.406957	-0.558281	-0.205546	0.117115	0.071093	-0.907587	(From F7 to F12)						
Variable	ctrtcski	ctrpmski	ctrexpcp	ctrcomad	ctrsuppc	endstreq	commwppt	pmufplng	pmctrsys	pjmgtsys	pmorgstr	cltddeci	ctrddeci
SV	1.22788	1.17239	0.82078	0.82078	1	-0.44619	1.58693	1.63299	1.66641	1.66365	1.68732	0.23905	-0.7303
FSC7	0.017	0.022	0.005	-0.009	-0.062	0.088	0.054	0.017	0.022	0.011	-0.054	0.101	-0.026
FSC8	0.02	0.011	-0.089	0.026	0.118	0.093	-0.015	0.025	-0.037	0.03	-0.016	-0.015	0.038
FSC9	-0.039	0.001	-0.081	0.063	0.148	0.121	0.032	0.181	-0.01	0.063	-0.099	-0.037	0.034
FSC10	-0.16	0.022	-0.073	0.119	0.235	-0.016	-0.113	0.049	-0.125	0.048	0.081	0.035	-0.012
FSC11	-0.116	-0.012	0.046	0.059	0.054	-0.021	-0.057	0.038	-0.115	0.133	0.015	-0.054	-0.081
FSC12	0.112	0.022	-0.03	-0.09	-0.013	0.222	0.09	0.02	-0.013	-0.004	-0.036	0.148	0.038
Sub-score	0.062551	0.009188	0.266301	0.035277	0.065831	0.046817	(From F7 to F12)						

Variable	cfdlvctr	chigdbtm	dbtmwkat
SV	0.99655	1.19257	1.33433
FSC7	-0.079	0.085	0.095
FSC8	-0.027	-0.072	0.009
FSC9	0.02	-0.143	0.009
FSC10	0.047	-0.068	0.011
FSC11	0.062	0.079	0.038
FSC12	-0.104	0.004	0.039

Factor	Sub-score
FS7	0.149402
FS8	-0.100763
FS9	-0.138598
FS10	-0.019579
FS11	0.206704
FS12	-0.046832

Case 5	
Factor	Score
7	0.74956
8	0.427262
9	0.803988
10	0.765066
11	0.795838
12	0.196791

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	cPSI	10.2910	5	1.25598	.56169
	aPSI	10.6900	5	2.16855	.96980
Pair 2	cTime	4.9590	5	1.00094	.44763
	aTime	5.6000	5	1.14018	.50990
Pair 3	cCost	5.4570	5	.57389	.25665
	aCost	5.2000	5	1.30384	.58310
Pair 4	cQuality	4.7990	5	.58950	.26363
	aQuality	5.4000	5	.96177	.43012
Pair 5	cFun	5.5170	5	.42013	.18789
	aFun	5.4000	5	1.34164	.60000

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	cPSI & aPSI	5	.723	.167
Pair 2	cTime & aTime	5	.469	.425
Pair 3	cCost & aCost	5	.695	.192
Pair 4	cQuality & aQuality	5	.742	.151
Pair 5	cFun & aFun	5	.730	.162

Paired Samples Test

		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper
Pair 1	cPSI - aPSI	-.39900	1.52960	.68406	-2.29826	1.50025
Pair 2	cTime - aTime	-.64100	1.10941	.49614	-2.01851	.73651
Pair 3	cCost - aCost	.25700	.99444	.44473	-.97776	1.49176
Pair 4	cQuality - aQuality	-.60100	.65690	.29377	-1.41664	.21464
Pair 5	cFun - aFun	.11700	1.07411	.48036	-1.21669	1.45069

Paired Samples Test

		t	df	Sig. (2-tailed)
Pair 1	cPSI - aPSI	-.583	4	.591
Pair 2	cTime - aTime	-1.292	4	.266
Pair 3	cCost - aCost	.578	4	.594
Pair 4	cQuality - aQuality	-2.046	4	.110
Pair 5	cFun - aFun	.244	4	.820

APPENDIX P

INTERVIEW DIALOGUES FOR VALIDATION

1. ***Project success of a D&B project can be measured in terms of time, cost, quality and functionality.***

All respondents agreed that the criteria of time, cost, quality and functionality can be applied to measure the success of a D&B project. Respondent 3 further clarified the definitions of quality, which can be divided into design and workmanship.

