Study of Factors Affecting the Selection of Procurement Systems in Construction Industry: A Multi-Criteria Decision Support Model

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Dedication……..

To

My beloved family

&

The peace of my mother land

Declaration

I hear by declare that this submission of thesis is my own work and that, to the best my knowledge and belief, it contain neither materials or facts previously published or written by another person nor materials or facts which to a substantial extent has been accepted for the award of any degree or diploma of a University or other Institute of higher studies, except where an acknowledgement is made in the text.

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R.Shiyamini

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List of Abbreviations

AHP	- Analytical Hierarchy Process
DSS	- Decision Support System
NEDO	- National Education Development Office
COV	- Coefficient of Variation
PCA	- Principal Component Analysis
MAUT	- Multi Attribute Utility Technique
UK	- United Kingdom
IDE	- Integrated Development Environment
SDK	- Soft Development Kit
BOT	- Build Operate Transfer
BOO	- Build Own Operate
ICTAD	- Institute for Construction Training And Development
BOOT	- Build Own Operate Transfer
SPSS	- Special Package for Standard Statistical
IPA	- Iterated Principal Axis
SD	- Standard Deviation
IT	- Information Technology
JDK	- Java Development Kit
J2SDK	- Java 2 Soft Development Kit
MS	- Microsoft
RDMS	- Relational Database Management System
NGO	- Non Governmental Organization

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Abstract

The procurement system is a key means through which the client creates pre-conditions for successful achievement of project specific objectives. Different procurement systems are used for different projects and the correct choice may help to avoid problems and be the key to the attainment of project specific goals. Procurement selection therefore received much attention from researchers in recent past. In dealing which procurement system to apply, there is a need to take into consideration various factors from the projects' internal and external environment in which the industry operates. Therefore, a systematic and realistic approach for the selection of best procurement system is critical to the success of any project thus to achieve the clients' ultimate goals and ensure value for money.

As far as the Sri Lankan construction industry is concerned, project procurement seems to be one of the key areas which have to be developed to a great extent. Majority of the public and private sector projects are procured through traditional procurement system, especially by Measure and Pay. The number of different types of procurement systems used in Sri Lanka is less when compared to other developing countries. Therefore, there is a need to explore new ways of delivering construction projects. Further, in Sri Lanka, the practice of procurement selection seems to be rather unstructured and ad hock. There is no logical & consistent approach is used to select an appropriate procurement system for a particular project. Therefore, a development and application of such approach for the selection is essential to aid the clients in selecting most appropriate procurement system. In this context, the major aim of this study is to develop a Decision Support System for the procurement selection which is useful for the construction clients and their consultants who often involve in procurement selection by the quickest and ad hoc methods without being fully aware of the various factors and alternative procurements options. The attempt to develop such a Decision Support System is based on the review of alternative approaches developed over the past decade and the current practice of procurement selection in construction industry.

This study has adopted the Delphi technique together with MAUT to develop the model. These two techniques were used to facilitate a more systematic and consistent approach in the selection process, hence improving objectivity and reducing subjectivity in decision making. Four rounds of Delphi survey were carried out to investigate the most significant factors and their level of

influence on various construction procurement systems. From the third and fourth round of Delphi, final set of selection criteria was determined and the utility values for each factor against various procurement systems were derived. Based on the selection criteria and the utility values, a Multi Attribute Utility model was developed. The special feature of this Decision support model is the inclusion of a set of exclusive selection criteria at macro level and wide range of various procurement options. The outcome of the model was evaluated for its applicability and efficiency with the use of case studies and an expert opinion survey. The implementation of this model to aid procurement selection is advocated to place the client in best possible position to select correct method of procurement for his project at a particular circumstance. The model has the potential to assist the clients/his consultants and it seeks to overcome any inconsistency in the effective decision making process.

Finally, the evaluated model was further enhanced to a Computer Aided Decision Support System (DSS). DSS allows users to make intelligent and informed decisions on selection of procurement routes for various building projects. It also provides an interactive and automated system for procuring construction projects in timely manner. The expert opinion survey, which targeted to validate the model, revealed that the DSS provides assistance in initial decision-making on project procurement selection to construction clients of the construction industry. DSS can be effectively used by the industry clients only through further development of a fully functional system

Key words: *Construction Procurement, Procurement selection, Multiple criteria model, Decision Support Systems,*

CHAPTER ONE

Introduction to Research

1. INTRODUCTION TO RESEARCH

1.1. Background

The construction industry is one of the backbones of the economy of many countries. Industry-wide studies on the performance of the construction industry (NWPC, 1990; Latham, 1994; Egan, 1998) have pointed to some key improvement areas, one of which is the use of an appropriate procurement method. The term procurement relates to the strategic organizational management of resources in a logical sequence in order to meet project objectives. In case of construction, fundamental to all procurement systems is the development of a framework that clearly establishes the boundaries of roles, responsibilities and relationship between the parties to a construction project. The activities of procurement relate to the set of actions to design, management and delivery of the project objectives (De Valence, 1999). Construction project procurement systems practiced in the industry have been subjected to changes resulting in many newly developed procurement systems that could be used to meet contemporary requirements of the clients.

Procurement has become a more central issue to the industry for several reasons. Clients are increasingly seeing the procurement method used as a key element in getting value for money from their projects. The procurement system is a key means through which the client creates pre-conditions for successful achievement of project specific objectives. A project may be regarded as successful if the project is delivered at the right time, at the appropriate quality standards, and provides the client with a high level of satisfaction (Barclay, 1994). Each project has its own characteristics and requirements and for projects to be successful, the procurement method must address the technical features of the projects alongside the clients and contractor needs. Client satisfaction is typically a function of time, cost, quality and environmental impact, which vary among different types of clients and projects.

In the last two decades, there have been significant changes in the technical and economic conditions prevailing in the construction industry. To overcome the shortcomings of the traditional procurement methods, the construction industry has developed a large number of alternative procurement methods. One of the aims of utilizing these alternative procurement methods is to enable the client to obtain value for money. Also, it is suggested that selection of

an appropriate procurement system for a project would assist clients to attain their objectives on financing of the project (Chege, 2001). Clients' needs in construction projects are sometimes unique and consequently each project meeting those needs has unique characteristics. Therefore, selection of suitable delivery systems is one of the major requirements of construction clients and the appropriate selection may help to avoid problems and be the key to the attainment of project specific goals. The selection should be done in a disciplined and objective manner within the framework of clients' overall strategic project objectives.

As the industry's characterization is determined by the external environment in which it operates, the development and the use of project procurement systems are affected by such environmental factors. These environmental factors influence the industry in various ways thus determining the procurement shares and trends. Therefore, examination such the factors influencing the change of procurement trend in the construction industry could be helpful for the development of the industry.

A review of current practice of procurement system in Sri Lankan Construction industry reveals that the majority of the public and private sector projects are procured by the use of traditional procurement system, especially by Measure and Pay (Rameezdeen and Silva, 2002). As far as the Sri Lankan construction industry is concerned, project procurement seems to be one of the key areas which have to be developed to a great extent. The number of different types of procurement methods used in Sri Lanka is less when compared to other developing countries. Therefore, there is a need to explore new ways of delivering construction projects.

Further, in Sri Lanka, the practice of procurement selection seems to be rather unstructured and ad hock. There is no systematic and realistic method is used to select an appropriate system for a particular project. Therefore, a development and application of a logical & consistent approach for the selection is essential to aid the clients in selecting most appropriate procurement systems. Furthermore, there can be several factors influencing in the selection of a suitable procurement methods for a particular construction project. Identification of relevant selection criteria based on their significance on procurement selection will be a first step to the formulation of such approach.

Therefore, investigation of significant factors affecting the selection of procurement systems and development of appropriate procurement selection criteria could be valuable. In this context, the aim of this research study is to develop a multi criteria selection model for the selection of best procurement system in construction to assist the construction clients in decision making on procurement selection. In addition, this research is conducted to identify the major reasons behind selecting the same procurement method for most of the projects in Sri Lanka.

1.2. Aim

The aim of this research is to investigate the significance factors that influence the selection of a procurement system at macro level and to develop a multi criteria selection model for the selection of a best procurement system for any kind of projects in construction.

1.3. Objectives

The targeted objectives for addressing the above aim are:

1. Identify the various types of procurement systems used in construction projects and their trend in the industry over time.
2. Identify and analyze the factors affecting the change in the use of procurement systems in Sri Lanka.
3. Investigate the reasons for the popularity of traditional procurement systems in Sri Lanka.
4. Identify the barriers for the implementation of other procurement systems in Sri Lanka.
5. Identify and analyze the macro level factors which affect the selection of a project procurement system.
6. Develop a multi criteria deceive factor model to aid the clients in the selecting the best procurement systems for different types of projects in Sri Lanka.
7. Enhance the model to Decision Support System (only prototype) that provides a user-friendly environment for procurement selection.

1.4. Methodology

The methodological approaches adopted for this study are as follows;

1. A comprehensive literature survey on construction procurement, procurement selection and research methods.
2. A Panel Data Analysis targeted at identifying the various types of procurement methods used in construction projects during last three decades.
3. A Desk study to analyze the impact of the following guidelines on procurement;
   (a) Guidelines on Government Tender Procedure – Part I (Procurements Financed by Public funds - Revised edition, August 1997)
   (b) Standard Bidding Document of ICTAD
   (c) Financial Regulations (FR)
   (d) Administration Regulations (AR)
   (e) Various Audit Guidelines / Procedures
   (f) Various Government Circulars
4. A Structured Questionnaire survey using Delphi method to determine the selection criteria and to obtain the utility values for Multi Attribute Utility Model
5. Development of a model using Multi Attribute Utility Technique (MAUT) to select the best procurement system for any kind of projects in the Sri Lankan construction industry
6. Case studies to test the applicability and effectiveness of the model
7. Semi-structured interviews with selected industry experts to check the consistency and validity of the DSS (Expert Opinion Survey)

1.5. Scope and Limitations

The research is limited to the building projects in Sri Lanka.

1.6. Research Output/Dissemination

Following are the expected outputs of this study:

1. Raise awareness and understanding of alternative procurements systems available and its application to building projects.

2. Raise awareness and understanding of factors affecting the selection of procurement systems at macro level.
3. Development of model for the selection of best procurement system to assists the client to achieve their project specific goals.
4. Produce user-friendly Decision Support System to assist the clients to make the procurement selection process effective and success.
5. Dissemination of knowledge and theory developed through publications.

1.7. The Structure of the Report

The outcome of the report consists of six chapters, references and Annexure.

Chapter one - Introduces the Background of research, Aim, Objectives, Research methodology, Scope & limitations as well as Expected research output/Dissemination of the research.

Chapter Two – Presents the overview of common types of procurement systems and review of past studied on procurement selection

Chapter Three - Explains the research methods adopted to achieve the objectives of the research.

Chapter Four - Discusses the trend of procurement system used in Sri Lanka and analyze the factors affecting the change in use of procurement system over the time.

Chapter Five – Identifies and analyzes the significant factors affecting the selection of construction procurement systems at macro level.

Chapter Six – Explains the objectives, development, use and evaluation of the multi criteria deceive factor model developed for the best procurement system selection in construction.

Chapter Seven – outlines the enhanced model (DSS) developed for selection of best procurement system and reviews the results of expert opinion survey.

Chapter Eight – Justifies the achievement of aim and objectives of this study and discusses the limitations and further development of this study.

CHAPTER TWO

Construction Procurement Systems and its Selection

2. CONSTRUCTION PROCUREMENT SYSTEMS AND ITS SELECTION

2.1. Introduction

There are a number of standard routes or processes, particularly with respect to the design, construction and management aspects, that need early consideration when procuring construction. Each route places different demands, risk allocation and responsibilities on everyone involved and different cash flow profiles on the client. A project delivery system has been defined as the set of "relationships, roles and responsibilities of project team members and the sequence of activities required for the deployment of a capital project" (Sanvido and Konchar, 1998). Given the fact that project objectives vary on a project-to-project basis, no one project delivery system is sufficient to address them (Construction Industry Institute, 2001). Therefore, it will be informative to specify what constitutes each procurement system in order to promote a more complete understanding of how to measure the impacts of the procurement system on project performance. The result of employing an imprudently selected procurement method could be an impediment to the realization of certain anticipated benefits associated with the designated method, and might eventually lead to project failure (Naoum, 1994; Sharif and Morledge, 1994; Rwelamila and Meyer, 1999; Ambrose and Tucker, 1999). This chapter provides brief description of main categorizes of procurement system and discuss the review of past studies related to procurement selection factors and alternative approaches developed for procurement selection up to date.

2.2. Construction Procurement Systems: An Overview

The procurement concept in construction has been defined in many ways (McDermott, 1999; Love *et al.* 1998). Masterman (1992) considered a construction procurement system to be "the organizational structure adopted by the client for the management of design and construction of a building project". In a more elaborative way, Love *et al.* (1998) viewed procurement systems as, "an organizational structure that arranges specific responsibilities and authorities to participants and defines the relationship of the various elements in the construction projects". In an attempt to develop a widely applicable definition, CIB at its commission meeting in 1991, developed a

working definition for procurement systems as "the framework within which construction is brought about acquired or obtained" (CIB, 1991).

NEDO (1983), Masterman (1992), Frank (1998) and many other authors in procurement have attempted in categorizing procurement systems in many ways. Based on the recent literature, procurement systems are categorized into four broader types in this study: Separated systems; Integrated systems; Management oriented systems; and Collaborative systems. Figure 2.1 illustrates this classification with most common arrangements belong to each category, supported by a brief description of each system:

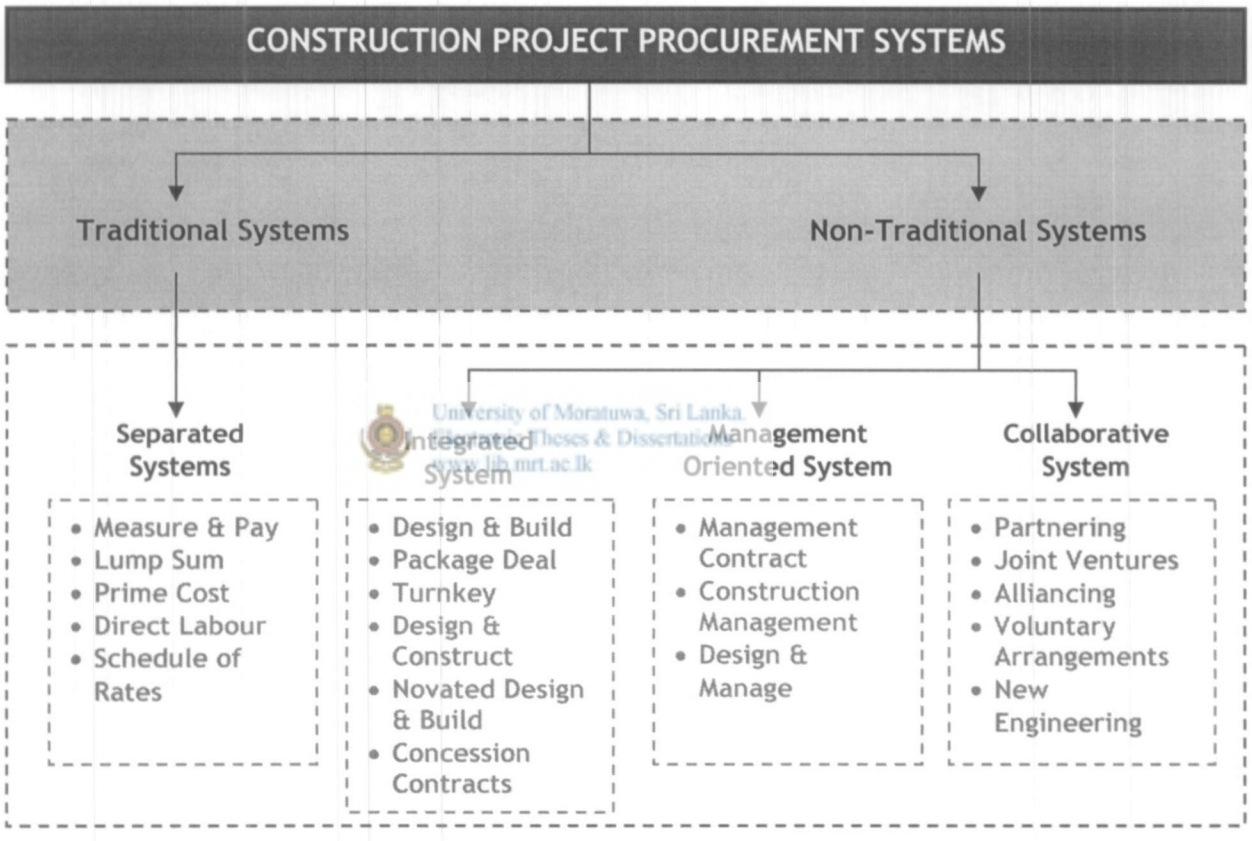

Figure 2-1 : Categories of Construction Project Procurement Systems

2.2.1 Separated Procurement Systems

These systems are also known as 'traditional' systems. The key characteristics of these systems are the rigid separation of design and the construction process and lack of integration across this boundary (Cox and Townsend, 1998). In this system, client appoints an independent team of consultants on a fee basis, who fully design the project and prepare tender documentation upon

which competitive bids are obtained from the contractors. The successful tenderer enters into a direct contract with the client and carries out the work under the supervision of the consultants. These systems offer minimal input of contractors to the design process (Rowlinson, 1999). The most common variants of the separated systems are the Lump Sum, Measure and Pay and Prime Cost.

2.2.2 Integrated Procurement Systems

Integrated Procurement Systems simply mean that one contracting organization offers to undertake the sole responsibility of design and construction of a project. Although, the contractor assumes the overall responsibility for project delivery, the client may appoint an independent adviser to monitor quality and cost (Cox and Townsend, 1998). There are some variants to the integrated procurement system, which have been introduced to bring more competition into the process and to achieve the balance of allocation of risks (Valance and Akintoye, 1996). The range of services offered by the contractor varies greatly with these variants (Frank, 1998). With some variants contractors find sites, arrange mortgages, sales and finance. Some even operate the constructed facility in addition to design and construction. The common variants are the Design and Build, Package Deal, Turnkey, Develop and Construct, Novated Design and Build and concession contracts such as BOT, BOO, BOOT etc., It has been widely accepted that closer integration of design and construction is a benefit of the system (McDermott, 1999).

2.2.3 Management Oriented Systems

The basic feature of these arrangements is the separation of management function from design and construction. With these arrangements client enters into a contract with an external organization, which is responsible for management and coordination of design and construction of the work. The common variants to these systems are Management Contracting and Construction Management.

2.2.4 Collaborative Systems

The basic principle of these systems is the collaboration between two or more parties to achieve successful project objectives through fair dealings, commitment, and shared investment. Various forms of joint ventures through combine investment of capital and expertise to undertake the works are also considered as collaborative procurement systems (De Valence and Huon, 1999). Partnering is the latest collaborative system that has enjoyed an increasing attention globally. Crowly and Karim (1995) stated that partnering is a decentralized organizational structure that allows better flexibility in meeting specific project needs through increased organizational competence. The common variants to the Collaborative systems are Partnering, Join ventures, Alliancing and Voluntary Arrangements.

2.3. Construction Procurement Selection: Review of past studies

2.3.1 Factors affecting the selection

Researchers have argued that identification of relevant selection factors is the first step to formalize the selection process in a systematic manner. Previous studies in construction procurement selection have identified several coherent procurement selection parameters, such as time certainty, cost certainty, speed, flexibility, responsibility, complexity, price competition, risk allocation, and quality (NEDO, 1985; Skitmore and Marsden, 1988; Franks, 1990; Love *et al.*, 1998). Further, several past studies related to construction procurement selection have identified number of selection factors based on clients' requirements, project profile and external environment. However, in reality whether such a large number of variables considered in procurement selection is doubtful. The following Table 2.1 and Table 2.2 summarize review of selection factors identified from past researches. The tabulated summary categorizes the identified factors which governing the selection of procurement system in terms of Internal and External environment respectively.

Table 2.1: Review of previous research on selection factors – Internal Environmental Factors

Procurement Selection Factors	Authors																				
	BF	H	HMSO	SM	F	MG	Lo.	Che.	Cha.	Lu.	NEDO	MD	GI	M	AM	BG	AT	NG	T	S	KD	R
Speed	✓		✓	✓			✓	✓		✓	✓					✓		✓		✓	✓	
Time Certainty	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓				✓				✓	✓	
Cost Certainty	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓				✓	✓	
Quality	✓		✓	✓	✓		✓	✓	✓	✓	✓					✓		✓		✓		
Complexity	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓				✓		✓	✓	✓		
Risk management	✓		✓	✓			✓	✓	✓	✓	✓					✓		✓		✓	✓	
Price competition	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						✓		✓	✓	
Flexibility	✓	✓	✓	✓			✓	✓	✓	✓	✓					✓		✓		✓	✓	
Accountability	✓	✓																				
Responsibility			✓	✓			✓	✓	✓	✓	✓					✓		✓		✓	✓	
Disputes & Arbitration			✓	✓			✓				✓									✓	✓	
Aesthetic aspects	✓								✓	✓	✓			✓	✓						✓	
Financial capability						✓				✓			✓	✓	✓							
Client's involvement	✓	✓		✓		✓				✓	✓										✓	
Value for money	✓										✓			✓							✓	
Project size									✓	✓					✓		✓					✓
Project type									✓	✓					✓		✓					✓
Building construction type									✓	✓					✓		✓				✓	✓
Client's type						✓				✓			✓		✓							✓
Client's experience						✓				✓			✓		✓							✓
Client's in-house technical capability						✓				✓			✓	✓								✓
Low operational & maintenance cost	✓														✓						✓	

BF - Bennett and Flanagan (1983), H - Hewitt (1985) , HMSO (1885), SM - Skitmore and Marsden (1988), F - Franks (1990), MG - Masterman and Gameson (1994), Lo. - Love *et al.* (1998), Lu. - Luu *et al.* (2003), N - NEDO (1985), Che. - Cheung *et al.* (2001), Cha. - Chan *et al.* (2001), GI - Gibb and Isack (2001), M - Molenaar (1999), AM - Alhazmi and McCaffer (2000), AT - Ambrose and Tucker (1999), R - Rowlinson (1999), T – Turner (1990), Ng *et al.* (2002), MD – Masterman and Duff (1994), S- Singh (1990), Bennett and Grice (1990), KD - Kumaraswamy and Dissanayaka (1998).