2. ***Project success of a D&B project is directly affected by the attractiveness of the project, the effectiveness of project management action and the application of innovative management approaches.***

According to Respondent 1, as the contractor was early involved in the design stage of a D&B project, the procurement of materials can be better controlled and so the budget can be properly maintained because it is at the expense of the contractor under the D&B method. The respondent also stressed that project management action is essential by means of regular meetings and informal but active communication channels through phones and e-mails, and D&B requires more effective project management action since the contractor has to communicate with all the stakeholders to a D&B project. The flexibility of the project can provide rooms for alternatives from the contractor, and performance specifications can allow flexibilities in construction materials and construction methods. The respondent also mentioned cost savings in builability, which was enhanced to make the design more practical so that time for reworks or abortive works can be reduced and the efficiency increased. Also, the flexibility in materials can make the best use of the contractor's connections with other suppliers. Innovative management approaches are considered essential in D&B projects and partnering and value engineering approaches were employed. Partnering had been implemented for all team players who can show correct attitudes towards completing a project. Instead of following strictly the provisions as laid down in the contract, all project team members worked towards the success of the project and resorted problems to other solutions so that the loss of the contractor can be kept under control. Value management was applied to the project in the choice of facades where several options of the facades were available and the most cost-effective one was selected in the value management exercise. The respondent also claimed that the application of innovative approaches can further realize the benefits of D&B on time and cost performance since much more time and cost will be lost if the parties do not have common goals on the project.

Respondent 2 agreed that D&B project success can be affected by the effectiveness of project management action, project nature and the use of innovative management approaches. He stressed that the type and nature of the project should be appropriate for the D&B procurement method, and the project management action should be structured and tailored to the D&B project properly. In fact, D&B should make use of contractor’s design ability but should not only be used to transfer risks to the contractor.

Respondent 3 demonstrated the effective project management action in the project with the control on a 4-day cycle by the system formwork so that the project can be completed at a fast pace. Such formwork has been tried run for several times to make sure that the workers are competent at work and the parts can be connected with each other. The preparation works for the formwork has started 6 months prior to the start of the works on site and the numbering of the pieces of formwork had been confirmed with the supplier. An organization chart has also been set up with a quality assurance and control team, and the contractor has a self control team of professionals to check the works prior to audit checks from the client. Respondent 3 believed that D&B should be applied to projects with more flexibility since the project should not be confined to the client’s requirements but the contractor should be able to offer alternatives. In the project, the contractor selected the best piling system and so cost was saved because of more flexibility from the available resources. He pointed out that partnering was not required in the project but the contractor gave recommendations to the client’s representatives. Therefore, the partnering approach was adopted which can be used as a gentle agreement. To ensure success for the D&B project, all project participants agreed that they should work as a team. If problems arise, the contractor should inform the client immediately and vice versa. Therefore, there is two-way communication instead of the superior and inferior status of the architect against the contractor. The relationship becomes closer through the partnering approach and a charter has been signed to bring the project team participants towards a common goal.

3. ***Time performance of a D&B project is directly affected by the project attractiveness, the effectiveness of project management action and the application of innovative management approaches.***

Respondent 1 claimed that if the communication channel is efficient, decisions can be made at a faster rate and time for a D&B project can be saved. Effective project management action can bring about team work to strengthen the communication process.
The use of partnering also brought to faster decision since the project team worked towards the common goal. In fact, D&B allows the contractor to provide expertise early at the design stage to make the design more buildable for the project. Therefore, time can be saved for less abortive works.

Respondent 2 stressed that the effectiveness of project management action is important to the time performance. The nature of the project is also a critical element as the contractor may find a profitable project attractive. He is more likely to finish the project quickly if he is going to lose money. The application of innovative management approaches means the use of better management methods, and the project should allow flexibility for the contractor to maximize the available resources.

Respondent 3 pointed out that the traditional timber formwork may prolong the construction time and affect the quality while the system formwork can shorten the construction time and deliver good quality with clear alignment. As a result, under proper management action, the fundamental works were closely monitored to save time and rubbish because of less abortive works. Because of the D&B nature, tenders can be invited so long as the brief was completed. The project was properly managed so that once the tender was accepted, foundation work can start at the same time the details of the superstructure works were under preparation and the overlapping effect is significant to shorten the overall construction time. Moreover, an executive summary has been prepared in documentation to demonstrate the superior offers. Improvements and better offers have also been clearly stated, which are different from other tenderers with achieving minimum requirements only. Partnering and value management were applied to the project to provide timely flow of information.