Table 2.2: Review of previous research on selection factors – External Environmental Factors

Procurement Selection Factors	Authors						
	W	HU	KD	AM	Cha	R	Lu
Market competitiveness	✓	✓	✓	✓		✓	✓
Technical feasibility	✓	✓		✓		✓	✓
Regulatory feasibility	✓	✓		✓		✓	✓
Material availability	✓	✓	✓				✓
Experienced contractor availability	✓		✓	✓	✓	✓	✓
Weather & natural disaster	✓	✓					✓
Political constraints	✓	✓				✓	✓
Cultural differences	✓	✓				✓	✓
Industrial actions	✓	✓				✓	✓
Objection from neighbor	✓	✓				✓	✓
Labour productivity	✓	✓	✓			✓	✓
Objection from local lobby groups	✓	✓				✓	✓

W – Walker (1989), HU –Hughes (1989), KD – Kumaraswamy and Dissanayaka (2001), AM – Alhazmi and McCaffer (2000), Cha. - Chan *et al.* (2001), R – Rowlinson (1999), Lu – Luu *et al.,* (2003)

Review of past studies reveals that the number of studies related to factors influencing from external environment is limited compared to internal environment. Most of the authors ignored some important factors related to external environment. Clients' requirements will ultimately be influenced by the context in which they operate; and this implies that the selection of factors may also be influenced by the predominant environment (Sheath *et al.* 1994; Chen, 2000). These may have direct or indirect influence on the formulation of selection criteria. Therefore, it is important to consider the factors related to internal and external environment for establishing a set of selection criteria for construction procurement selection.

2.3.2 Alternative approaches to procurement selection

According to Masterman, (1992) the practice of procurement selection is rather unstructured and ad hock. One of the pertinent questions is that, in reality does the client or his representative use a structured model for procurement selection? Several procurement selection systems have been developed to help the clients to choose the most appropriate procurement systems, ranging from simple rating systems (Franks, 1990) to highly complex systems such as multi-attribute and matrix based systems (Skitmore and Marsden, 1988; Liu, 1994). However, in all of the models there is always a need to input the specific characteristics of client, project and possibly procurement process features that are subjective based on the point of view of the user. Further, it is strategic important to make sure that the selection is done systematically and in a closely controlled manner. The following Table 2.3 summarizes the review of alternative approaches to procurement selection and their basic methodology developed over the past two decades.

Table 2.3: Review of alternative approaches to procurement selection

Author	Year	Description of Alternative Approaches
NEDO	1985	Rating system using a client's priority for nine key areas
Skitmore and Marsden	1988	Two systems: a multi-attribute model based on the NEDO model with a rating system and weighting of client priorities; and a discriminate analysis technique utilizing variances in procurement characteristics under certain criteria.
Brandon *et al.*	1988	A computer expert system called ELSIE, which determined suitable procurement systems, based on project characteristics and client requirements.
Franks	1998	Simple rating system based on client's performance requirements.
Singh	1990	Two systems: a multi-attribute model based on the NEDO model with a rating system and weighting of client priorities; and a discriminate analysis technique utilizing variances in procurement characteristics under certain criteria.
Bennett and Grice	1990	System based on the NEDO and Skitmore and Marsden models and allows clients to weight specific criteria multiplied by set utility ratings for the various systems.
Mohsini	1993	A knowledge-based expert system (project acquisition strategy consultant), which starts by establishing the project characteristics and the client's posture towards project control and risk taking

Table 2.3: Review of alternative approaches to procurement selection (Continued)

Author	Year	Description of Alternative Approaches
Gordon	1994	Three drivers of project, owner, and market as well as a risk-allocation analysis and a commodity versus service analysis, to guide the clients into using an appropriate procurement method.
Liu	1994	An organizational behaviour-based model utilizing an act-to-outcome process governed by organizational goals, which in turn are subject to moderators, which determine goal/performance relationship.
Chan *et al.*	1994	A model utilizing the Bennett and Grice model, but uses a different procurement category developed for the Australian construction industry.
Love	1996	A systematic first-principle analysis
Love *et al.*	1998	A procurement path decision chart, which allows clients to weight a simple set of criteria based on clients' requirements multiplied by set utility ratings for the various systems.
Dell'Isola *et al.*	1998	Decision matrix-based model that rates the performance of each procurement system for selected issues and their relative importance on a client/project profile.
Tucker and Ambrose	1999	A three-dimensional interaction matrix that provides a procedure to evaluate the appropriateness of a procurement system for a particular project and the needs of the client.
Alhazmi and Mccaffer	2000	A Project procurement system selection model which is an integration of Parker's judging alternative technique of value engineering and Analytical Hierarchy Process (AHP)
Chan *et al.*	2001	A multi attribute model, which allows clients to weight a set of exclusive criteria multiplied by set utility ratings for limited number of procurement systems.
Cheung *et al.*	2001	A procurement selection model based on multi-attribute utility technology with the use of Analytical Hierarchy Process (AHP) to determine the importance weightings of the selection criteria based on client requirements.

Among these models, Multi Attribute Utility Technique (MAUT) received the greatest attention. Chang and Ive (2002) discussed some of the inherent problems of using MAUT for procurement selection. One of strongest criticisms was the selection of procurement variables. The other is the utility value developed through opinions of industry experts. Particularly they are critical about the subjective nature of assigning values to procurement selection parameters to obtain mean utility values. The main difficulties common to these alternative approaches developed during the past two decades could be pointed out as follows;

- All models failed to include some important factors based on main criteria for the selection of most appropriate procurement systems. Some of the models only include limited number of criteria based client's requirements and certain models consider limited number of client's requirements and project characteristics.

- The available procurement systems included in the existing models are limited. Certain models seem to ignore the variants of the main categories of procurement systems. Some of other models include limited number of variants of main categories.

- Some models are conditional and cannot be used by any types of clients (Alhzmi and Mccaffer, 2000).

- Some of the models require the use of advanced mathematical techniques, which are considered to be time consuming (Alhzmi and Mccaffer, 2000).

- Some of the models require the use of advanced computer packages, which can not be used by all the clients/consultants.

- A number of existing models adopt a primitive approach to the selection process and limit the number of options to be considered (Alhzmi and Mccaffer, 2000).

Against this background, this study has attempted to develop a selection model by which most of the difficulties pertaining to the existing models could be overcome.

2.4. Summary

Selection of appropriate procurement system is a complex task and it requires a systematic and consistent approach for its effective process. There have been number of approaches developed over the past years to fulfill this function and in reality whether the client or his/her representative use a structured model for procurement selection is doubtful. This chapter has briefly reviewed the past studies on factors affecting the procurement selection and alternative approaches developed for the procurement selection. In addition, brief description on main categories procurement systems also given.

CHAPTER THREE

Research Methodology

3. RESEARCH METHODOLOGY

3.1. Introduction

This chapter illustrates the methods adopted to achieve each objectives of the study. It mainly focuses on the Delphi method and Multi Attribute Utility Techniques (MAUT). Further, it briefly discusses the other methods used to analyze the trend of the use of procurement of procurement systems in Sri Lanka.

3.2. Methods adopted to analyze the trend

The necessary data, among other information, were collected from building projects undertaken by M1 and M2 grade contractors in Sri Lanka. The regulatory authority of construction in Sri Lanka namely, the Institute for Construction Training and Development (ICTAD) categorizes contractors into grades. M1 contractors are eligible for construction of buildings over Rs.300 million in value. M2 grade contractors are eligible for construction of buildings between of Rs.150 and 300 million in value. The method used for the collection of data was a survey on project documents in four panels. A random sample of M1 and M2 grade contractors were selected from the ICTAD list of registered contractors. Projects undertaken by those contractors became the subjects of this study. The first panel of data was collected in 1992 corresponding to projects undertaken during 1977-1992 period. The second panel of data was collected in 1997 corresponding to 1992-1996 period. Similarly, surveys in 2001 for 1997-2000 data and early 2004 for 2001-2003 data were carried out. Panel Data Analysis refers to the pooling of observations on a cross-section of the subjects over several periods of time (Tan, 2002). It follows a given sample of individual over time, and thus provides multiple observations on each individual in the sample (Hsiao, 2003). Thus, the same set of contractors was visited all along four panels. The sample represents approximately 73% of the total population of M1 and M2 contractors operating in Sri Lanka. This is considered to be a good representation and these contractors together cover a major portion of large building projects in Sri Lanka. Table 3.1 presents the profile of the contractors participated in the survey.

Table 3.1: Profile of the Sample

Grade	Sample	Number of registered Contractors
M1	12	15
M2	12	18
Total	24	33

In addition to the survey, the following methods were used to explore the factors that cause the change of procurement method over time.

1. Desk studies on Guidelines on Procurements
2. A Content Analysis of government procurement guidelines.
3. A questionnaire survey on culture among construction professionals.

3.3. The Delphi Technique

3.3.1 An Overview

Linstone & Turoff (1975) define Delphi as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. Sackman (1975) further defines Delphi as an attempt to elicit expert opinion in systematic manner for useful results. The objective of the Delphi method is to obtain a reliable response to a problem or question from a group of experts. This is done by giving individuals in the group a series of questionnaires (or interviews) that reiterate the same questions while providing group feedback from previous rounds (Helmer, 1983, p. 135). Delphi experiments tend to produce convergence of opinion – not just toward the mean but toward the true value (Helmer, 1983, p. 153). The Delphi technique is based on the qualities of "anonymity, statistical analysis, and feedback" (Armstrong, 2000, cited in Gunaydin, 2004). Further, in a Delphi study, the participants do not interact with one another, their responses are anonymous, the group results are given in terms of means, medians, or standard deviations, and participants are given the opportunity to reconsider their response after receiving the group feedback. Although originally developed and used by Rand as a forecasting methodology, the Delphi technique is used today in business, education, and the social sciences for a number of applications, including management decision making, policy evaluation, program planning, and prioritization of issues or actions. (Delbecq *et al.* 1975; Dunham, 1998; Gunaydin, 2004, p.9).

3.3.2 Advantages of Delphi

According to Turoff (1975) the Delphi technique overcomes a number of problems that would normally be associated with a small consultative committee, such as:

- The dominating personality, or outspoken individual that takes over the committee process
- The unwillingness of individuals to take a position on an issue before all the facts are in or before it is known which way the majority is headed
- The difficulty of publicly contradicting individuals in higher positions
- The unwillingness to abandon a position once it is publicly taken
- The fear of bringing up an uncertain idea that might turn out to be idiotic and result in a loss of face.

The advantages of conventional Delphi, at least in this reviewer's estimation, are primarily low cost, versatile application to virtually any area where "experts" can be found, ease of administration, minimal time and effort of the part of the director and panelists, and the simplicity, popularity, and directness of the method (Sackman, 1975).

3.3.3 Limitations of Delphi Method

Even though, the Delphi method possess several advantages, it has certain limitations

- Delphi should not be used when any of the following three critical conditions are not present: adequate time, participant skill in written communication, and high participant motivation.
- The use of unclear evaluation scales and poor techniques in interpreting results.
- The problem of bias in Delphi studies that can occur from poorly worded or leading questions or selective interpretation of the results.
- The participant dropout can be a problem in Delphi studies.

The use of multi attribute decision analysis has been considered the foremost technique for examining client needs and the weighting of preferences from experts for each procurement (Chan *et al.* 2001, p.699), but the major difficulty with these selection systems lies in the lack of

consensus among the experts on the utility factors. To overcome above deficiencies, a Delphi technique was adopted in order to identify the factors affecting the procurement selection.

Chan *et al.* (2000) in their study prove that the Delphi method is a powerful and appropriate technique for deriving objective opinions in a rather subjective area such as the multi attribute methodology for the selection of procurement system. Therefore, the Delphi method was considered to be appropriate to achieve the objectives of this study.

3.4. Selection of expert panel

The success of the Delphi method depends principally on the careful selection of the panel of experts (Goldstein, 1975). The panel size of seventeen fits within the guidelines recommended for Delphi studies. A panel of 7 experts has been selected for the original Delphi experiment in 1953 (Helmer, 1983). On the other hand, Turoff, (1975) has suggested a panel size of anywhere from 10 to 50 participants (p.86). A Delphi panel that consists of a homogeneous group, such as a group of experts from the same general discipline area, need only to be involved 10 to 15 people (Delbecq *et. al*, 1975). Wicklein, (2000) used a panel of 25 experts in his study. Dalkey, (1969) found that error decreased rapidly as the group size increased from one to about thirteen; further small decreases in error continued to a size of about 25 people, at which point, the error rate stabilized. Based on these findings, they continued their experiments using groups of fifteen to twenty people (Gunaydin, 2004, p.11). The length of the list should anticipate an acceptance rate between 35 and 75 percent (Gordon 1994, p.6).

With respect to the review of past studies, a panel of was selected to have upper limit of the reliable sample size (15- 35), which consists of 35 experts/practitioners from the industry. The purposive selective sampling approach was used to select this focused group of experts, as the opinions to be derived from experts require in depth knowledge and extensive working experience on selection criteria and various types of procurement options.

The following criteria were adopted to identify eligible the participants for the Delphi survey.

- Practitioners who have far-reaching working experience in the construction industry in Sri Lanka
- Experts, who directly involved in the management of construction projects in Sri Lanka.
- Experts, who have superior knowledge on all types of procurement options.

In order to meet all stipulated requirements and increase the efficiency of opinions required, the experts/practitioners who met all the criteria were selected. Thirty five (35) members of panel represent wide distribution of professionals from several disciplines practicing in public and private sector organizations. The following Table 3.2 presents the profile of the panel involved in the survey.

Table 3.2: Profile of the Panel of Experts/Practitioners

Category	No
Project Directors	8
Project Managers/Manager Contracts	6
Project Engineers/Civil Engineers	2
Chief/Senior Quantity surveyors	5
Quantity Surveyors	14
Total	**35**

3.5. Formats of Delphi Rounds

The Delphi method adopted in this research consists of four rounds. The following Table 3.3 summarizes the format of all four rounds.

Table 3.3: Formats of Delphi Rounds

	Round 1	Round 2	Round 3	Round 4
Instrument	Questionnaire 1	Questionnaire 2	Questionnaire 3	Questionnaire 4
Purpose	To gather a set of exclusive selection criteria for procurement system	To identify the level of importance of each selection criteria	To assess the suitability of each procurement system against each selection criteria	To reconsider and reassess the suitability of each procurement system against each selection criteria
Number of experts selected	35	35	30	25
Data base for the design of Questionnaire	Literature review	Results from round one	Results of factor analysis carried out for round two results and various procurement options	Results from round three
Duration	Two weeks	Eight weeks	Four weeks	Five weeks

3.6. Data Collection

Qualitative and Quantitative data were required to establish the procurement selection criteria and a Delphi method was used to collect the empirical data from the experts. The following section briefly explains the activities involved in the four rounds of Delphi survey.

3.6.1 Delphi Round One: Identification of factors affecting the selection of procurement

The first round was aimed to identify the macro level factors, which influence the selection of procurement systems. The questionnaire consists of a list of factors identified from literature and an open-ended question to identify the additional factors, which affect the procurement selection in the Sri Lankan context (Refer Annexure 3.1 for the questionnaire).

3.6.2 Delphi Round Two: Refining the identified factors

The Delphi round two was targeted to identify the level of importance of each factor identified from round one (Refer Annexure 3.2 for the questionnaire). The respondents were requested to reconsider the all factors identified in round one and indicate the relative importance of each factor using a simple 3 level scale where 3 represents *'Very important'*, 2 represents *'Important'* and 1 represents *'Not important'*.

3.6.3 Delphi Round Three: Obtaining the utility values

At this round, experts were asked to provide the utility values for each factor to assess the degree of importance of each factor against each procurement system (Refer Annexure 3.3 for the questionnaire). The utility values were defined using a score starting from 10 to 110, in which 10 represents '*low suitability'* and 110 represents '*high suitability'*. The purpose of using the score on a scale of 10-110 was to avoid any possible imbalance due to the occurrence of zero (Fellows and Langford, 1980). The factors, that are to be considered against various procurement systems, were derived from the analysis of the data collected from Delphi round two.

3.6.4 Delphi Round Four: Re-assessing the utility values

The fourth round was designed to re-assess the utility values provided by the respondents in the third round. Questionnaires were issued among 25 respondents with the feed back of the round three. The questionnaire comprised with average utility values for each factor against various procurement system and the own score provided by the respondents (Refer Annexure 3.4 for the questionnaire). The experts were asked to re-assess their scores with respect to the average values scored by the experts.

3.7. The Multi Attribute Utility Technique

MAUT is a methodology that may be used as a tool for measuring objectivity in an otherwise subjective area (Fellows *et al.*, 1983). The use of MAUT can minimize the subjective elements that tend to predominate in the decision making process and can increase transparency (Shen *et al.*, 1998).This Technique has been well received in areas such as Maintenance (Shen *et al.*, 1998), Quantity Surveying (Ashworth, 1988), and Project Procurement (Chan, 1998; Cheung *et al.*, 2001).

This study employed Multi Attribute Utility Techniques (MAUT) for the development of model to be used as a decision making tool for best procurement selection in construction. Procurement system is the overall managerial approach by which a client commissions and obtains a building. MAUT is an attempt to apply a quantitative decision method to the context of construction procurement route selection, so as to provide clear normative advice for improving the quality of clients' decision-making (Skitmore and Marsden, 1988; Chan, 1995; Love *et al.*, 1998; Ambrose and Tucker, 2000). Therefore, Multi-Attribute Approach was considered to be the foremost technique appropriate for examining the main selection criteria & their variables and the preferences of experts' weights for each method in the most objective way. In this study, MAUT is used to integrate both priority ratings and the utility values derived from the respective factors.

3.8. Summary

The research involved an empirical study, which focused on the selection of best procurement system for any kind of projects. The objectives of this research were achieved using several research methods. This chapter has briefly explained the various research methods adopted to this study. It briefly discussed the methods used to analyze the trend of procurement system in Sri Lanka. In particular, it focused on the Delphi method and MAUT and their suitability for this research.

CHAPTER FOUR

Trend of Procurement Systems Used in Sri Lanka

4. TREND OF PROCUREMENT SYSTEMS USED IN SRI LANKA

4.1. Introduction

Characterization of the construction industry is determined by the external environment in which it operates, and the development & the use of procurement systems are also affected by such environmental factors (Rowlinson, 1999). These environmental factors influence the industry in various ways thus determining the procurement shares and trends. Therefore, it is very important to know that what forces from the environment drive the procurement system and how these forces might change the trend of procurement systems over the time. Walker (1996) states the forces such as political, economical, legal, technical and sociological, affects from environment and it is essential that the forces, which may affect the project, are identified prior to identifying the selection criteria. These environmental factors influence the industry in various ways thus determining the procurement shares and trends. This chapter deals with such environmental factors identified in the Sri Lankan context and analyzes how the influences of these factors are directed towards procurement trend in Sri Lanka. The underlying factors responsible for the change are discussed with comparisons from other countries.

4.2. Trend of the use of procurement systems

The result of Panel Data Analysis is presented in Table 4.1. It gives the usage rate of various procurement methods over time. The results clearly highlight the dominance of Measure and Pay system throughout the period. It ranges between 50 – 72 percent. The share decreased considerably in certain periods (particularly during 1982-1986 and 1992-1996) paving way for other systems. Majority of public works in Sri Lanka are found to be procured using this method. Transparency and accountability are the main driving forces for favoring this method over others in the public sector.

The Lump Sum arrangement ranges between 5-12% of the total. This system is popular among private sector clients in Sri Lanka. There is a clear decline of Prime Cost as a procurement system in large building projects. However, it is the most favored system in the informal sector of the industry. Informal sector accounts for a considerable amount of workload in the housing

sub-sector. Design and Build has recorded a usage rate of 20-35% over the years. This system is used mainly for industrial buildings in Sri Lanka. It was found that they are mainly of prefabricated type. Management contracting approach records only 1% throughout the study period. Only few projects have been procured through this method and all of them were very complex and large-scale. Collaborative systems have just started to emerge. It was observed that this is due to the involvement of international contractors in Sri Lanka. International contractors form joint venture arrangements with local counterparts when entering the Sri Lankan market.

Table 4.1: Trend of the use of Construction Procurement Systems in Sri Lanka

Procurement System	% Use (average)					
	1977 - 81	1982 – 86	1987 - 91	1992 - 96	1997 – 00	2001 – 03
Measure and Pay	55	50	58	50	64	72
Lump Sum	12	10	8	7	10	5
Prime Cost	10	8	5	4	3	1
Design and Build	22	31	28	35	21	22
Management Contracting	1	1	1	1	1	0
Joint venture	0	0	0	3	1	0
Total	100	100	100	100	100	100

The following chapter explores the variables that can be used to describe the observed trend in procurement usage.

4.3. Factors affecting the change in use of procurement systems

4.3.1 Economic and Market Aspects

Cyclical demand in the construction industry is caused by the economic status of the country. Moor (1984) highlighted the decrease in construction work load in 1970's, due to the recession in UK, which resulted in contractors diversifying into areas of design and management to ensure adequate work for survival. Such situations have resulted in the growth of new arrangements such as Design and Build and Management Contracting in UK construction industry. Further, in UK, the oil crisis in 1970's, which resulted in high inflation, coupled with high borrowing rates made the client realise the essence of construction time and gave rise to fast track project procurement arrangements like Management Contracting.

In examining the share of project procurement arrangements used from 1987 – 1997, Ladenpera, *et.al.* (1999) stated that the changes in economic conditions may have had an impact on project procurement arrangements used in Finland. In Finland, economic boom in the end of 1980s was followed by a sharp decline of over 50% of the construction workload within three years. In 1996-97 volumes started to grow again. The traditional method seemed to be the choice especially in the recession in early 1990s with a low market structure. As the economy revived in 1996-97, the shares of Design and Build and Management oriented procurement systems increased possibly due to the need for shorter project duration (Ladenpera *et. al*, 1999).

In Sri Lanka, with the market changing from closed to open economy in 1977, there has been a tremendous increase in construction workload (see Figure 4.1). This had resulted in a considerable increase in the use of non-traditional forms of construction project procurement arrangements. The share of non-traditional procurement systems increased from 23% to 32% in the 1982-86 period compared to the previous one. Such a change was due to the burning requirement for faster implementation of projects and increased involvement of foreign contractors and consultants in the industry. Similarly, the rise of non-traditional systems could be observed in the 1992-96 period. The share has increased up to 39%. In both these periods, Design and Build constitutes the largest share among the non-traditional systems. The study found that Design and Build is mainly used for industrial buildings especially for pre-fabricate type of constructions. Thus, the increase of Design and Build could be attributed to the increase in industrial activity in the country. The growth of the manufacturing sector as shown in Figure 3.2 has resulted in an increase in the share of Design and Build, especially during 1982-86 and 1992-96 periods. During both these periods the manufacturing value added recorded a peak growth rate of more than 8%.

In examining the organizational structure of Japanese contractors operating in Sri Lanka Rameezdeen and Welaratne (2001), found that all Japanese contractors have entered the Sri Lankan market through Joint venture procurement arrangements. Joint venture provides an opportunity to reduce the cultural gap between the international contractor and the host nation, in addition to numerous other advantages to the newcomer. Even a minute share of Collaborative systems during the periods of 1992-96 and 1997-2000 are due to the involvement of international contractors in Sri Lanka.

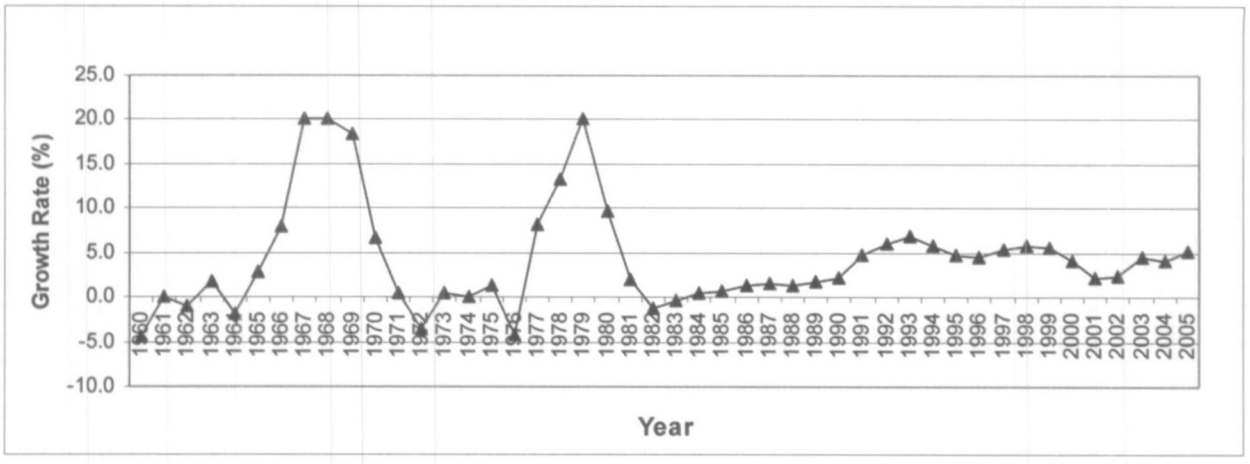

Figure 4-1: Growth Rate of Construction Value Added at Constant 1996 Prices (3 year moving average)

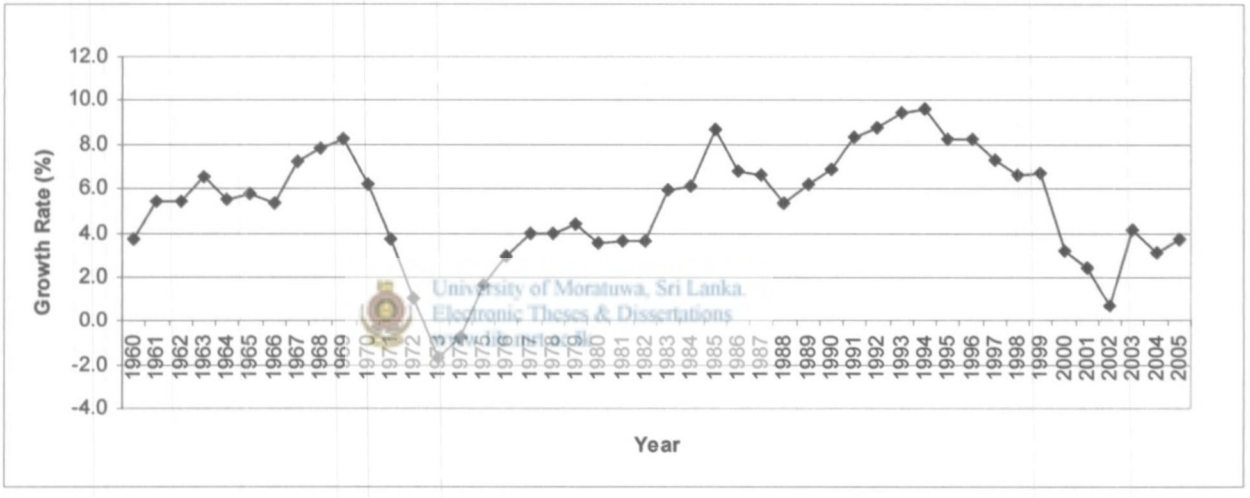

Figure 4-2: Growth Rate of Manufacturing Value Added at Constant 1996 Prices (3 year moving average)

4.3.2 Technological Aspects

It is clear that building is increasingly becoming more complex. New technological improvements and innovations in engineering have increased the complexity of construction. This led the industry to seek improved project organisation procedures and practices in order to be in line with these technological shifts. Within this context, project procurement arrangements have been identified as one of the areas that need to be re-appraised (Kumaraswami, 1994).

To find the relationship between technology and procurement method selection, large-scale complex projects were analyzed separately in the sample. It was found that Lump Sum method

has been used more than its proportion in procuring large-scale complex projects. The sample had 19 large scale complex projects. Table 4.2 gives the distribution of procurement methods used in those projects. It is interesting to note that Lump Sum even though rank second, represents more than its share in large scale complex projects. It may be due to the need for price certainty from a clients' point. As inflation rate is high in Sri Lanka, clients naturally tend to minimize the risk in large scale projects, which runs for a longer duration.

Table 4.2: Procurement systems used in large scale and complex projects

Procurement Method	No of Projects
Measure and pay	10
Lump sum	6
Design and Build	1
Turn key	1
Management Contracting	1
Total	**19**

4.3.3 Government as a Client

The Government is an important participant in the construction industry of every country playing the role of a major client (Ofori, 1990). De Valance and Huon (1999) and many other researchers (Mustapha, *et. al.*, 1994; Mukalula, 1996; Azis and Ofori, 1996) have stated that changes in state regulations and policies have made an impact on the procurement trend. Further, some governments directly influence the project procurement through their policies. It is the stated policy of the government of Sri Lanka to procure future investments for new infrastructure projects through various forms of Concession Contracts (especially BOT or BOO). By such policies, Government expects to provide solutions to the problem of insufficient funds for investment (Presidential Policy Statement: Sri Lanka, 1996). Government being a major client creates an impact on the construction market, thus indirectly regulating the project procurement practice in a country. In Sri Lanka, majority of public works are procured using Measure and Pay system. The reluctance of the public sector to use other non-traditional procurement methods is due to the bureaucratic barrier created by financial and administrative regulations of the country. Among others, transparency and public accountability are very important requirements in public work projects. Transparency in procurement can be defined as "the extent to which construction

procurement is conducted in an open, clear, measurable and verifiable manner". Transparency shall ensure that there is a fair competition in the tender process and the government purchases best value for money (Rogge, 2003). Transparency involves following key elements (World Bank, 1995).

- Notification and advertising
- Pre-disclosure of relevant information
- Public bid opening
- Use of standard bidding and contract documents
- Accessibility of applicable laws and regulations
- Appeal mechanisms
- Debriefing
- Publication of awards

Transparent systems have clear procedures for public decision-making and open channels of communication between stakeholders and officials and make wide range of information accessible. Open processes according to general rules subject to monitoring regarded as the basis of accountability. As the funds for public sector projects are channeled through the Treasury, accountability is considered a major requirement. Accountability is the "Responsibility for the justification of expenditure, decisions or the results of the discharge of authority and official duties". Measure and Pay procurement method ensures both transparency and accountability compared to any other method. As such, bureaucrats prefer Measure and Pay over other methods for public sector projects. It is interesting to note that 100% of the public sector projects in the sample had been procured using Measure and Pay method.

4.3.4 Government as Regulator

The Government is not only a major client but also the regulator and the administrator of the development of the industry. The Ministry of Finance is responsible for public works procurement administration in Sri Lanka. All government agencies follow the Finance Ministry guidelines in procurement of works, goods, and services. These guidelines form several published documents. Minor changes are communicated through circulars directed at various government agencies. The construction regulatory authority in Sri Lanka, Institute for

Construction Training and Development (ICTAD), also publishes guidelines specially aimed at the construction industry. Unfortunately, both the Ministry of Finance and ICTAD take into account only public works in preparation of these procurement guidelines. The documents are highly biased towards Measure and Pay, even though; these guidelines are widely used by the private sector as well.

Very little effort has been taken by the ICTAD to promote other procurement methods in Sri Lanka. Only as lately as year 2001, ICTAD published a guideline called "Standard Bidding Document for Procurement of Works – Design and Build Contracts". This is the first and only guideline to be published by ICTAD for an alternative procurement arrangement.

A Content analysis carried out on all published documents of Ministry of Finance and ICTAD proved the above observation. Content Analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts (Weber, 1990; Holsti, 1969). Table 4.3 provides the summary of the results of content analysis.

Table 4.3: Frequency of Themes on the Selected Variable Categories

Variable category	Frequency
Measure & Pay	31
Lump Sum	1
Design and Build	3
Management Contracting	1
Total	**36**

Out of the 36 references on procurement methods, only 5 belong to non-Measure and Pay methods. It shows that government guideline mainly promote Measure and Pay as the procurement method in Sri Lanka. Therefore, the dominance of Measure and Pay in Sri Lanka is mainly attributable to the institutionalisation of this procurement method by the Government and virtual negligence of other methods over time.

4.3.5 Financial Aspects

Most developing countries frequently obtain finance for major development projects through development aid funds. Both bi-lateral and multi-lateral aids constitute a major portion of the development budget of Sri Lanka. These lending institutions essentially safeguard their interests

by dictating the methodologies that the borrowers should follow. The procurement route is one such area where their advice is focused. For example, if the project is funded by World Bank or Asian Development Bank, the procedures for procurement will be according to their whims and fancies. Thus, the issue of client's choice in the procurement becomes secondary to the perceived benefits of financial arrangements.

It is also observed that many arrangements for transactions between client, contractors and financiers have evolved in recent years. In a situation where client has no financial resources, projects are implemented through procurement arrangements such as BOT, BOO etc. These have caused new financial structures and also have led to a change in project procurement practice in the construction industry.

4.3.6 Socio-cultural Aspects

Hofstede (1984) has maintained that the concept of culture is a prime driver of both individuals and organizations. Trust and institutions are two major dimensions related to culture. Latham (1994) accepted 'trust' as the gatekeeper to any real progress in improving procurement and contractual relations in the UK construction industry. His report attempted to rebuild the trust in UK construction industry through the advocating of partnering and encouraging restructuring of client, contractor, subcontractor, supplier and consultant institutions. The importance of institutions in establishing procurement policies and practices are well established by many researchers (Ng, 1994; Ofori and Pin, 1996; Azis and Ofori, 1996). Analysing the relationship between procurement system and clients interests in both countries, Saito (1994) made clear that procurement difference in UK and Japan is based on cultural differentiation. Western organisations may need to learn to work with Asian professionals by accepting their cultural composition (Matthews *et. al.,* 1999).

Rameezdeen and Gunaratne (2003) found that the separation between design and construction dates back to the Colonial rule (1815-1948) in Sri Lanka. This spilt has given rise to two separate cultures between Contractor and Consultant. It was revealed that Consultants are oriented towards a clan dominated culture mix, while contractors towards a market dominated culture mix. Consultants emphasize on loyalty and comfortable working environment. Contracting organizations on the other hand are driven towards output maximization. They encourage on

goal accomplishment. Thus, the popularity of Measure and Pay is historical and it became institutionalised in the Sri Lankan society as the method of procurement.

Using the four dimensions of national culture established by Hofstede (1980), Rameezdeen (2004) examined what constitute the Culture of Sri Lankan Construction Professionals. The results show a relatively large Power Distance and a very strong Uncertainty Avoidance among construction professionals. It was found that they are Collectivists and Feminine. The main characteristics emanating from the above culture mix on Procurement selection can be given as follows. These characteristics are based on Hofstede (1980).

1. Fear of ambiguous situations and of unfamiliar risks.
2. Suppression of deviant ideas and behavior; resistance to innovation.
3. Motivation by security and esteem or belongingness.
4. Status quo. Is accepted and not challenged.
5. Dominant role of the state in the economic system.
6. Harmony and consensus in society is highly valued.
7. Dominant values in society are caring for others and preservation.
8. Resolution of conflicts by compromising and negotiation.

Therefore, it is clear that Sri Lankan construction industry is characterized by the notion of acceptance of the status quo. Changes to accepted systems are very difficult to come about. Thus, the nature of Sri Lankan construction culture itself contributes to the dominance of Measure and Pay procurement method.

4.4. Prediction of Future Trend

During the past, Measure and Pay system has continued to be widely used while non-traditional systems like Design and Build, Management Contracting & Joint venture also gained recognition in the industry. The growth in the industrial sector has resulted in the use of Design and Build as an alternative procurement system. The construction sector has grown by 6.5 % in the third quarter of 2004 (Central Bank of Sri Lanka, 2005). The growth has mainly due to refurbishment and expansion of hotel projects and housing construction, including mix developments and condominiums. The on going foreign funded projects such as water supply, roads, airports and power sector development also contributed to the growth performance of this sector. In addition, the manufacturing, which is the largest sub-sector in the industry, has grown by 5.4 % as against

an increase of 1.7% during the corresponding period of previous year (Central Bank of Sri Lanka, 2005). With respect to the above developments and future demand for industrial buildings, an increase in the use of Design and Build system can be expected in the near future.

In future, construction demand in Sri Lanka will require the package of services that provides a single solution to client requirements, thus demanding co-operation in the project delivery process based on partnering or joint venture arrangements. In this context, organizations will seek collaboration to provide entire project services with horizontal integration, strategic alliances, joint ventures or consortia to combine strengths to become single problem solver to the client. As a development country with financial constraints for infrastructure developments, Sri Lanka will experience total package options such as BOT, BOO and BOOT. As a result, foreign contractors will be increasingly involved in the form of Joint venture or partners in the Sri Lankan construction industry. Economic and Political stability will determine the possibility of attracting foreign investment for BOT, BOO or BOOT projects. Thus, the trend of procurement will largely depend on the solutions to the ethnic problem in the North and the role of the government as a provider of infrastructure. There is a clear sign that private sector is increasingly invited to share the burden of infrastructure provision in Sri Lanka. With these developments, the government policies will be the key deterministic factor with its traditional role changing from that of a client and a regulator to that of a facilitator in the construction industry. While these policies lead to a larger private sector participation in infrastructure and industrial development with increased foreign involvement, it has also put the domestic industry under pressure to change due to such developments. As such, the role of contracting firms together with the project delivery process and project procurement system will be subject to change to meet new demand conditions.

4.5. Conclusion

This chapter highlighted the dominance of separated procurement systems in Sri Lanka from year 1977-2003. Among the variants of separated system, Measure and Pay had the highest share. It ranged from 50-72% of the total. The popularity of Measure and Pay is mainly due to the Government influence on the construction industry of Sri Lanka. Government as a major client and the regulator neglected the development of alternative procurement methods. Bureaucratic red tape of the Government created a barrier for the growth of alternative

procurement methods in the name of accountability and transparency of public work projects. In addition, it was found that the combination of national culture and organizational culture of construction has created an environment that did not favor the use of new procurement methods. The organizational culture of construction in Sri Lanka is characterized by the separation of design and construction from the Colonial days. The culture of construction professionals is marked by a high power distance with very strong uncertainty avoidance. The construction professionals are found to be collectivists and feminine. Therefore, this culture mix does not challenge the status quo. Thus, there is no room for new procurement methods to be experimented in the Sri Lankan construction industry. As a result, the Measure and Pay became institutionalized and never being challenged.

However, economic growth has favored some of the alternative methods to emerge in Sri Lanka. Design and Build is one such method, which became popular mainly due to the industrial growth of the country. Industrial buildings were mainly procured using Design and Build method. Joint venture arrangements became popular due to the involvement of international Contractors in Sri Lanka.

With respect to the future procurement trend, there is a clear sign of increase in the use of Design and Build. With a larger role for private sector in infrastructure provision and increased foreign involvement, systems such as Joint Venture and Concession Contracts (BOT, BOO, BOOT) will become popular in the future. Construction companies will seek collaboration to provide entire project services with horizontal integration, strategic alliances, joint ventures or consortia to combine strength to become single problem solver to the client.

CHAPTER FIVE

Factors Affecting the Selection of Procurement Systems

5. FACTORS AFFECTING THE SELECTION OF PROCUREMENT SYSTEMS

5.1. Introduction

Different procurement systems are used for different projects and the correct choice may help to avoid problems and be the key to the attainment of project specific goals. The wrong choice of procurement method may in turn lead to time, cost overruns and leads to a general dissatisfaction of the client. The selection process has become increasingly complex, mainly as a result of the continuing proliferation of alternative methods for procuring building projects, their ever increasing technical complexity and clients' continuing desire for speedy commencement and completion, all of which has led to the demand more sophisticated methods of selection being devised (Masterman and Gameson, 1997). In addition, due to fragmented and complex nature of construction projects, there is no one-way of dealing with procurement, as often they are different in scale, complexity and nature. Ashworth (1988) suggests that 'the correct choice of procurement arrangements is now complex owing to the wide variety of options and procedures that are available in the response to;

- Changes in the method of working, particularly subcontracting
- Changes in construction techniques
- Changes within the roles of participants
- Change in contractual procedures

Clients' requirements will ultimately be influenced by the context in which they operate and this implies that the selection of procurement system may also be governed by the predominant environment. The external environment is a structure of several other systems such as economics, politics, finance, legal, technology, etc. The selection process is an open system, which receives information from its environment, transforms and returns as an output to the environment (Mcdomott and Rowlinson, 1999). From the synthesis of the outcome of past studies, overall factors affecting the procurement selection can be grouped under three main criteria. This study has focused on the macro level factors from both environments, which influences the performance of procurement system.

They include:

1. Internal Environment
2. External Environment

The Figure 5.1 portrays the conceptual framework developed based on the project's environments which determine the selection criteria.