4. ***Cost performance of a D&B project is directly affected by the project attractiveness, the client's input in the project and the application of innovative management approaches.***

Respondent 1 believed that the client's input can control cost since clear client's requirements can reduce abortive works, and the subsequent variation orders and claims which are cost significant. The clear specifications on materials can also reduce unnecessary costs of the contractor. The concept of partnering brought about team work, which is particularly important in the design stage and as explained by Respondent 1, spending one more hour in the office on clarifying design issues can save five hours of abortive works on site. The attitudes of the project participants are also important, especially in the acceptance of alternative designs. Partnering, as Respondent 1 claimed, can save costs since agreement among project participants can be reached at a faster rate and costs can be saved from revising designs and construction works as a result of difference in opinions. Value management can also save costs from selecting the best option.

Respondent 2 pointed put that the input of the client is crucial, which can determine whether the project is suitable for the D&B method and whether the procedures for working can be properly structured to realize cost effectiveness.

Respondent 3 expressed the input of the client in terms of confirmation of end-users' requirements. In a D&B project, the brief may not be detailed enough since no drawings were prepared at that time and the layout was absent. The client should consult the end users' feedback and respond quickly so that the general layout can be confirmed to save costs from abortive works. Mutual respect is established on the self discipline of the contractor. If the contractor does not perform well, no trust can be developed. In the project, the contractor had its internal checking team to carry out full checks on the works prior to audit checks by the client in order to establish mutual trust. Respondent 3 emphasized that partnering is attributed to trust, which relies on the performance as a fundamental element. He also suggested that D&B should focus on the 'value' of the project, rather that the 'price' of the project since D&B projects are not bid on price only, but the technical aspects of the project. Value management was also applied to the project. After the value management studies, the installation of fins was found unnecessary since no value was added but only cost was increased.

5. ***Quality performance of a D&B project is directly affected by the effectiveness of project management action and the working relationships among project team members.***

Respondent 1 pointed out that quality is restricted by specifications and effective project management action can monitor whether quality can be met with those specified in the requirement through regular meetings and control measures. In fact, the client had an auditing team to ensure that the works can meet the required quality standard. Team work in the project also fostered better communication, through which design specifications can be transferred effectively from the management level to the worker level. Project participants cooperated with each other and worked as a team to tackle the problems together. In the project, the contractor employed an external party to audit the quality of the works. The structural designer was also employed by the contractor to safeguard the work quality. Respondent 1 believed that the economic environment may affect the specifications of the project.

Respondent 2 recalled that effective project management action can ensure that the D&B project is managed to the required quality. He further pointed out that harmonious working relationships among project team members is essential to project success.

Respondent 3 believed that the client should respond fast to confirm details on drawings; otherwise, time will be wasted and construction works may be caught in a hurry, which can seriously affect the quality and remedial works are needed. He pointed out that some client's input is a hindrance but confirmation from the client is necessary, provided that the client's requirements are not changed. Moreover, he emphasized that the contractor should behave and exercise self discipline to ensure the works are in good order so that trust can be established from performance to show that the contractor is capable by demonstration. However, he thought that quality may not be purely affected by the economic environment.

6. ***Functionality performance of a D&B project is directly affected by the effectiveness of project management action.***

Respondent 1 emphasized that frequent meetings through effective project management action were organized to bring along with clear client's requirements so as to enhance the functionality of the project. He also believed that time and cost have been the most concerned areas for clients, especially for public sector projects where time and cost has to be accountable to the public.

Respondent 2 believed that every client under the D&B contract emphasizes time and cost, and considers them as the ultimate goal of a project. The proper project management action and a positive economic environment can also ensure that the D&B project meets the functional requirements of the client. He added that the client, contractor and consultant should be familiar with the operation of the D&B method and their individual responsibilities for successful project implementation.

Respondent 3 believed that the design of a D&B project is, in many ways, driven by the client's requirements as well as the construction methods, which are controlled by time and cost. Functionality is judged on whether the client's requirements are met, and it may be affected by the project management action and the economic environment.