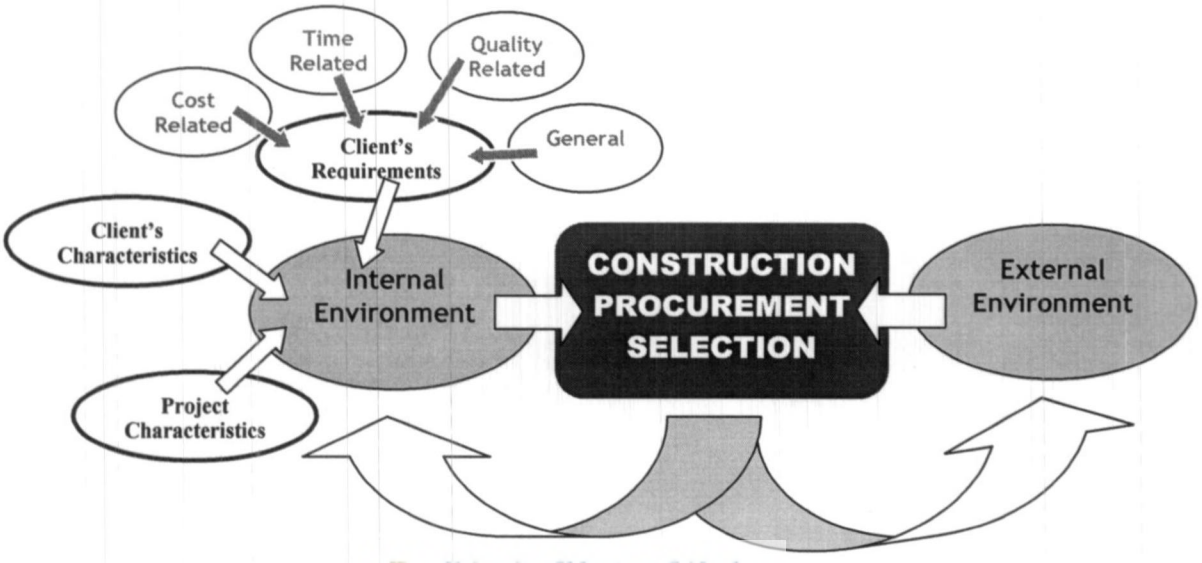

Figure 5-1: Conceptual framework for the determination of selection criteria.

In dealing which procurement system to apply, there is a need to take into consideration various factors from the project's internal and external environment in which the industry operates. A variety of factors has to be taken into account before any practical decisions can be made. Therefore, identification and analysis of significant factors affecting the procurements selection is critical for clients and independent advisors who involve in the project procurement selection. The following section discusses the results of Delphi survey used to identify and analyze the macro level factors affecting the selection of procurement system in the Sri Lankan construction industry.

5.2. Data Analysis Techniques

Data analysis involves reducing accumulated data to allow summarizing, comparing, syntheses and applying statistical techniques in order to interpret relation of results to the researched problems (Kumar, 1996; Leedy, 1997).

The techniques used to analyze the data derived from each round include the followings;

1. Mean Weighted Rating
2. Severity Index
3. Coefficient of Variation (COV)
4. Factor Analysis
5. Concordance Coefficient (W)

In addition to the above techniques, Special Package for Standard Statistical (SPSS) and MS Excel software packages were used as tools in data analysis. SPSS facilitates statistical data analysis including descriptive statistics as plots, frequencies, charts, and lists as well as sophisticated inferential and multivariate statistical procedures like analysis of variance, factor, cluster, and categorical data analysis. Being user friendly, MS Excel assisted in plotting charts. The following section briefly defines each technique and justifies the selection of each technique particularly for this study.

5.2.1 Mean Weighted Rating

Mean Weighted Rating = ($\sum$ i Vi *Fi) / n

Where,

Vi - Rating of each Factor

Fi - Frequency of Responses

n - Total number of responses

Since ratings range between 1 and 3, point 2 is considered as the neutral point.

A mean weighted rating for each factor was computed to get an indication of the importance of each factor for the Delphi round two.

5.2.2 Severity Index

$S.I. = (\sum Wi * Fi) * 100\% / n$

Where,

i - Represent Ratings

Fi - Frequency of Responses

n - Total number of responses

Wi - Weight for each factor

The severity index calculation was used to rank the factors according to their importance on procurement system selection.

5.2.3 Coefficient of Variation (COV)

Coefficient of Variation (COV) expresses the standard deviation as a percentage of the mean and it is useful to compare relative variability of different responses. COV is defined as follows by the formula;

$COV = (S / \overline{X}) * 100\%$

Where,

COV - Coefficient of Variation

S - Standard Deviation

X - Weighted Mean of Sample

Coefficients of Variation were computed to compare the relative importance of each factor against various procurement systems.

5.2.4 Factor Analysis

Factor analysis is a data reduction technique that is 'used to discover patterns among the variations in values of several variables (Nkado, 1999). This is done essentially through the

generation of artificial dimensions (factors) that correlate highly with several of the real variables and that are independent of one another' (Babbie, 1998 p418).

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 to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables.

A typical factor analysis suggests answers to four major questions:

1. How many different factors are needed to explain the pattern of relationships among these variables?
2. What is the nature of those factors?
3. How well do the hypothesized factors explain the observed data?
4. How much purely random or unique variance does each observed variable include?

5.2.4.1 Steps of Factor Analysis

Step One: The first step in factor analysis is to estimate the factor loadings. In Principal component factor analysis, which is used to find the first few principle components as un-rotated factors, the cut off criterion to select principal components is usually eigenvalues > 1. Sometimes, Scree plot is used to determine a natural break instead of mechanically using the unity criterion (Tan, 2002, p.327).

Step Two: The second step is to rotate the factor loadings so that factors are easier to interpret. The rotational may be orthogonal or oblique. Orthogonal rotation is frequently used as it ensures factors are independent but it is more desirable to rotate factor loadings such that they are close to 0 to 1 to facilitate interpretation. Varimax rotation contains this feature (Tan, 2002, P327-328).

Step Three: The last step in factor analysis is to compute the factor scores (Tan, 2002, P329). This is not always carried out because factor scores are not always computed particularly if the study focused on relative factors rather than individuals.

5.2.4.2 Factor loading matrix

The points of the previous section apply when the predictor variables are factors. Think of the *m* factors F as a set of independent or predictor variables, and think of the *p* observed variables X as a set of dependent or criterion variables. Consider a set of *p* multiple regressions, each predicting one of the variables from all *m* factors. The standardized coefficients in this set of regressions form a *p* x *m* matrix called the *factor-loading matrix*.

5.2.4.3 Rotation

Rotation is the step in factor analysis that allows you to identify meaningful factor names or descriptions like these. A rotation that requires the factors to remain uncorrelated is an *orthogonal* rotation, while others are *oblique* rotations. Oblique rotations often achieve greater simple structure; though at the cost that you must also consider the matrix of factor inter correlations when interpreting results. Manuals are generally clear which is which, but if there is ever any vagueness, a simple rule is that if there is any ability to print out a matrix of factor correlations, then the rotation is oblique, since no such capacity is needed for orthogonal rotations (Darlington, 1973, p.9).

5.2.4.4 Principal Component Analysis (PCA)

The central concept in PCA is representation or summarization. Suppose we want to replace a large set of variables by a smaller set, which best summarizes the larger set. Define each component's *eigenvector* or *characteristic vector* or *latent vector* as the column of weights used to form it from the X-variables. If the original matrix R is a correlation matrix, define each component's *eigenvalue* or *characteristic value* or *latent value* as its sum of squared correlations with the X-variables. If R is a covariance matrix, define the eigenvalue as a weighted sum of squared correlations, with each correlation weighted by the variance of the corresponding X-variable. The sum of the eigenvalues always equals the sum of the diagonal entries in R.

Each component's eigenvalue is called the "amount of variance" the component explains. The major reason for this is the eigenvalue's definition as a weighted sum of squared correlations. However, it also turns out that the actual variance of the component scores equals the eigenvalue (Darlington, 1973, p.12).

Eigenvalue - Based Rules for Selecting the Number of Factors

Henry Kaiser suggested a rule for selecting a number of factors *m* less than the number needed for perfect reconstruction: set *m* equal to the number of eigenvalues greater than 1. This rule is often used in common factor analysis as well as in PCA. Raymond B. Cattell suggested an alternative method called the scree test. In this method, you plot the successive eigenvalues, and look for a spot in the plot where the plot abruptly levels out. Cattell named this test after the tapering "scree" or rockpile at the bottom of a landslide. One difficulty with the scree test is that it can lead to very different conclusions if you plot the square. Another approach is very similar to the scree test, but relies more on calculation and less on graphs. For each eigenvalue L, define S as the sum of all later eigenvalues plus L itself. Then L/S is the proportion of previously unexplained variance explained by L (Darlington, 1973, p.19).

5.2.4.5 Output

The basic output of FACTOR consists of four tables:

1. Eigenvalues
2. Factor loading matrix (called factor pattern for IPA)
3. Variance explained by factors (usually equal to eigenvalues)
4. Proportion of variance explained by factors
    - Rotated factor loadings
    - Variance explained by rotated factors
    - Proportion of variance explained by rotated factors
    - Initial communality estimates
    - An index of changes in communality estimates
    - Final communality estimates
    - Input correlation or covariance matrix R
    - Matrix of residual covariance -the off-diagonal part of U
    - A scree plot
    - Plots of factor loadings, two factors at a time (Darlington, 1973, p.19)

In this study, Factor analysis was applied to the ratings of the importance of the number of factors identified form round two questionnaires. The factor analysis was carried out on the re-scaled data. It was mainly performed to draw out the underlying relationships among the important factors determined from round two and to reduce the selection factors into a small number of components. An emphasis in factor analysis is parsimony, *i.e.* the fewest meaningful number of factors. Too many factors will lead to difficulty in the interpretation of results and too few factors may result in important factors being missed.

5.2.5 Concordance Coefficient (W)

Kandall's coefficient of concordance (W) is a measure of the agreement among several (p) judges who are assessing a given set of *n* objectives.

$$W = \frac{12\,S}{P^2(n^3-n) - p\,T}$$

S – Sum of squares statistic over the row sums of ranks R_i .R is the mean of the R_i values.

$$S = \sum_{i=1}^{n} (R_i - \bar{R})^2$$

n – Number of objectives *P – Number of judges* *T – Correlation factor for tied*

t_k *– number of tied ranks in each (k) of m groups of ties*

Kendall's coefficient of concordance and associated p-value were calculated to indicate the overall level of concordance. Kendall's coefficient ranges in value from 0 to 1, where 0 means that there is no agreement and 1 means that there is a complete agreement. The p-value is the probability that there is no agreement, given that conclusion has been reached that there is concordance. Therefore, for this study, the p-value provided a means of informing the Delphi director of the probability of error when assessing the degree of concordance between the experts (Outhred, 2001, p.8).

5.3. Results and Analysis

This section discusses the results of four round of Delphi survey in detail.

5.3.1 Results of Delphi Round One

At this round, the respondents agreed with most of the factors included in the questionnaire and provided some additional factors based on Sri Lankan context. Factors, which carried similar meanings were combined together and rephrased. Further, these identified factors were classified under relevant categories in terms of their environment. Environment, by which the project is influenced, was divided into two: Internal Environment and External Environment. Criteria were considered based on Client's requirements, Project characteristics and External environment. Criteria for client requirements were further categorized as cost, time, quality and general. Table 5.1 presents the results of round one.

Altogether, 35 clients' requirements, 13 project characteristics and 19 external environmental factors were identified. All these factors were included in the questionnaire designed for round two.

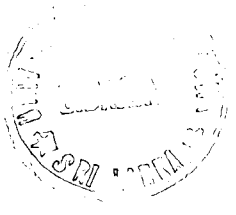

Table 5.1 : Macro level factors affecting the selection of construction procurement system

SELECTION CRITERIA	
CLIENTS' REQUIREMENTS	**PROJECT CHARACTERISTICS**
Cost Related Factors • Capital cost • Maintenance cost • Prequalification and tendering cost • Financial risk • Price competition • Completion within the budget **Time Related Factors** • Planning and designing time • Tendering and evaluation time • Construction time • The early start of the project • Speed of construction • Time overruns • Quick response to clients new requirements (extra work and variations) • Maximizing of activities interfacing • Stage completion **Quality Related Factors** • Design reliability • Aesthetic appearance of the building • Workmanship • Functionality (suitability for the intended users) • Design innovation **General Needs** • Allocation of responsibility • Professional team performance • Parties involvement • Accountability • Transparency • Safety requirements • Corporation and motivation • Existing building operation • Familiarity (Client's awareness of construction procurement system) • Tender evaluation criteria • Clear express of end user's requirements • Flexibility • Consultants' attitude towards clients • Types of client	• Project type • Project size • Project cost • Degree of flexibility • Degree of complexity • Time constrains • Payment method • Integration of design and construction • Project funding method • Project site location • Site risk factors • Construction method • Degree of innovative technology involvement
	EXTERNAL ENVIRONMENT
	• Market competitiveness • Government as a policy maker • Government as a major client • Regulatory feasibility • Technological feasibility • Source of finance for the project • Experienced contractor availability • Education of builders • Economic condition of the country • Availability of material • Information Technology • Influence of Intuitional bodies • Natural disaster • Industrial actions • Socio cultural differences • Goodwill of the contractor • Environmental issues • Civil war condition • Objections from neighbours / public

5.3.2 Results of Delphi round two

There were 35 questionnaires distributed among the experts and only 31 questionnaires were received. The results from round two were subjected to several analyses which are included under main two steps as follows;

Step 01 – Identification of Significant Factors

- A mean weighted rating for each factor was computed to derive an indication of the importance of each factor.
- The severity index was calculated to rank the factors based on their significance on procurement selection.
- Coefficient of Variation (COV) expresses the standard deviation as a percentage of the mean and it was useful to compare the relative variability of different responses.

The following section discusses the results of the analysis of step one in terms of Client's requirements, Project characteristics and External Environment.

Clients' Requirements

Table 5.2 presents the results of step one for Client requirements. Out of 34 factors, 25 were assigned by mean ratings of higher than the neutral point 2, and each of them maintained a Severity Index, which ranges between 65% - 95%. Remaining 9 factors gained mean rating of less than 2 and 8 out of 9 gained the Severity Index, which ranges between 45% - 65%. This indicates that these 25 factors significantly affect the selection of procurement system in terms of Clients' requirements (Refer Annexure 5.1 for the overall results of round two).

Table 5.2: Ranking of significant factors in terms of Clients' Requirements

	Clients' Requirements	Severity Index	Mean	Rank	SD	COV	COV %
	Cost Requirements						
1	Capital Cost	83.33%	2.50	10	0.682	0.273	27.29%
2	Maintenance Cost	66.67%	2.00	25	0.743	0.371	37.14%
3	**Prequalification and tendering cost**	**63.33%**	**1.90**	**27**	**0.662**	**0.348**	**34.83%**
4	Financial Risk	86.67%	2.60	6	0.621	0.239	23.90%
5	Price competition	81.11%	2.43	14	0.568	0.234	23.36%
6	Completion within the budget	91.11%	2.73	1	0.521	0.191	19.05%
	Time Requirements						
7	Planning and designing time	86.67%	2.60	6	0.498	0.192	19.16%
8	Tendering and evaluation time	82.22%	2.47	12	0.507	0.206	20.57%
9	Construction time	88.89%	2.67	2	0.479	0.180	17.98%
10	The early start of project	87.78%	2.63	3	0.728	0.276	27.64%
11	Speed of construction	80.00%	2.40	15	0.498	0.208	20.76%
12	Time overruns	83.33%	2.50	10	0.626	0.250	25.04%
13	Quick responses to the clients' new requirements (Extra works and variations)	84.44%	2.53	9	0.571	0.226	22.55%
14	Maximizing of activities interfacing	71.11%	2.13	23	0.556	0.261	26.07%
15	**Stage completion**	**60.00%**	**1.80**	**32**	**0.664**	**0.369**	**36.91%**
	Quality Requirements						
16	Design reliability	87.78%	2.63	3	0.490	0.186	18.61%
17	**Aesthetic appearance**	**63.33%**	**1.90**	**27**	**0.759**	**0.399**	**39.94%**
18	Workmanship	72.22%	2.17	21	0.648	0.299	29.89%
19	Functionality (Suitability for the intended users)	73.33%	2.20	19	0.714	0.325	32.47%
20	Design innovation	76.67%	2.30	16	0.651	0.283	28.32%
	General Requirements						
21	Allocation of responsibilities	82.22%	2.47	12	0.571	0.232	23.16%
22	Professional team performances	86.67%	2.60	6	0.498	0.192	19.16%
23	Parties involvement	87.78%	2.63	3	0.556	0.211	21.12%
24	Accountability	76.67%	2.30	16	0.535	0.233	23.26%
25	Transparency	74.44%	2.23	18	0.504	0.226	22.57%

Table 5.2 : Ranking of significant factors in terms of Clients' Requirements (Continued)

	Clients' Requirements	Severity Index	Mean	Rank	SD	COV	COV %
	General Requirements Continued						
26	**Safety requirements**	**62.22%**	**1.87**	**29**	**0.681**	**0.365**	**36.51%**
27	**Corporation and motivation**	**62.22%**	**1.87**	**29**	**0.681**	**0.365**	**36.51%**
28	**Existing building operation**	**48.89%**	**1.47**	**34**	**0.629**	**0.429**	**42.87%**
29	Familiarity	67.78%	2.03	24	0.643	0.316	31.64%
30	**Tender evaluation criteria**	**65.56%**	**1.97**	**26**	**0.765**	**0.389**	**38.89%**
31	Clear expression of end user's requirements	73.33%	2.20	19	0.761	0.346	34.60%
32	Flexibility	72.22%	2.17	21	0.592	0.273	27.33%
33	**Consultant attitude towards the client**	**56.67%**	**1.70**	**33**	**0.794**	**0.467**	**46.73%**
34	**Type of clients**	**62.22%**	**1.87**	**29**	**0.681**	**0.365**	**36.51%**
SD - Standard Deviation, COV – Coefficient of Variation							

Further, analysis of COV indicates that coefficient of variation for the response on factors is relatively low. This is a good indication to prove the relative strong agreement among respondents. All 25 factors identified have coefficient of variations, which range between 15% - 40%. Relatively, higher coefficients of variations, range between 30% - 50%, were computed for remaining 9 factors.

Project Characteristics

Out of 13, 11 were assigned mean ratings of higher than the neutral point 2, and each of them maintained a Severity Index, which ranges between 65% - 95 %. Remaining 2 factors gained mean rating of less than 2 and Severity Index, which ranges between 50% - 65%. This indicates that the 11 factors significantly affect the selection of procurement system in terms of project characteristics. Table 5.3 presents the results of step one for Project characteristics.

Table 5.3: Ranking of Significant Factors in terms of Project Characteristics

	Project Characteristics	Severity Index	Mean	Rank	SD	COV	COV %
1	Project type	81.11%	2.43	4	0.626	0.2572	25.73%
2	Project size	75.56%	2.27	7	0.691	0.3050	30.51%
3	Project cost	84.44%	2.53	3	0.629	0.2482	24.82%
4	Degree of flexibility	77.78%	2.33	6	0.547	0.2342	23.43%
5	Degree of complexity	85.56%	2.57	1	0.504	0.1963	19.64%
6	Time constraints	85.56%	2.57	1	0.568	0.2214	22.14%
7	Payment method of the project	81.11%	2.43	4	0.626	0.2572	25.73%
8	Integration of Design and Construction of the project	74.44%	2.23	9	0.679	0.3039	30.40%
9	Project funding method	70.00%	2.10	10	0.712	0.3390	33.90%
10	**Project site location**	**53.33%**	**1.60**	**13**	**0.675**	**0.4216**	**42.17%**
11	**Site risk factors**	**64.44%**	**1.93**	**12**	**0.691**	**0.3576**	**35.77%**
12	Construction method	75.56%	2.27	7	0.521	0.2297	22.98%
13	Degree of innovative technology involvement	70.00%	2.10	10	0.607	0.2892	28.93%
SD - Standard Deviation, COV – Coefficient of Variation							

From the results, it is clear that variation in responses on factors affecting procurement selection under project characteristics is relatively low as indicated by the coefficient of variation. This is a good indication to reflect the high level of agreement among respondents. All 11 factors identified have coefficient of variations ranging between 15% - 35%. Relatively, higher coefficients of variations, ranging between 35% - 45%, were computed for remaining 2 factors.

External Environment

With respect to the factors related to External environment, out of 21, 14 were assigned mean ratings of higher than the neutral point 2, and each of them maintained a Severity Index, which is more than 65%. Among the remaining 7 factors, 5 factors gained mean value less than 2 and Severity Index, which ranges between 50% - 65%. This indicates that the 14 factors significantly affect the selection of procurement system from external environment. Other than the

Information Technology and Regulatory feasibility, remaining 12 factors show lower level of variation among respondents. Table 5.4 reveals the analysis of step one for External environment.

Table 5.4: Ranking of Significant Factors from External Environment

	External Environment	Severity Index	Mean	Rank	SD	COV	COV %
1	Market competitiveness	76.67	2.30	3	0.868	0.3775	37.75
2	Technological feasibility	73.33	2.20	5	0.876	0.3983	39.83
3	Regulatory feasibility	66.67	2.00	9	1.095	0.5477	54.77
4	Availability of experienced Contractor	78.89	2.37	1	0.930	0.3929	39.29
5	Education of Contractors	72.22	2.17	6	0.785	0.3622	36.22
6	Availability of materials at site	66.67	2.00	9	1.033	0.5164	51.64%
7	**Material availability : Scarcity of natural material**	**55.56**	**1.67**	**17**	**0.911**	**0.5465**	**54.65**
8	**Weather & Natural Disaster**	**47.78**	**1.43**	**21**	**1.006**	**0.7016**	**70.16**
9	Cultural differences	66.67	2.00	9	1.155	0.5774	57.74
10	Government as a policy maker	66.67	2.00	9	0.966	0.4830	48.30
11	Government as a major Client	70.00	2.10	8	0.928	0.4419	44.19
12	Finance for the project : Donors	77.78	2.33	2	0.974	0.4173	41.73
13	Finance for the project : Aids	75.56	2.27	4	0.962	0.4245	42.45
14	Economic condition of the country	72.22	2.17	6	1.030	0.4752	47.52
15	Information Technology	66.67	2.00	9	1.033	0.5164	51.64%
16	**Institutional Bodies**	**54.44**	**1.63**	**18**	**0.826**	**0.5055**	**50.55**
17	**Industrial actions**	**58.89**	**1.77**	**16**	**1.099**	**0.6219**	**62.19**
18	**Objections from Neighbors / Public**	**48.89**	**1.47**	**20**	**0.997**	**0.6801**	**68.01**
19	**Civil war condition**	**53.33**	**1.60**	**19**	**1.127**	**0.7042**	**70.42**
20	Environmental issues	66.67	2.00	9	0.966	0.4830	48.30
21	**Good will of the Contractor**	**63.33**	**1.90**	**15**	**0.989**	**0.5208**	**52.08**
SD - Standard Deviation, COV – Coefficient of Variation							

Step 02 – Factors Analysis

Unimportant factors identified from step one analysis were ignored and only the significant factors were considered as eligible factors for factor analysis. In addition, the following tests were carried out to remove the factors which have low level of significance among the resulted factors from step one analysis.

(a) ***Bartlett test of Sphericity*** was carried out with the associated significance level in order to find out the significant correlation between the factors

(b) ***Kaiser-Meyer-Olkin Measure*** was carried out to test the adequacy of sampling (suitability of data).

The results of tests are summarised in the Table 5.5

Table 5.5: Results

Criteria	Client Requirements	Project Characteristics	External Environment
Bartlett's test of Sphericity	357.480	69.400	170.605
Significance Level	0.013	0.041	0.000
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.320	0.377	0.569

The results confirms that the associated significance level for factors related to External environment is comparatively very low and for factors related to client requirements & project characteristics are also low. This indicates that there were significant correlations between the factors. Further, Kaiser-Meyer-Olkin Measure of Sampling Adequacy shows the satisfactory sampling adequacy and it conforms that the inputs selected for the factor analysis are in an appropriate sample.

Factor analysis was performed to elicit the underlying relationships among the eligible factors affecting the procurement selection and to reduce the factors in to a small number of components (Luu *et al.* 2003, p212). The factors analysis was carried out using SPSS package. The first stage of factor analysis was to determine the strength of relationship amongst the factors affecting the procurement selection based on their Correlation Coefficients (Refer Annexure 5.2, 5.3 and 5.4 for the Correlation Coefficients matrix of the factors related to Clients' requirements, Project characteristics and External Environment respectively).

Based on the principle component method, the factor solutions with eigenvalues greater than 1 were produced. Varimax orthogonal rotation was employed to transform the factor matrix produced by un-rotated principle component matrix into one that is easier to interpret.

Clients' Requirements

The Table 5.6 and the Scree plot (Figure 5.2) illustrates that the nine factors has already explained 77.304 percent of the variance.

Table 5.6: Total Variance Explained in Factor Analysis – Clients' Requirements

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.474	17.897	17.897	4.474	17.897	17.897	2.880	11.518	11.518
2	3.600	14.401	32.298	3.600	14.401	32.298	2.536	10.146	21.664
3	2.413	9.652	41.951	2.413	9.652	41.951	2.247	8.988	30.652
4	2.049	8.198	50.148	2.049	8.198	50.148	2.215	8.860	39.512
5	1.608	6.433	56.581	1.608	6.433	56.581	2.103	8.414	47.926
6	1.484	5.937	62.518	1.484	5.937	62.518	1.973	7.890	55.816
7	1.370	5.479	67.997	1.370	5.479	67.997	1.860	7.438	63.254
8	1.244	4.976	72.973	1.244	4.976	72.973	1.787	7.150	70.404
9	1.083	4.331	77.304	1.083	4.331	77.304	1.725	6.899	77.304
Extraction Method: Principal Component Analysis.									

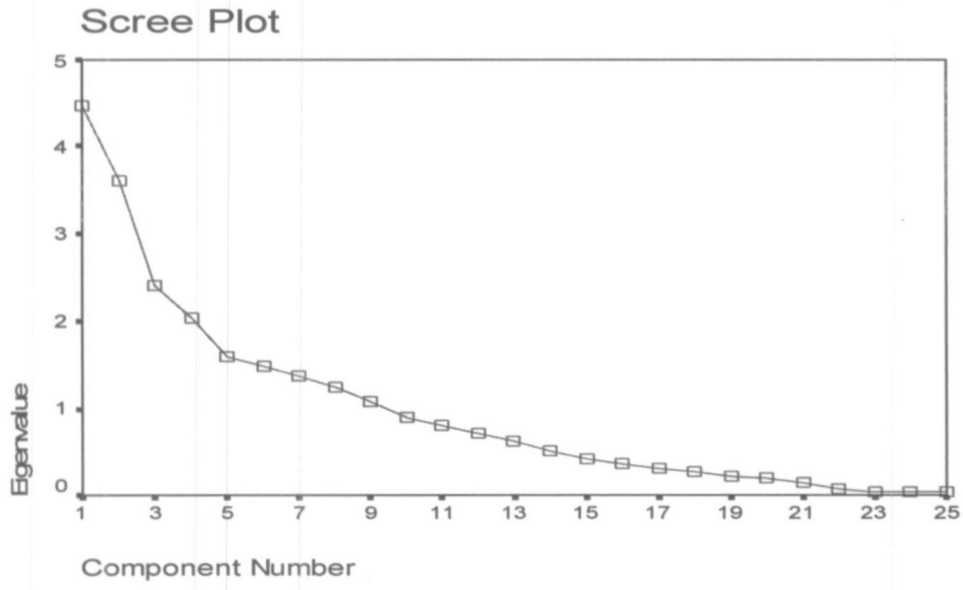

Figure 5-2: Scree Plot of the nine factors resulting from factor analysis– Clients' Requirements

Table 5.7: Rotated Component Matrix – Clients' Requirements

Factor	Component								
	1	2	3	4	5	6	7	8	9
Cost Requirements									
Capital cost	0.029	(0.114)	0.742	(0.334)	0.111	(0.105)	(0.115)	0.266	0.203
Maintenance cost	(0.065)	(0.162)	0.268	(0.774)	(0.121)	0.066	0.094	0.220	(0.012)
Financial Risk	0.848	0.071	0.123	0.034	0.054	(0.000)	0.095	(0.046)	(0.166)
Price competition	(0.072)	0.250	0.489	0.582	(0.205)	(0.118)	0.264	0.282	0.013
Completion within the budget	0.241	0.187	0.824	0.055	(0.141)	0.024	0.077	0.025	0.086
Time Requirements									
Planning and designing time	0.245	0.534	0.492	(0.081)	(0.114)	0.227	0.345	(0.181)	0.028
Tendering and evaluation time	0.220	0.344	(0.245)	0.042	(0.592)	0.122	0.058	(0.056)	0.193
Construction time	(0.097)	0.744	(0.097)	(0.113)	0.436	(0.218)	(0.053)	(0.034)	0.352
The Early start of project	(0.082)	0.774	(0.037)	(0.363)	(0.146)	(0.094)	(0.050)	0.254	(0.115)
Speed of construction	0.193	0.732	(0.089)	0.235	0.112	0.159	(0.026)	0.031	(0.009)
Time overruns	0.123	0.746	0.254	(0.282)	(0.048)	0.015	(0.062)	0.111	0.041

Table 5.7 : Rotated Component Matrix – Clients' Requirements (Continued)

Factor	Component								
	1	2	3	4	5	6	7	8	9
Time Requirements (Continued)									
Quick responses to the clients new requirements (Extra works and variations)	0.090	0.195	(0.019)	0.069	(0.108)	0.175	(0.260)	0.814	(0.152)
Maximizing of activities interfacing	0.377	0.492	(0.232)	(0.059)	(0.035)	0.064	0.505	0.146	0.105
Quality Requirements									
Design Reliability	0.345	0.153	0.158	(0.088)	0.206	0.747	(0.141)	0.069	0.054
Workmanship	(0.267)	0.251	0.484	(0.021)	0.179	0.557	(0.162)	0.408	0.200
functionality	(0.006)	(0.003)	(0.027)	0.013	0.174	0.688	0.440	0.288	0.157
Design innovation	0.318	0.136	(0.040)	0.173	0.057	0.536	0.016	(0.084)	(0.578)
General Requirements									
Allocation of responsibilities	0.394	0.010	(0.157)	0.426	(0.271)	(0.257)	(0.136)	0.072	0.534
Professional team performances	0.140	0.051	0.164	(0.027)	0.099	0.764	0.151	(0.168)	(0.023)
Parties involvement	0.000	0.104	0.236	(0.096)	0.205	0.209	0.091	(0.059)	0.845
Accountability	0.372	0.035	0.168	(0.055)	0.725	0.268	0.272	0.048	0.010
Transparency	(0.258)	(0.259)	0.403	0.310	0.474	0.285	0.185	(0.053)	0.164
Familiarity	(0.112)	0.040	(0.060)	0.061	(0.123)	0.214	0.660	(0.866)	0.026
Clear expression of end user's requirements	0.669	0.194	0.285	(0.377)	0.118	0.218	0.206	0.057	0.086
Flexibility	(0.116)	0.057	0.061	(0.152)	(0.185)	0.305	(0.027)	0.850	0.009
Extraction Method: Principal Component Analysis. **Rotation Method**: Varimax with Kaiser Normalization.									
a. Rotation converged in 21 iterations.									

Maintenance cost, Tendering & evaluation time and Transparency recorded the values lesser than 0.5 (Refer Table 4.4), hence they were removed from the factor categories. The extracted nine factor categories were grouped using Varimax orthogonal rotation. The Table 5.8 shows the key factors and associated variables based on varimax orthogonal rotation.

Table 5.8: Factor analysis grouping using varimax orthogonal rotation - Client Requirements

No	Factor	Associated Variables
1	Risk Management	• Financial risk • Clear expression of end user's requirement
2	Time availability and predictability	• Planning and designing time • Construction time • Time overruns • Speed of construction • The early start of project
3	Price certainty	• Capital cost • Completion within the budget
4	Price Competition	• Price competition
5	Accountability	• Accountability
6	Quality of work	• Design reliability • Workmanship • Functionality • Design innovation • Professional team performance
7	Familiarity	• Familiarity • Maximizing of activities interfacing
8	Flexibility for changes	• Quick responses to the client's new requirements • Flexibility to design changes
9	Responsibility and Party's involvement	• Allocation of responsibilities • Party's involvement

Project Characteristics

The Table 5.9 and the Scree plot (Figure 5.3) illustrates that the six factors has already explained 81.524 percent of the variance.

Table 5.9: Total Variance Explained in Factor Analysis – Project Characteristics

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.460	22.361	22.361	2.460	22.361	22.361	1.713	15.568	15.568
2	1.693	15.389	37.750	1.693	15.389	37.750	1.664	15.126	30.695
3	1.468	13.347	51.097	1.468	13.347	51.097	1.607	14.608	45.303
4	1.214	11.040	62.137	1.214	11.040	62.137	1.371	12.466	57.769
5	1.076	9.785	71.922	1.076	9.785	71.922	1.361	12.377	70.146
6	1.056	9.602	81.524	1.056	9.602	81.524	1.252	11.378	81.524

Extraction Method: Principal Component Analysis.

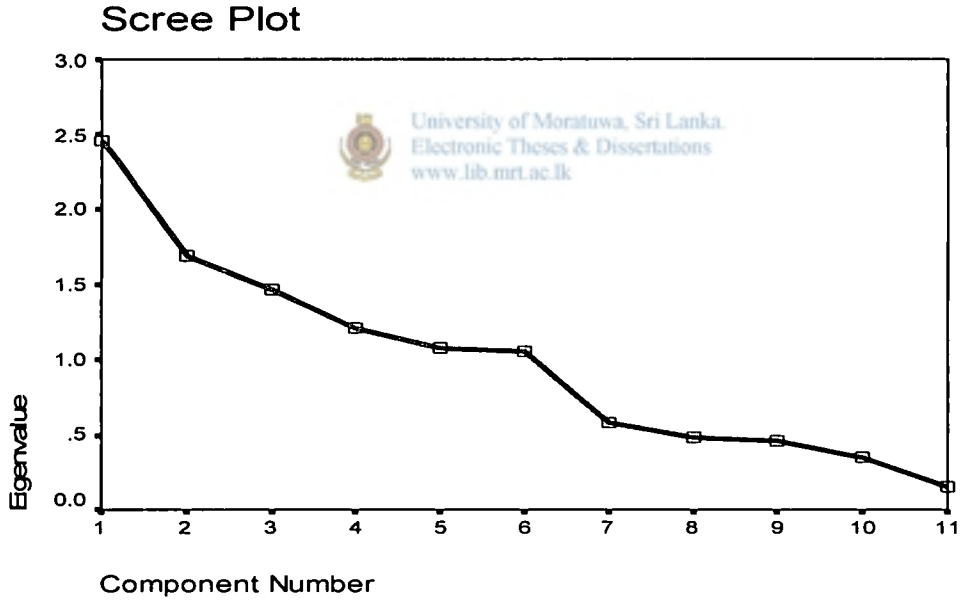

Figure 5-3: Scree Plot of the six factors resulting from factor analysis – Project Characteristics

Table 5.10: Rotated Component Matrix – Project Characteristics

Factor	Component					
	1	2	3	4	5	6
Project Type	(0.020)	0.143	0.506	(0.762)	0.046	0.135
Project Size	(0.320)	0.820	0.072	(0.025)	(0.151)	(0.318)
Project Cost	0.771	0.371	0.023	(0.120)	0.043	0.139
Degree of Flexibility	(0.078)	0.357	0.353	0.025	0.899	(0.609)
Degree of Complexity	(0.129)	0.859	0.030	0.089	0.104	(0.041)
Time Constraints	(0.102)	0.112	0.303	0.847	0.077	0.045
Payment Method of the project	(0.147)	0.198	0.152	(0.054)	0.250	0.833
Integration of Design and Construction of the project	0.107	0.122	0.107	0.044	0.900	0.115
Project Funding Method	0.859	0.126	0.019	(0.072)	0.296	0.153
Construction Method	0.372	0.302	0.695	0.186	(0.345)	0.090
Degree of Innovative Technology Involvement	(0.032)	(0.090)	0.838	(0.063)	0.283	(0.024)
Extraction Method: Principal Component Analysis. **Rotation Method**: Varimax with Kaiser Normalization.						
a. Rotation converged in 8 iterations.						

The extracted six factor categories were grouped using Varimax orthogonal rotation. Factor Analysis revealed six factor categories which include Project cost & method of funding, Project complexity, Time constraints, Degree of flexibility and Payment modality. The Table 5.11 shows the key factors and associated variables based on varimax orthogonal rotation.

Table 5.11: Factor analysis grouping using varimax orthogonal rotation -Project Characteristics

No	Factor	Associated Variables
1	Project cost & Method of funding	• Project cost • Funding method
2	Project Complexity	• Project size • Degree of complexity
3	Project type	• Project type • Construction method • Degree of involvement in innovative technology
4	Time constraints	• Time constraints
5	Degree of Flexibility	• Degree of flexibility • Integration of design and construction
6	Payment modality	• Payment modality

External Environment

Five factor solutions with Eigenvalues greater than 1 were produced. The Table 5.12 and Figure 5.4 of Scree Plot depicts that the five factors have already explained 77.491 % of the variance. This indicates that the first 5 factors out of total can explain the 77.49 % of the total factors.

Table 5.12: Total Variance Explained in Factor Analysis – External Environment

Component	Initial Eigenvalues		Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings			
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.063	29.019	29.019	4.063	29.019	29.019	2.953	21.089	21.089
2	2.937	20.978	49.997	2.937	20.978	49.997	2.412	17.225	38.315
3	1.574	11.244	61.241	1.574	11.244	61.241	2.092	14.944	53.259
4	1.237	8.833	70.075	1.237	8.833	70.075	1.830	13.075	66.334
5	1.038	7.417	77.491	1.038	7.417	77.491	1.562	11.158	77.491

Extraction Method: Principal Component Analysis.

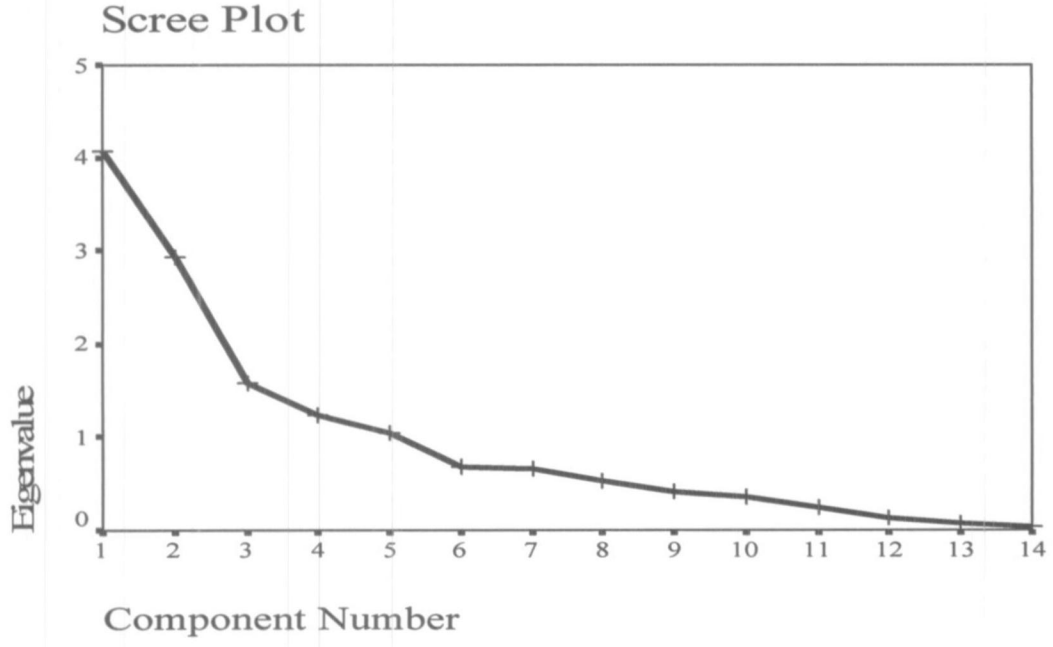

Figure 5-4: Scree Plot of the five factors resulting from factor analysis – External Environment

Table 5.13 : Rotated Component Matrix – External Environment

Factor	Component				
	1	2	3	4	5
Market Competitiveness	0.288	**0.529**	(0.469)	(0.320)	(0.002)
Technological Feasibility	0.301	0.250	0.237	**0.509**	(0.603)
Regulatory Feasibility	(0.160)	0.353	(0.152)	(0.102)	0.681
Availability of experienced Contractor	0.243	**0.650**	(0.267)	0.527	0.201
Education of Contractors	(0.149)	(0.098)	0.847	0.232	(0.148)
Availability of Material at site	0.153	**0.506**	(0.524)	(0.304)	0.129
Cultural Differences	0.185	0.374	**0.545**	(0.599)	0.136
Political Constraints : Government as a policy maker	**0.537**	(0.577)	0.120	0.162	0.334
Poetical Constraints : Government as a major Client	**0.761**	(0.398)	(0.008)	0.280	0.276
Finance for the project Donors	**0.849**	(0.291)	(0.092)	0.076	(0.268)
Finance for the project Aid	**0.856**	(0.140)	(0.140)	0.097	(0.281)
Economic Condition of the country	**0.666**	0.054	0.560	(0.026)	0.257
Information Technology	(0.258)	0.494	0.281	**0.563**	0.076
Environmental Issues	0.057	0.114	**0.680**	0.313	0.377
Extraction Method: Principal Component Analysis. **Rotation Method**: Varimax with Kaiser Normalization.					
a. Rotation converged in 13 iterations.					

The extracted five factor categories were grouped using Varimax orthogonal rotation. Factor analysis revealed five main groups of factors which include Market Condition, Economic condition & the fiscal policy, Technology, Socio Cultural suitability, and Regulatory Environment. The Table 5.14 shows the key factors and associated variables based on varimax orthogonal rotation.

Table 5.14: Factor analysis grouping using varimax orthogonal rotation -External Environment

No	Factor	Associated Variables
1	Market condition	• Market Competitiveness • Availability of experienced Contractors • Availability of Material
2	Economic condition and fiscal policy	• Economic condition of the country • Source of finance: Donor/Aid • Government as a policy maker • Government as a major client
3	Technology	• Technological feasibility • Information Technology
4	Socio Cultural suitability	• Cultural differences • Education of Contractors • Environmental issues
5	Regulatory Environment	• Regulatory feasibility

5.3.3 Results of Delphi Round Three

In the third round of Delphi, experts were asked to provide the utility values for each factor against various procurement systems (Refer Annexure 3.3 for the questionnaire). A wide range of variants under each main categories of procurement system were adopted. The utility values were defined using a score starting from 10 to 110, in which 10 represents 'low suitability' and 110 represents 'high suitability' . The analysis was based on the utility values provided by the experts. The means of the utility values were computed for the responses. To obtain a measure of consistency, Coefficient of Concordance (w) of utility values were calculated using SPSS package in order to measure the rate of agreement. Coefficient of Concordance (w) ranges between 0-1 where, 0 represents 'No agreement' and 1 represents 'Complete agreement'. In this study, a concordance coefficient of 1 indicates that all experts ranked the procurement paths identically (Chan *et al.*, 2001, p. 704).

Further, significance rate was calculated to gain the significance level of each factor. The significance level (α) is based on the asymptotic distribution of a test statistic. Typically, a value that is less than 0.05 is considered as significant. The asymptotic significance is based on the assumption that the data set is large. If the data set is small or poorly distributed, this may not be a good indication of significance.

Clients' Requirements

Table 5.15 shows that the mean utility values provided for the eight factors were sufficiently consistent at significance level of 0.05 or smaller. The results point out that the experts had difficulty in assessing certain factors such as Responsibility and Party's involvement (α = 0.7075). Further, values of concordance coefficient (w) for the nine factors range between 0.02 - 0.48. These values indicate less strong agreement among experts during Delphi round three on ranking of factors related to clients' requirements.

Project Characteristics

Table 5.16 shows that the utility values for five factors were sufficiently consistent at significance level of 0.05 or smaller. The results show that the experts had difficulty in assessing the certain factors such as project type (α = 0.2613). Further, values of concordance coefficient (w) for the six factors range between 0.04 - 0.15. These values indicate less strong agreement between experts during Delphi round three, on ranking of factors related to project characteristics.

External Environment

Table 5.17 shows the utility values for four factors were sufficiently consistent at significance level of 0.05 or smaller. Compared to other related factors, market competition is having a considerable level of correlation among the participants. There is a considerable level of significance for the factors other than the socio cultural suitability, which scored 0.258 (> 0.05). This shows the less significance of the socio cultural suitability. Even though, significance level for the Socio Cultural suitability is low, based on its influence on industry practice, it was considered to be appropriate selection criteria particularly for Sri Lankan industry.

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Table 5.15: Concordance Coefficient of the utility values in Delphi round 03 – Clients' Requirements

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS													
		Average Utility Values												Concordance Coefficient (w)	Significance (α)
	Clients' Requirements	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Risk Management	63.60	78.80	54.60	77.20	71.40	79.60	58.40	57.20	65.40	59.80	56.40	58.60	0.1440	0.0000
2	Time Availability and Predictability	56.80	68.60	68.60	80.60	79.40	82.60	60.00	53.00	67.00	63.60	54.00	53.80	0.2548	0.0000
3	Price Certainty	63.40	92.12	48.00	76.80	74.20	80.00	57.00	55.20	60.83	58.33	53.33	58.96	0.3068	0.0000
4	Price Competition	89.00	77.20	67.60	65.00	62.92	53.80	50.42	48.96	62.50	58.54	46.04	60.00	0.2812	0.0000
5	Accountability	88.60	73.75	80.21	59.17	57.29	57.92	58.75	54.38	68.60	66.20	68.00	66.80	0.2188	0.0000
6	Flexibility for Changes	91.20	42.00	73.40	49.80	47.00	42.20	54.20	51.80	67.00	63.60	65.40	61.20	0.3271	0.0000
7	Quality of Work	77.20	67.80	67.40	71.60	65.60	63.00	61.00	61.80	77.40	76.80	70.20	70.00	0.1464	0.0000
8	Responsibility and Parties Involvement	75.63	67.71	64.17	69.58	67.50	71.52	68.54	67.92	74.58	72.71	67.71	67.71	0.0293	0.7075
9	Familiarity	97.40	81.40	68.60	72.80	57.60	60.00	52.20	46.60	47.00	48.00	38.80	42.20	0.4789	0.0000

Table 5.16: Concordance Coefficient of the utility values in Delphi round 03 – Project Characteristics

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS													
		Average Utility Values												Concordance Coefficient (w)	Significance (α)
	Project Characteristics	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Project Cost and Funding method	68.20	90.00	63.40	76.80	70.42	79.80	54.60	56.40	64.58	62.29	57.92	63.13	0.1527	0.0000
2	Project Complexity	62.60	59.17	61.30	69.00	61.46	49.17	71.88	68.75	78.96	76.46	73.70	78.48	0.0952	0.0061
3	Project Type	70.65	70.43	63.70	76.88	62.83	60.22	74.13	62.83	75.00	74.57	65.00	66.74	0.0491	0.2613
4	Time Constrains	53.75	62.71	62.71	81.67	78.75	74.58	69.17	66.46	68.75	65.21	69.58	65.42	0.0814	0.0215
5	Degree of Flexibility	80.20	53.20	70.21	55.40	48.33	45.63	53.96	48.54	66.04	65.21	69.58	61.67	0.1380	0.0001
6	Payment Modality of the Project	77.62	72.75	73.25	66.25	67.25	54.75	61.75	50.50	66.04	65.50	59.00	58.25	0.1025	0.0030

Table 5.17 : Concordance Coefficient of the utility values in Delphi round 03 - External Environment

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS													
		Average Utility Values												Concordance Coefficient (w)	Significance (α)
	External Environmental Factors	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Market competition for the project	73.92	69.80	57.80	77.60	67.00	69.72	66.40	65.00	61.00	59.80	51.20	55.40	0.105	0.001
2	Economic condition and the fiscal policy	59.60	69.00	56.00	70.60	59.32	59.40	58.80	66.60	65.40	62.08	71.80	73.60	0.074	0.041
3	Technology	57.60	59.00	51.00	80.00	66.40	73.92	68.20	67.20	64.20	65.28	71.80	74.40	0.089	0.011
4	Socio Cultural suitability	56.20	54.80	87.32	52.40	51.20	51.80	46.80	57.40	60.00	61.04	62.40	65.32	0.049	0.258
5	Regulatory environment	56.60	55.60	53.08	61.20	61.40	63.60	66.20	68.60	69.00	66.00	65.88	69.60	0.089	0.011

5.3.4 Results of Delphi Round Four

There were 23 out of 25 questionnaires received in the fourth round. The consistency of the experts' utility values was again tested by calculating the Kendall coefficient of concordance using SPSS package. Summary of comparison of the results are given in the following Table 5.18, Table 5.19 for Clients' requirements, Table 5.20, Table 5.21 for Project characteristics and Table 5.22, Table 5.23 for External Environment respectively.

Clients' Requirements

Table 5.18 shows that the utility values of all nine factors were sufficiently consistent at level of significance of 0.05 or smaller. Further, values of concordance coefficient (w) range between 0.08 - 0.46 for certain factors such as Risk management, Time availability & predictability, Accountability, Quality of works, and Responsibility & party's involvement. This indicates less strong agreement among experts during Delphi round four. The values of concordance coefficient (w) range between 0.59 - 0.73 for certain factors such as Price certainty, Price competition, Flexibility for changes and Familiarity indicate the strong agreement among experts during fourth round of Delphi.

Table 5.18: Concordance Coefficient of the utility values in Delphi round 04 – Clients' Requirements

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS													
		Average Utility Values												Concordance Coefficient (w)	Significance (α)
	Clients' Requirements	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Risk Management	62.83	81.74	55.06	77.83	69.57	81.43	57.83	57.17	61.09	63.48	71.30	69.57	0.1855	0.0000
2	Time Availability and Predictability	58.83	60.00	65.00	82.17	81.30	84.13	61.96	54.35	63.09	63.50	57.78	56.52	0.2548	0.0000
3	Price Certainty	66.41	95.43	43.70	82.83	76.71	86.96	58.48	54.35	60.43	58.57	50.57	52.74	0.6229	0.0000
4	Price Competition	93.26	82.83	69.57	64.57	62.35	51.74	49.45	42.96	64.13	59.57	42.61	58.04	0.5931	0.0000
5	Accountability	89.13	76.30	84.57	57.17	56.52	51.09	57.70	54.48	72.98	70.13	69.78	70.26	0.4661	0.0000
6	Flexibility for Changes	95.43	38.70	78.70	51.96	50.87	38.48	56.30	51.30	71.70	68.48	70.22	66.04	0.6508	0.0000
7	Quality of Work	77.61	72.17	67.00	67.78	64.57	59.70	62.74	57.57	78.35	78.35	75.82	76.30	0.4024	0.0000
8	Responsibility and Parties Involvement	67.87	70.13	60.43	72.09	67.39	74.35	68.91	68.08	70.57	69.74	69.35	71.09	0.0807	0.0399
9	Familiarity	97.83	90.00	73.17	72.61	57.61	59.13	54.83	47.10	43.04	42.09	33.48	36.74	0.7397	0.0000

Table 5.19: Comparison of Concordance Coefficient of the utility values in Delphi round 03 and Round 04 – Clients' Requirements

	Selection Factors Clients' Requirements	Concordance of Coefficient (W)			Significance Level	
		Round 03	Round 04	% Improvement	Round 03	Round 04
1	Risk Management	0.1440	0.1855	28.82%	0.0000	0.0000
2	Time Availability and Predictability	0.2548	0.2548	0.00%	0.0000	0.0000
3	Price Certainty	0.3068	0.6229	103.02%	0.0000	0.0000
4	Price Competition	0.2812	0.5931	110.93%	0.0000	0.0000
5	Accountability	0.2188	0.4661	113.04%	0.0000	0.0000
6	Flexibility for Changes	0.3271	0.6508	98.96%	0.0000	0.0000
7	Quality of Work	0.1464	0.4024	174.84%	0.0000	0.0000
8	Responsibility and Parties Involvement	0.0293	0.0807	175.17%	0.7075	0.0399
9	Familiarity	0.4789	0.7397	54.45%	0.0000	0.0000

The concordance analysis shows (Table 5.19) that the consistency of the experts' ranking for the selection factors against procurement systems have improved over the successive round. The coefficient of concordance for all the factors (except for Time availability & predictability) improved from 28% to 174.84%. In this round, nine factors were considered sufficiently consistent compared to third round. The results shows that the experts had over come the difficulty in assessing the Responsibility and party's involvement since the significance improved lesser than 0.05 (α reduced from 0.7075 to 0.0399 in the successive rounds).

Project Characteristics

Table 5.20 shows that the utility values for all six factors were sufficiently consistent at level of significance of 0.05 or smaller. Further, values of concordance coefficient (w) range between 0.29 - 0.38 for all six factors and this indicate less strong agreement among respondents during Delphi round four.

The concordance analysis shows (Table 5.21) that the consistency of the experts' ranking for procurement systems against each factor had improved over the successive round. The coefficient of concordance for all the factors improved from 154.64% to 581.644%. In this round of the Delphi, six factors were considered sufficiently consistent compared to previous round. The results shows that the experts had over come the difficulty in assessing the factor, particularly, project type since the significance improved lesser than 0.05 (α reduced from 0.2613 to 0.0000 in the successive rounds).

Table 5.20: Concordance Coefficient of the utility values in Delphi round 04 – Project Characteristics

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS												Concordance Coefficient (w)	Significance (α)
		Average Utility Values													
	Project Characteristics	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Project Cost and Funding method	63.04	90.13	59.57	78.04	71.76	82.78	54.35	56.13	63.26	59.78	60.77	63.91	0.3827	0.0000
2	Project Complexity	66.47	55.87	61.83	67.00	63.04	50.60	74.00	68.20	81.35	78.04	74.73	81.87	0.3092	0.0000
3	Project Type	75.90	66.30	65.65	72.83	63.91	58.70	75.13	60.65	76.26	75.39	68.61	70.78	0.3346	0.0000
4	Time Constrains	49.78	61.96	79.13	83.04	77.87	75.65	70.65	66.70	66.52	62.70	60.78	64.78	0.3382	0.0000
5	Degree of Flexibility	89.35	50.39	73.91	54.74	49.13	42.77	56.74	46.30	69.13	69.35	73.00	66.26	0.3558	0.0000
6	Payment Modality of the Project	77.50	77.22	78.00	72.22	69.43	51.30	65.48	53.70	69.83	69.57	68.04	66.74	0.2978	0.0000

Table 5.21: Comparison of Concordance Coefficient of the utility values in Delphi round 03 and Round 04 – Project Characteristics

Selection Factors Project Characteristics	Concordance of Coefficient (W)			Significance Level	
	Round 03	Round 04	% Improvement	Round 03	Round 04
Project Cost and Funding method	0.1527	0.3827	150.64%	0.0000	0.0000
Project Complexity	0.0952	0.3092	224.90%	0.0061	0.0000
Project Type	0.0491	0.3346	581.05%	0.2613	0.0000
Time Constrains	0.0814	0.3382	315.30%	0.0215	0.0000
Degree of Flexibility	0.1380	0.3558	157.94%	0.0001	0.0000
Payment Modality of the Project	0.1025	0.2978	190.70%	0.0030	0.0000

External Environment

The re-assessment of utility values at fourth round made considerable improvement in the significance level. The socio cultural suitability was changed in to the significant level of 0.021(<0.05) which shows the higher level of significance. Economic condition and the fiscal policy were changed from 0.041 to the 0.012, this also indicates the increased level of significance. The significance level of Technology, Regulatory environment and Market condition for the project were increased to the maximum from the 0.011 and 0.001 respectively.

On the other hand, the correlation between the parties regarding the external environmental factors was also increased. This indicates that the participants possess closer opinion of the factors influencing the procurement selection. Significant change occurred for the socio cultural suitability, which changed from 0.049 to 0.135. Further, changes have been occurred to other factors such as technology (from 0.089 to 0.172), regulatory environment, market condition and the economic condition and fiscal policy.

Table 5.22: Concordance Coefficient of the utility values in Delphi round 04 – External Environment

	SELECTION FACTORS	PROCUREMENT ARRANGEMENTS													
		Average Utility Values												Concordance Coefficient (w)	Significance (α)
	External Environmental Factors	Separated			Integrated					Management Oriented		Collaborative			
		Measure & Pay	Lump Sum	Prime Cost	Design & Build	Package Deal	Turnkey	Develop & Construct	PFI	Const. Mgt.	Mgt Cont.	Partnering	Joint Venture		
1	Market competition for the project	73.61	68.87	59.13	77.00	68.39	70.78	67.20	65.64	59.78	58.83	54.57	57.61	0.160	0.000
2	Economic condition and the fiscal policy	55.57	69.13	55.78	69.09	53.88	55.57	56.87	66.51	64.57	63.92	71.56	73.04	0.096	0.012
3	Technology	53.91	53.48	47.83	78.04	63.17	71.87	64.43	65.75	62.83	61.39	73.04	74.78	0.172	0.000
4	Socio Cultural suitability	54.65	53.70	61.87	50.22	49.13	49.04	45.00	58.61	59.57	60.04	59.30	61.43	0.135	0.021
5	Regulatory environment	54.35	52.91	51.39	59.57	59.35	62.35	64.57	69.91	66.74	63.70	65.66	68.04	0.147	0.000

Table 5.23: Comparison of Concordance Coefficient of the utility values in Delphi round 03 and round 04 – External Environment

Selection Factors External Environment		Concordance of Coefficient (W)			Significance Level	
		Round 03	Round 04	% Improvement	Round 03	Round 04
1	Market competition for the project	0.105	0.160	52.38%	0.001	0.000
2	Economic condition and the fiscal policy	0.074	0.096	29.73%	0.041	0.012
3	Technology	0.089	0.172	93.26%	0.11	0.000
4	Socio Cultural suitability	0.049	0.135	175.51%	0.258	0.021
5	Regulatory environment	0.089	0.147	65.17%	0.011	0.000

5.4. Rate of responses from Delphi survey

Success of a Delphi survey and the efficiency of the responses depend of the rate of responses from the survey. The following Table 5.24 summaries the rate of response at each round.

Table 5.24: Rate of responses of Delphi survey

	Round one	Round two	Round three	Round four
No of questionnaire issued	35	35	30	25
No of questionnaires received	35	30	25	23
Rate of responses (%)	100	86	83	92

With respect to the success of Delphi survey, this study was undertaken with the success rate at each round. The 90% of relative response rate achieved in this study is relatively very high and considered to be acceptable for the purposes of this research.

5.5. Summary

Obtaining set of criteria for the selection of procurement system in construction has been a continuous concern in previous researches (Ireland, 1985; Love et al., 1998; Chan et al., 2001). This study has identified and analyzed a set of exclusive selection criteria based on main three parameters which have been commonly accepted by several authors.

It was found that the client's requirements and the project characteristics are significantly influence the procurement selection together with external environment in which the industry operates. All together, 9 clients' requirements, 6 project characteristics and 5 external environmental factors have been identified as significant factors which influence the selection of construction procurement system in the Sri Lanka. Further, utility values were obtained for the factors against a wide range of procurement system. This exclusive set of selection criteria and the utility values were used as the inputs to the multiple criteria decisive factor model which will be discussed in detail in the following chapter.

CHAPTER SIX

The Multiple Criteria Decisive Factor Model

6. THE MULTIPLE CRITERIA DECISIVE FACTOR MODEL

6.1. Introduction

Rubenstin and Firstenberg (1995), define models as an abstract description of real world, a simple representation of more complex reality, a construct of the way things are, or a paradigm way the world is viewed. The model presented in this paper is a device for selecting an optimum procurement option for various types of projects in construction industry. The model consists of a set of selection criteria, a set of utility values, and a broader categorization of various procurement systems (12 types). This chapter presents objectives, development and practical use of the model. Further, it discusses the testing and evaluation of the model carried out through the use of case studies in actual projects and an expert opinion survey.

6.2. Objectives of the model

The model was designed for construction clients and/or their consultants/principal advisers, particularly those who use an unrealistic method to select the procurement system and responsible for the selection process. Primarily, this model guides how to select an optimum procurement system, which not only considers the requirements of clients and project's profile but also considers the impact of external environment. In this way, it will be possible to ensure that project is procured in an efficient and effective way that will lead to added value to the client. This will further facilitate the construction clients or/and their consultants/principal advisers in intelligent and informed decision making in available procurement routes for various types of building projects.

6.3. Development of the model

Development of the model consists of two main phases: Design phase and Development phase. Designing phase of the model was further considered in two processes: conceptual designing and information modeling. Conceptual design demonstrates the principles of the model while information model deals with the contents of the model. Conceptual design illustrates basic concepts behind procurement selection, which is based on secondary data collected through

literature and results from Delphi survey carried out in four rounds. Figure 6.1 illustrates conceptual design of proposed project procurement selection model.

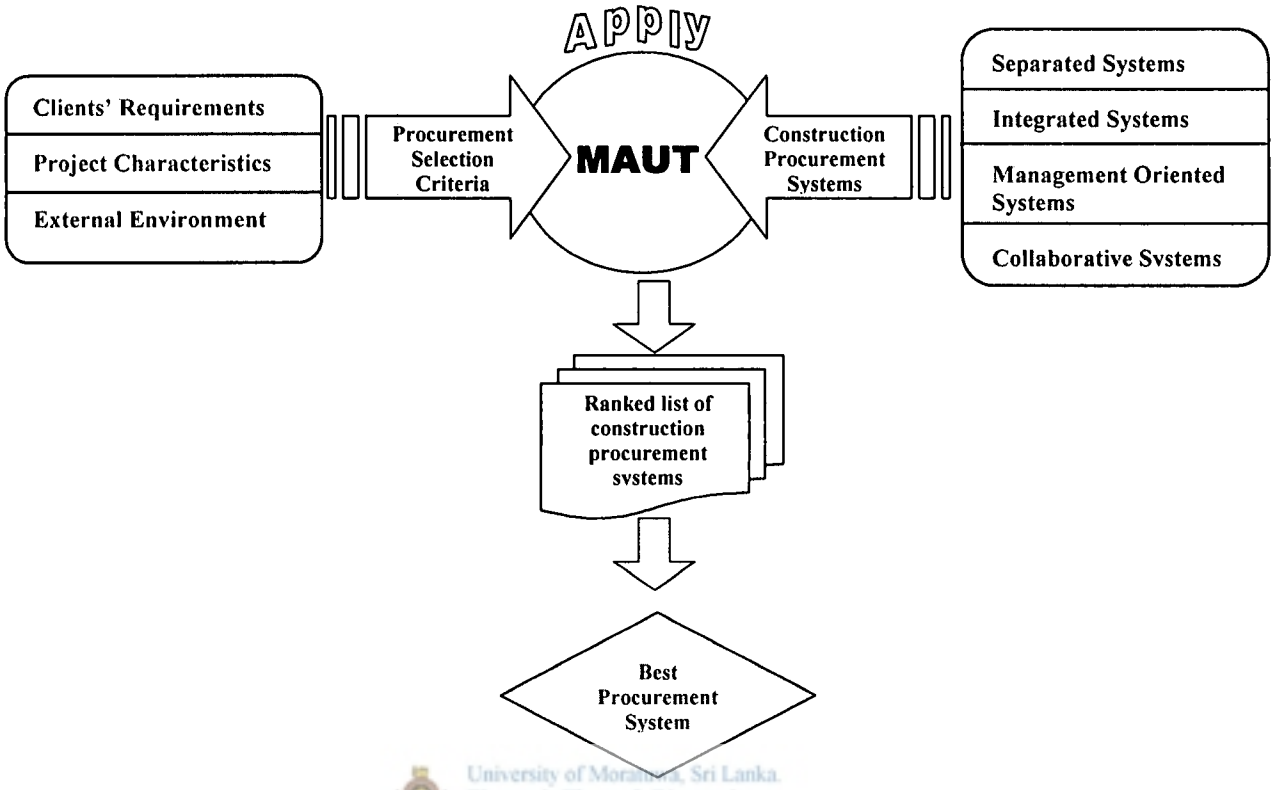

Figure 6-1: Detailed design of conceptual framework for procurement selection model

The steps involved in developing the contents of the model are:

(1) Determination of selection criteria;

(2) Determination of various procurement systems;

(3) Collection of utility values; and

(4) Collection of selection criteria weightings for each selection criteria.

Step 1 and Step 3 were achieved using Delphi technique and the step 4 was achieved using interviews with project's client or his/her consultants. The client weights the relative importance of each criterion on a scale of 1-5. This relative importance score is termed as priority rating. Finally, the MAUT was applied to achieve the selection procedure in a systematic and disciplined manner. The Delphi technique and MAUT were used to facilitate a more systematic and logical approach in the selection process, hence improving objectivity and reducing subjectivity in decision-making.

6.4. Use of the model

The model developed in this study can be used by following the steps as listed below.

Step 1 : The end user (either client or his/her principal advisor) consider all priority factors and gives the relative importance for each factor in the table on a scale of 1 to 5, where 1 represent 'least significant' and 5 represent 'most significant'. The prioritization exercise enables the end users to specify their requirements according to the characteristics of the project and influence of external environment.

***Step 2*:** Each priority rating is taken in turn and multiplied by each of utility values in the table and the results are entered into the appropriate columns respected to each procurement options. These are compared to all factors and procurement options.

***Step 3*:** The overall utility value of each of the resulted column, under each procurement options, are calculated, and ranked in descending order. The best procurement option will have the highest overall utility value.

6.5. Illustration of the selection model

The illustration of the model applied for a Club building is portrayed in the Figure 6.2. With this procurement selection decision chart being organized in a spreadsheet, the utility values were calculated against each factor, in accordance with the priority level and the ranking in accordance with the order of overall utilities derived were organized.

Figure 6-2: Illustration for the use of Multi Attribute Utility Model

	SELECTION CRITERIA	Client's Priority rating	Utility values											
			Separated			Integrated					Management Oriented		Collaborative	
			M & P	LS	PC	D & B	PD	TK	D & C	PFI	CM	MC	Part	JV
	Clients' Requirements													
1	Risk Management	5	62.83	81.74	55.06	77.83	69.57	81.43	57.83	57.17	61.09	63.48	71.30	69.57
			314.15	408.7	275.3	389.15	347.85	407.15	289.15	285.85	305.45	317.40	356.50	347.85
2	Time Availability & Predictability	5	58.83	60.00	65.00	82.17	81.30	84.13	61.96	54.35	63.09	63.50	57.78	56.52
			294.15	300.00	325.00	410.85	406.50	420.65	309.8	271.75	315.45	317.50	288.90	282.60
3	Price Certainty	5	66.41	95.43	43.70	82.83	76.71	86.96	58.48	54.35	60.43	58.57	50.57	52.74
			332.05	477.15	218.50	414.15	383.55	434.80	292.40	271.75	302.15	292.85	252.85	263.70
4	Price Competition	3	93.26	82.83	69.57	64.57	62.35	51.74	49.45	42.96	64.13	59.57	42.61	58.04
			279.78	248.49	208.71	193.71	187.05	155.22	148.35	128.88	192.39	178.71	127.83	174.12
5	Accountability	2	89.13	76.30	84.57	57.17	56.52	51.09	57.7	54.48	72.98	70.13	69.78	70.26
			178.26	152.6	169.14	114.34	113.04	102.18	115.4	108.96	145.96	140.26	139.56	140.52
6	Flexibility for Changes	4	95.43	38.70	78.70	51.96	50.87	38.48	56.3	51.30	71.70	68.48	70.22	66.04
			381.72	154.80	314.80	207.84	203.48	153.92	225.20	205.20	286.80	273.92	280.88	264.16
7	Quality of Work	5	77.61	72.17	67.00	67.78	64.57	59.70	62.74	57.57	78.35	78.35	75.82	76.30
			388.05	360.85	335.00	338.90	322.85	298.50	313.70	287.85	391.75	391.75	379.10	381.50
8	Responsibility & Parties Involvement	5	67.87	70.13	60.43	72.09	67.39	74.35	68.91	68.08	70.57	69.74	69.35	71.09
			339.35	350.65	302.15	360.45	336.95	371.75	344.55	340.4	352.85	348.7	346.75	355.45
9	Familiarity	3	97.83	90.00	73.17	72.61	57.61	59.13	54.83	47.10	43.04	42.09	33.48	36.74
			293.49	270.00	219.51	217.83	172.83	177.39	164.49	141.3	129.12	126.27	100.44	110.22
			2801.00	**2723.24**	**2368.10**	**2647.12**	**2474.10**	**2521.56**	**2203.00**	**2041.90**	**2421.92**	**2387.36**	**2272.81**	**2320.12**
	Project Characteristics													
1	Project Cost & Funding method	2	63.04	90.13	59.57	78.04	71.76	82.78	54.35	56.13	63.26	59.78	60.77	63.91
			126.08	180.26	119.14	156.08	143.52	165.56	108.7	112.26	126.52	119.56	121.54	127.82
2	Project Complexity	2	66.47	55.87	61.83	67.00	63.04	50.60	74.00	68.20	81.35	78.04	74.73	81.87
			132.94	111.74	123.66	134.00	126.08	101.20	148.00	136.40	162.70	156.08	149.46	163.74
3	Project Size	2	75.90	66.30	65.65	72.83	63.91	58.70	75.13	60.65	76.26	75.39	68.61	70.78
			151.80	132.60	131.30	145.66	127.82	117.4	150.26	121.3	152.52	150.78	137.22	141.56
4	Time Constrains	3	49.78	61.96	79.13	83.04	77.87	75.65	70.65	66.7	66.52	62.7	60.78	64.78
			149.34	185.88	237.39	249.12	233.61	226.95	211.95	200.1	199.56	188.10	182.34	194.34
5	Degree of Flexibility	2	89.35	50.39	73.91	54.74	49.13	42.77	56.74	46.30	69.13	69.35	73.00	66.26
			178.7	100.78	147.82	109.48	98.26	85.54	113.48	92.60	138.26	138.70	146.00	132.52
			738.86	**711.26**	**759.31**	**794.34**	**729.29**	**696.65**	**732.39**	**662.66**	**779.56**	**753.22**	**736.56**	**759.98**
	External Environment													
1	Market condition	5	73.61	68.87	59.13	77.00	68.39	70.78	67.20	65.64	59.78	58.83	54.57	57.61
			368.05	344.35	295.65	385.00	341.95	353.90	336.00	328.20	298.90	294.15	272.85	288.05
2	Economic condition	5	55.57	69.13	55.78	69.09	53.88	55.57	56.87	66.51	64.57	63.92	71.56	73.04
			277.85	345.65	278.90	345.45	269.40	277.85	284.35	332.55	322.85	319.6	357.80	365.20
3	Technological aspects	4	53.91	53.48	47.83	78.04	63.17	71.87	64.43	65.75	62.83	61.39	73.04	74.78
			215.64	213.92	191.32	312.16	252.68	287.48	257.72	263.00	251.32	245.56	292.16	299.12
4	Socio cultural suitability	2	54.65	53.70	61.87	50.22	49.13	49.04	45.00	58.61	59.57	60.04	59.30	61.43
			109.30	107.40	123.74	100.44	98.26	98.08	90.00	117.22	119.14	120.08	118.60	122.86
5	Regulatory Environment	2	54.35	52.91	51.39	59.57	59.35	62.35	64.57	69.91	66.74	63.70	65.66	68.04
			108.70	105.82	102.78	119.14	118.70	124.70	129.14	139.82	133.48	127.40	131.32	136.08
			1079.50	**1117.14**	**992.39**	**1262.20**	**1081.00**	**1142.01**	**1097.20**	**1180.8**	**1125.69**	**1106.79**	**1172.73**	**1211.31**
	Overall Utility		**4619**	**4552**	**4120**	**4704**	**4284**	**4360**	**4033**	**3885**	**4327**	**4247**	**4182**	**4291**
	Overall Ranking		**2**	**3**	**10**	**1**	**7**	**4**	**11**	**12**	**5**	**8**	**9**	**6**

M & P – Measure & Pay, LS –Lump sum, PC – Prime Cost, D & B – Design & Build, PD – Package Deal, TK – Turnkey, D & C – Design & Construct, PFI – Private Finance Initiative, CM – Construction Management, MC – Management Contracting, Part – Partnering, JV – Joint Ventures

6.6. Model Evaluation

Next stage was the evaluation of the practical use of the model through to ensure the consistency and soundness of the model. Multiple case studies with the sample of 42 building projects and unstructured interviews with selected clients/consultants from the industry were conducted to test the practical use of the model. These case studies demonstrate how this model could be applied in reality to come up with the best procurement systems for various types of building projects. In addition, an expert opinion survey was conducted to check applicability and efficiency through a series of demonstrations, semi-structured interviews and discussions.

6.6.1 Review of case studies

All together, 44 case studies were carried out to evaluate the applicability of the model. The results of the model were compared with the actual procurement system adopted to each project selected. Results of the case studies carried out for different types of buildings are presented in the following Table 6.1. The actual procurement systems used for selected projects includes thirty seven 'Traditional measure and pay', one 'Traditional lump sum', five 'Design and build' and one 'Turn key' (one number), suggesting a seemingly dominant use of the traditional measure and pay system.

Table 6.1: Review of case studies: Procurement systems compared (Actual versus Recommended)

No	Type of project	Client type	Actual procurement system used	Procurement system recommended through the model
1	Office Complex	Private	Traditional Measure & Pay	Traditional Measure & Pay
2	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
3	Library	Public	Design & Build	Design & Build
4	Residential and commercial	Private	Traditional Measure & Pay	Traditional Measure & Pay
5	Resort Hotel	Private	Traditional Measure & Pay	Traditional Measure & Pay
6	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
7	Children's village	Private	Traditional Measure & Pay	Design & Build
8	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
9	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
10	Factory	Public	Design and Build	Traditional Measure & Pay
11	Office Complex	Private	Traditional Measure & Pay	Traditional Measure & Pay
12	Community Housing	Private	Traditional Measure & Pay	Traditional Measure & Pay

Table 6.2: Review of case studies: Procurement systems compared (Continued)

No	Type of project	Client type	Actual procurement system used	Procurement system recommended through the model
13	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
14	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
15	Life Style Complex	Private	Traditional Measure & Pay	Traditional Measure & Pay
16	Court Complex	Public	Traditional Measure & Pay	Design & Build
17	Educational	Public	Traditional Measure & Pay	Traditional Lump sum
18	Head Quarters	private	Traditional Measure & Pay	Design & Build
19	Educational	Private	Traditional Measure & Pay	Traditional Measure & Pay
20	District Secretariat Building	Public	Turn key	Design & Build
21	Residential	Private	Traditional Measure & Pay	Design & Build
22	Hotel	Private	Traditional Measure & Pay	Traditional Measure & Pay
23	Hospital & Housing	NGO	Traditional Measure & Pay	Traditional Measure & Pay
24	Disaster Management Center	NGO	Traditional Measure & Pay	Traditional Measure & Pay
25	Institutional	Private	Traditional Measure & Pay	Traditional Measure & Pay
26	Residential	Public	Traditional Measure & Pay	Traditional Measure & Pay
27	Hospital	Private	Traditional Measure & Pay	Traditional Measure & Pay
28	Commercial	Private	Traditional Measure & Pay	Traditional Measure & Pay
29	Court Complex	Public	Design and Build	Traditional Measure & Pay
30	Eden Garden	Private	Traditional Measure & Pay	Traditional Measure & Pay
31	Refurbishment of Hotel	Private	Traditional Measure & Pay	Traditional Measure & Pay
32	Residential	Private	Traditional Lump sum	Traditional Measure & Pay
33	Residential and commercial	Private	Traditional Measure & Pay	Traditional Measure & Pay
34	Residential	Private	Traditional Measure & Pay	Design & Build
35	Secretariat Complex	Public	Traditional Measure & Pay	Traditional Measure & Pay
36	Factory Complex	Private	Traditional Measure & Pay	Design & Build
37	Rotary Club Building	Private	Traditional Measure & Pay	Design & Build
38	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
39	Residential	Private	Design and Build	Traditional Measure & Pay
40	Eye hospital	Private	Traditional Measure & Pay	Traditional Measure & Pay
41	Residential	Private	Traditional Measure & Pay	Traditional Measure & Pay
42	Residential and commercial	Private	Traditional Measure & Pay	Traditional Measure & Pay
43	Commercial	Private	Design and Build	Design and Build
44	Hospital	Public	Traditional Measure & Pay	Traditional Measure & Pay

As indicated in Table 6.1, out of the 44 case studies conducted, there were 31 (70%) matching results and 13 (30%) non-matching results observed. Even though the selection practice of construction procurement is rather unstructured and ad hoc, the results reveled from the model

represents that 70 % of the results tally with the procurement system already adopted. Therefore, it can be stated that the applicability of the model is efficient up to 70%.

It is also important to note that for all the residential developments (except No. 39) 'Traditional measure and pay' has been selected as the recommended procurement option, there did not appear to be an overriding criterion that had led to its selection. This suggests that the 'Traditional measure and pay' system is perceived to offer many advantages to residential types buildings. The AHP based procurement selection model developed by Cheung *et al.* (2001) recommends the similar procurement system for residential types of buildings in Hong Kong. This comparison further validates the applicability of the model to the Sri Lankan context.

Figure 6.2 portrays the model based on a case study carried out for a club building (N. 37). For this project, which involved building for Rotary club, 'Traditional measure and pay' was actually adopted. Comparison of overall utility values of 12 types of procurement systems clearly shows that Design and Build system has scored the highest overall utility value among others. The outcome of the model recommends that Design and Build system is the appropriate procurement option for this selected club building. To analyze the results and investigate the reasons for the non-matching results, the priority level for each factors were re-considered. There appear to be an overriding priority level that had led to its selection. Client who is a private body has given high priority to certain factors. Evidently, completion within the budget, early start of the project, responsibility, risk, quality of work, ect. were the critical selection criteria. These can be achieved by procuring the project through a procurement option that will facilitate integration of design and construction, early start before the completion of drawings, minimal of cost and time overrun and selecting a sole contractor for the design and construction work. Since, the contractor was selected based on selective tendering, quality of work could be ensured. In this regard, 'Design and Build' has been selected as appropriate delivery method to this particular project scenario.

6.7. Conclusion

The special feature of this model is the inclusion of set of selection criteria and a wide range of procurement systems, which are commonly used in the industry. The selection process should be structured well and realistic. The multiple decisive factor model introduced in this research is a potential tool which assist the clients and their consultants in the decision making process of procurement selection in a systematic manner. The outcome of the interviews conducted among the industry expert indicated the effectiveness and validity of this model for the use by industry clients and consultants. The application of the model developed in this study seeks to overcome any inconsistency in the decision making process due to the influence of individuals and other external factors.

CHAPTER SEVEN

Decision Support Systems for Procurement Selection

7. DECISION SUPPORT SYSTEM FOR PROCUREMENT SELECTION

7.1. Introduction

Decision Support System (DSS) is a computer based information system that actively supports decision making in management by providing interactive access to data and mathematical models (Scott, 1971). DSS for construction procurement provides user-friendly environment for selecting best procurement system for an exclusive set of selection criteria and various procurement options. DSS development herein is restricted to a scaleable prototype, which is used only for demonstration purposes of a real system. This chapter provides details of the DSS and its evaluation through an expert opinion survey to consider acceptability.

7.2. Objectives of DSS

Main objective of DSS is to facilitate a user-friendly environment for intelligent and informed decision making on construction procurement selection. Additionally, the DSS facilitates the following:

- Ensures systematic and consistent approach for procurement selection through the application of relevant research methods
- Assists construction clients in initial decision making on appropriate procurement selection for any kind of buildings projects.
- Provides better understanding on selection criteria, which influence the procurement selection and various types of traditional as well as alternative construction procurement systems in practice.
- Provides report on ranked list of procurement systems

7.3. Development Phases of DSS

DSS was developed based on the evaluated model discussed in chapter six. The DSS consisted of three main phases.

7.3.1 Database development

A database is a collection of data, which provides meaningful information. It facilitates data integrity, consistency and independence and reduces redundancy. DSS database uses structure of relational model as it provides ability for end users to create and change the records in the database in a user-friendly process (Lonnie and David, 1997). Moreover, many standard software packages facilitate development of relational databases. Relationships among entities of DSS are illustrated at object model in Figure 7.1.

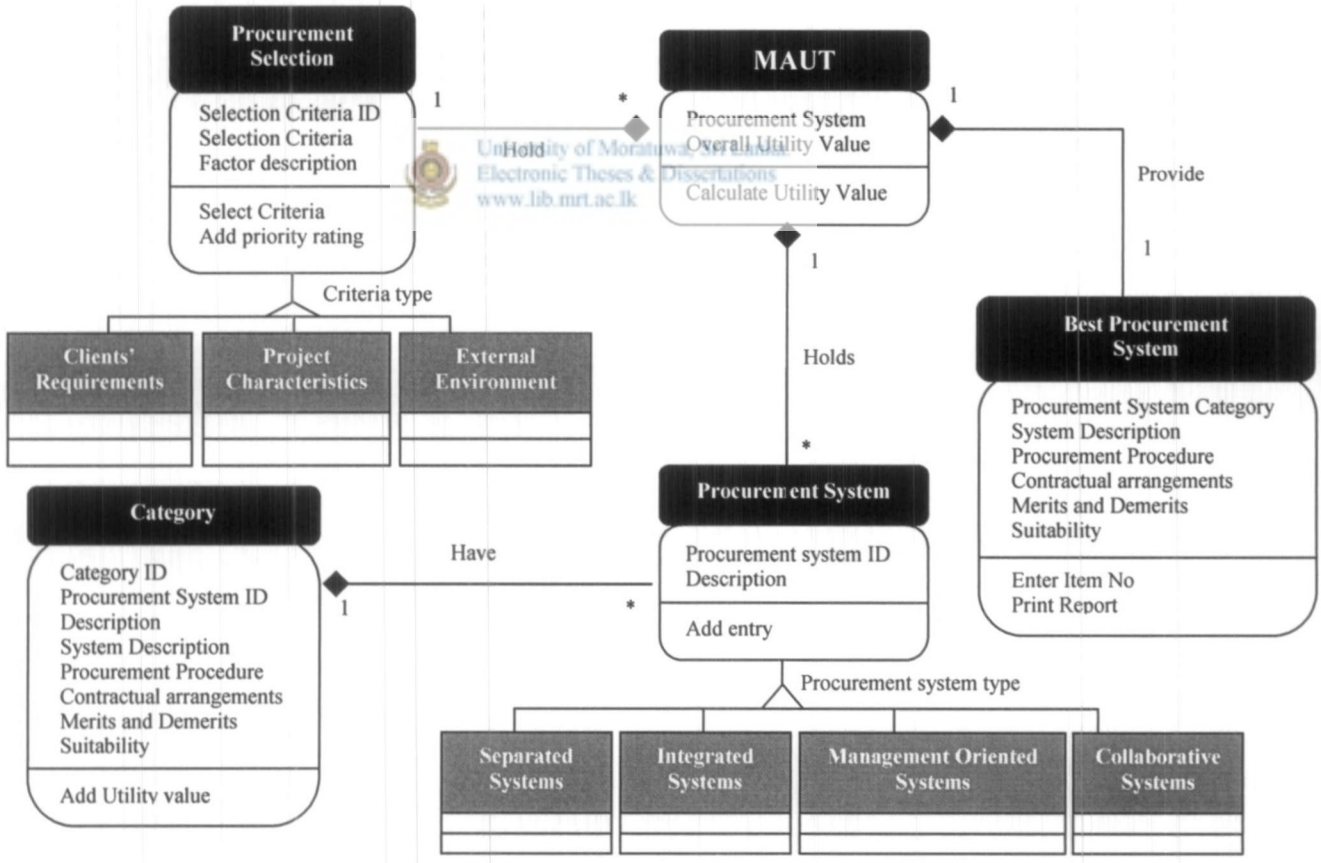

Figure 7-1: Object oriented model for procurement selection

7.3.2 System interfaces

System interfaces were developed using Java programming language, which incorporates certain features such as polymorphism and inheritance, illustrated at object model for IT procurement. Java development environment offers benefits such as faster development, reusability, increased quality, modular architecture, better mapping of problem domain and client/ server applications (Adhikari, 1995; Taylor, 1990).

There are four user interfaces including main and sub menu that work with DSS, details of which are discussed below:

1. Main menu
2. Construction procurement selection criteria and the priority level entry form
3. Ranked list of procurement systems
4. Report on selected procurement system

7.3.2.1 Main menu

This is the path to the DSS. It consists of five main menus and certain main menus possess some sub menus. Main menu of DSS comprises certain components as depicted in Figure 7.2.

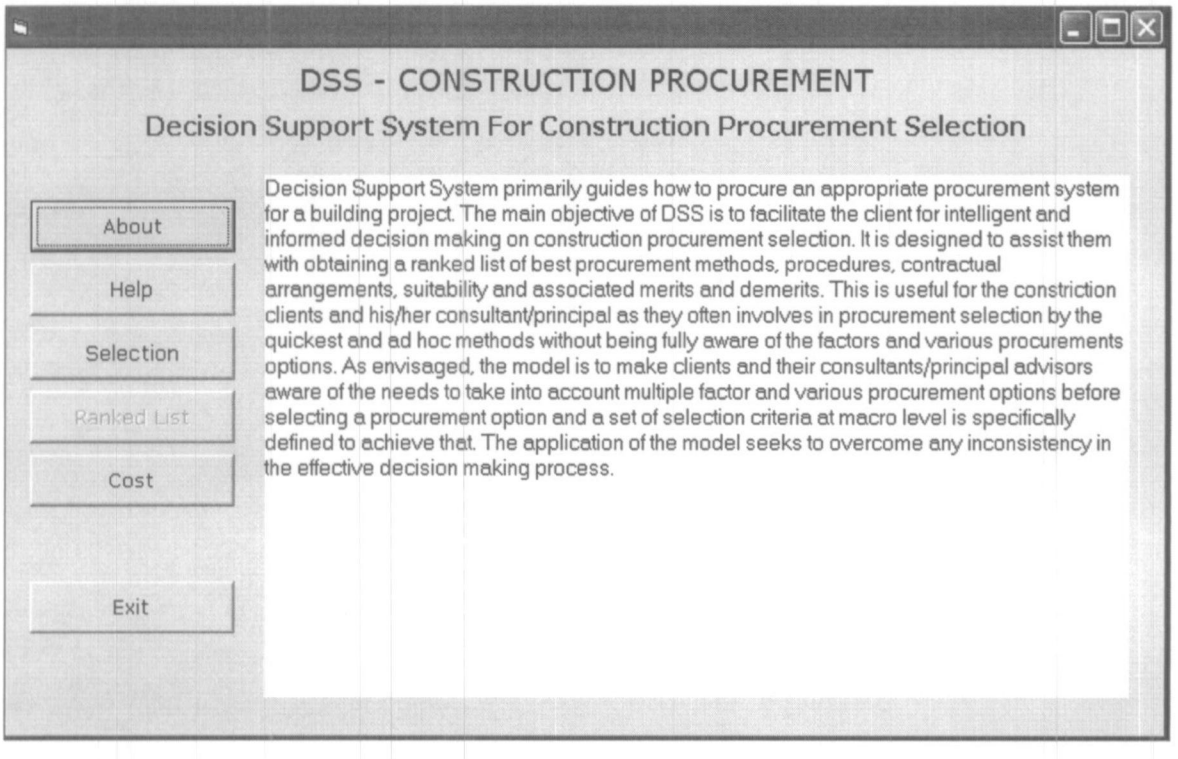

Figure 7-2: Main Menu

This illustrates five options:

- **About** : Provides introduction to DSS and its special features
- **Help** : Guide the end user, how to use the model
- **Selection**: This is the main component of DSS. This enables the end user to consider important selection factors at macro level and give the priority according to the client's specific requirements, project profile and influence of external environment.
- **Ranked list**: Provides a ranked list of procurement systems, which assist the end user in initial decision making to select appropriate procurement options for his/her project.
- **Cost** : Provides understanding of true cost saving in each procurement option
- **Exit**: Exit from the system.

7.3.2.2 Construction procurement selection criteria and the priority level entry form

This form facilitates to provide the priority level (relative important weightings) of each factor under three main criteria. Further, it provides brief description for each factor included in the database. Components of form are shown in the Figure 7.3.

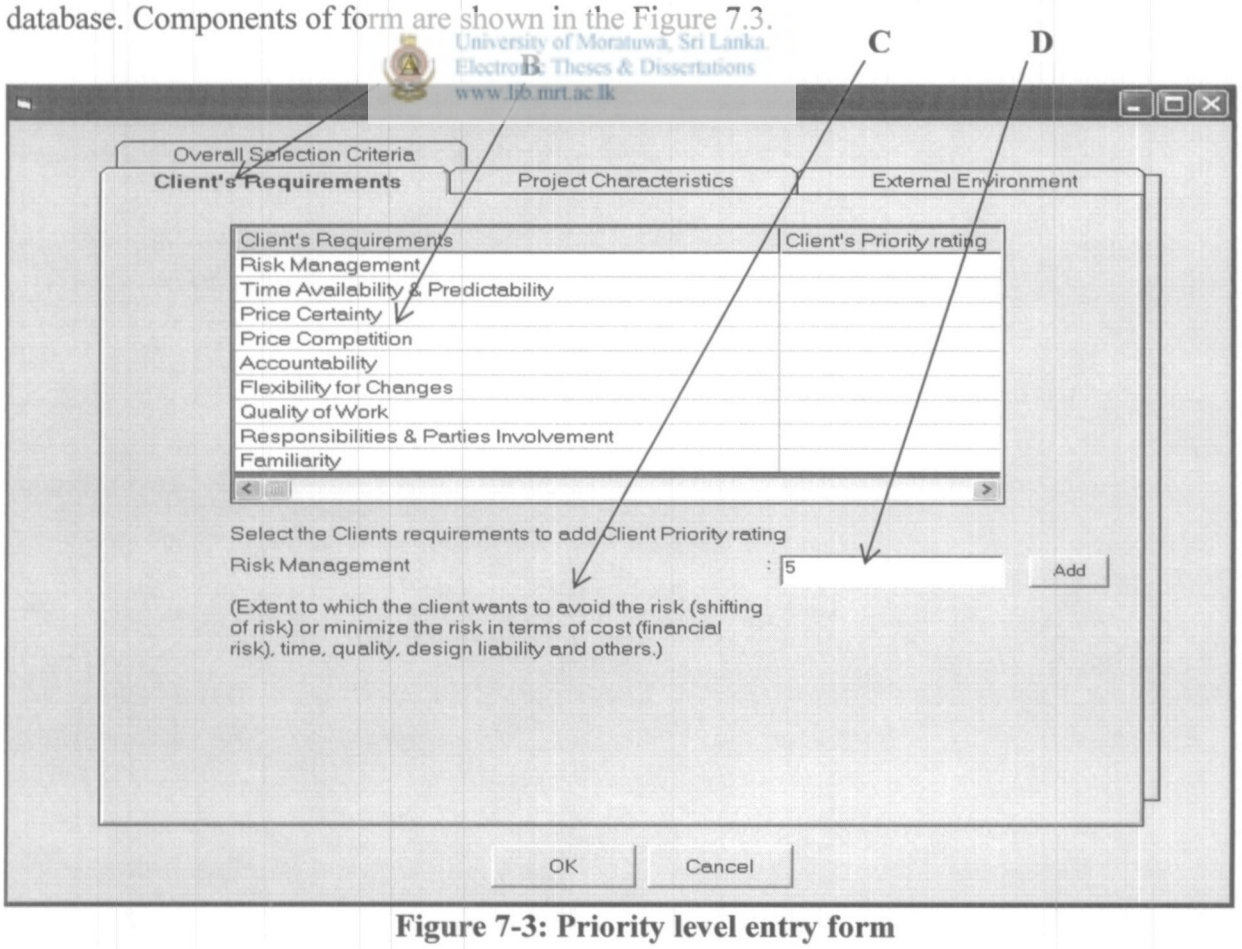

Figure 7-3: Priority level entry form

This form is used to identify the selection factors and enter priority levels for individual projects.

A. Consider key selection criteria

   E.g. : Client's requirements, Project characteristics, External Environment and Overall criteria

B. Determine the factors, which influence the selection of procurement for the particular project.

C. Provides descriptions for each selection factor

D. Place relative important weightings to each factor (weightings 1-5)

7.3.2.3 Ranked list of procurement systems

This form (Figure 7.4) provides ranked list of procurement options for given project.

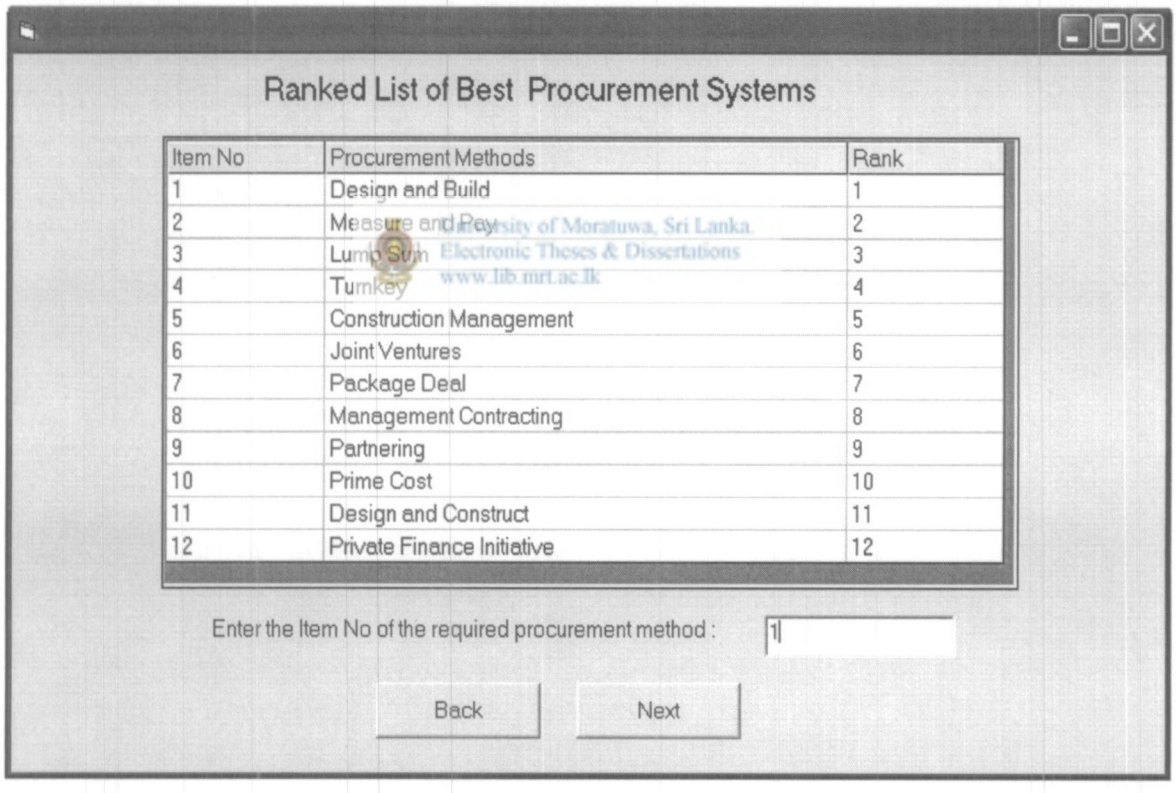

Figure 7-4: Ranked list of procurement systems

This facilitates selection of an appropriate procurement system from the ranked list of procurement options. The end user gets the idea of suitable procurement options according to the ranks derived from the system.

7.3.2.4 Report on selected procurement system

This form provides on screen or printed form of report on selected procurement method. The report consists of the following;

- Description for the system
- Procurement procedures associated with the systems
- Contractual arrangements of the system (Relationship between parties involved)
- Merits and demerits of the system
- List of suitable projects which can be procured through the selected procurement system

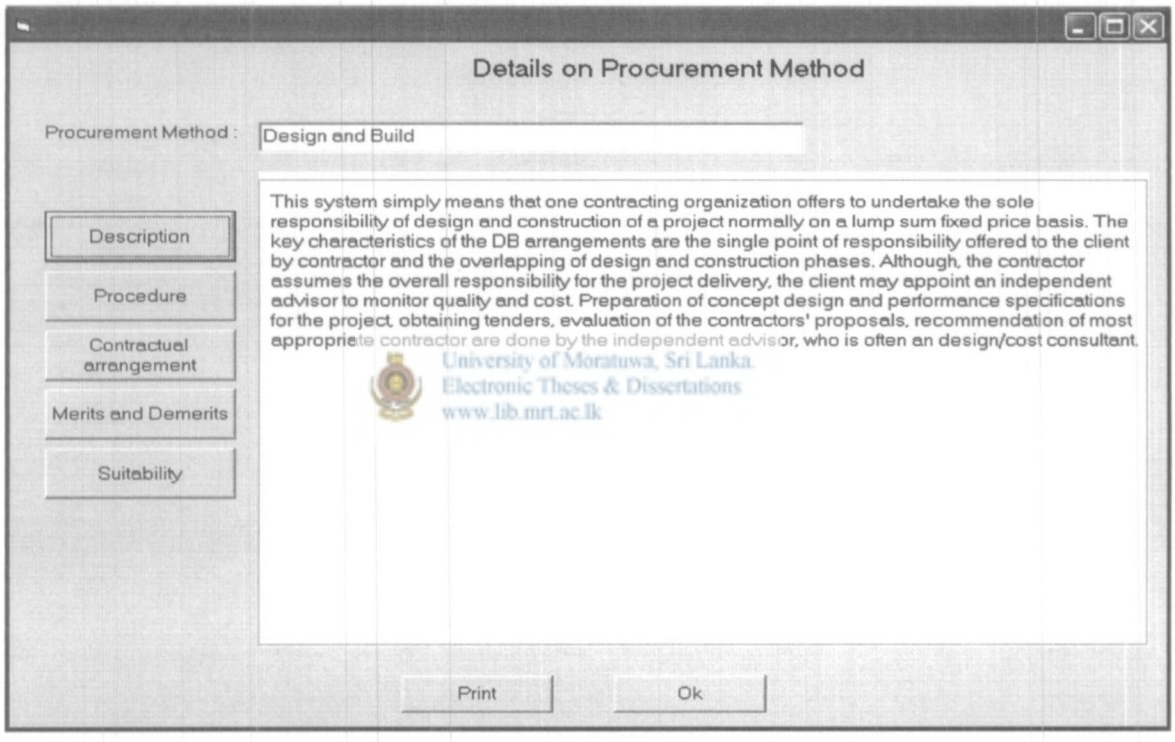

Figure 7-5: Report on selected procurement method - Description

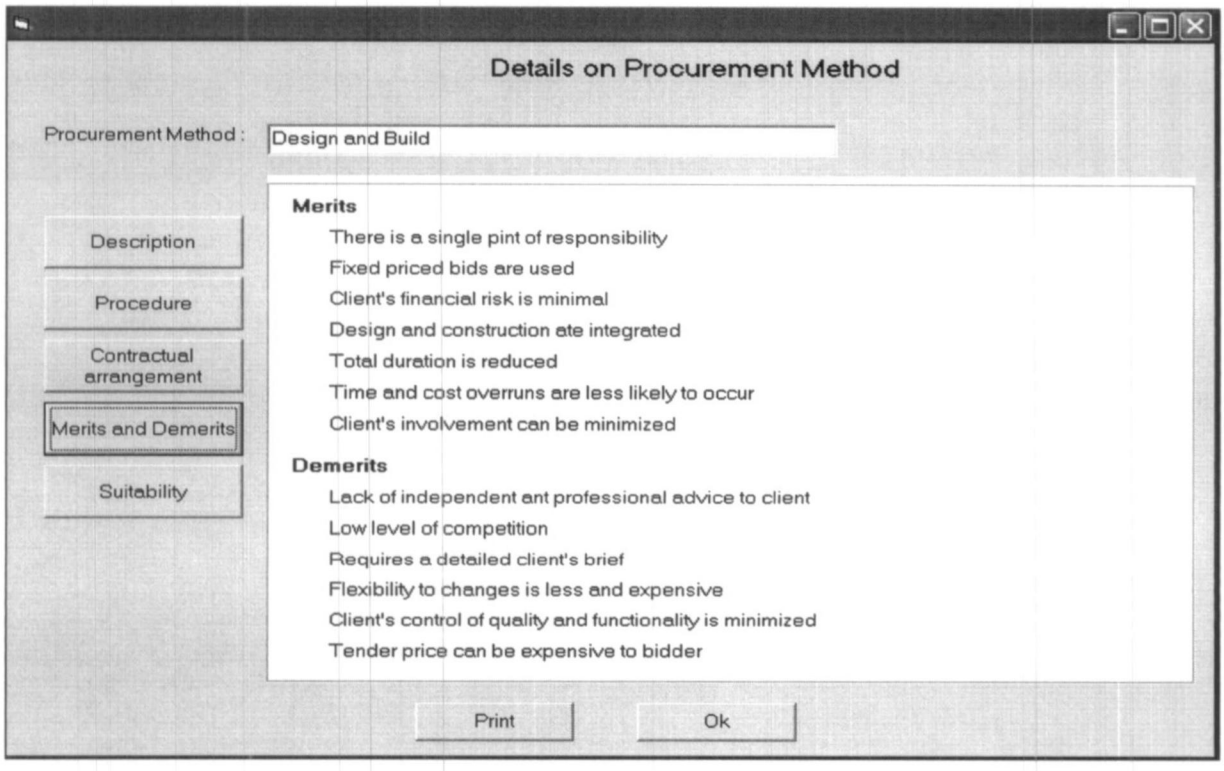

Figure 7-6: Report on selected procurement method – Merits and Demerits

The main objective of this report is to provide more information on selected procurement method. Above Figure 7.5 and Figure 7.6 illustrates details on the *'Design and Build'* procurement system. They depict the description of the system and merits and demerits of such system respectively. Refer Annexure 7.1 for further interfaces, which provide more information on selected procurement system.

7.3.3 System testing

Testing object-oriented software presents new challenges. Many conventional techniques are still in practice. E.g.: functional testing of object oriented will be no different from functional testing of conventional software. However, structural testing of object-oriented software varies form conventional. There are two techniques adopted at present: method-message testing and function fair testing.

Testing of Java programs brings higher degree of complexity than with other programs because Java is portable. Therefore, it is necessary to consider multiple platforms, operating systems and Java runtime environments.

DSS was tested in two stages by using sample data and actual data. At first stage by using hypothetical cases prototype was tested to validate the development process. Then the model was tested with actual scenarios developed by results extracted from the industry-based case studies to verify accuracy.

7.3.4 Development tools

As indicated in 7.3, prototype development was conducted in two phases and the following section will explain development tools used for each phase.

7.3.4.1 Database development

There are various software programmes available for database development such as Oracle, Microsoft SQL and IBM™ DB compatible with Java development. Microsoft™ "Access 2000" was used for database development of this DSS because:

- Development is restricted to a prototype. (Only for demonstrative purposes)
- Most organizations possess Microsoft Office Standard packages.
- Access is designed for Relational Database Management Systems (RDMS).
- Tools are user-friendly and it has a powerful development environment.

7.3.4.2 System interface development

Net Beans IDE 3.6 (Integrated Development Environment) was made use of as the tool to develop system interfaces due to its user-friendly development environment avoiding basic programming complexities. It is a free product with no restrictions, which can write, compile, debug and deploy Java programs. In addition, it enables delivery of high quality, highly functional software faster with lesser maintenance over time.

Before implementing, DSS should be developed further with the use of similar software programmes or any other appropriate programmes, for a fully functional software programme.

Since this DSS is a prototype, most interfaces are saddled with default outputs. DSS can be effectively used by the industry clients only through further development of a fully functional system.

7.4. Features of DSS

Special features of the DSS are addressed below.

- Decision support system designed for construction procurement selection :
  System assists the clients in initial decision making for suitable procurement selection with the clear overview of that particular procurement system.
- Flexibility in indicating priority level (relative importance weighting) for procurement selection criteria.
  System provides opportunity to indicate priority level (relative importance weighting) for procurement selection criteria according to their importance ranging from 1 to 5. Based on levels, system provides ranked list of best procurement options.
- Raising awareness on factors to be considered in selection and various types of procurement systems.
  System includes factors in terms of three main selection criteria at macro level with standard definitions for each factor included in the system.
- Reporting on selected procurement system.
  As indicated in Figure 7.5, Figure 7.6 and Annexure 7.1, users can obtain report on selected procurement options, which consists of description, procurement procedures, contractual arrangements, merits and demerits and suitability of best procurement methods on screen as well as a printed form of documents.

7.5. System Requirements and Guidelines for execution

7.5.1.1 System requirements

Since Net Beans IDE is written in pure Java, it should be run on any working implementation of Java 2 SDK, Standard Edition version 1.4 or latest version. If one of the Net Beans IDE installers is used, it will need to have version 1.4.1 or compatible of the J2SDK installed.

- Minimum configuration of hardware: 125 megabytes disk space, 256 megabytes memory, PIII/500 processor
- Operating System: Microsoft Windows (XP Professional SP1/2000 Professional SP3), Solaris (SPARC® / x86) ver. 8 and 9, Linux Red Hat 9.0

7.5.1.2 Execution guidelines

1. Install JDK 1.4 or above which is available from Java.sun.com.
2. Save DSS in separate folder (C:\project) or installed JDK bin file.
3. Open command prompt and go to specific folder (project or JDK bin file).
4. Compile Java files

   E.g.: C:\ project>Javac *. Java or C:\JDK\bin>Javac *. Java
5. Run the DSS

   E.g.: C:\project>java FrontPane or C:\JDK\bin>java FrontPane

7.6. Review of Expert Opinion Survey

The objective of the expert opinion survey was to verify the acceptability and efficiency of the model and to validate research and DSS through experts' opinion. Information was elicited through semi-structured interviews, demonstrations, and discussions as such methods provide openness to an interviewee (client/consultant/principal advisor) to express genuine opinion, feeling at ease. Interview guidelines developed for expert opinion survey are illustrated at Annexure 7.2. The following Table 7.1 presents the review of the results of expert opinion survey.

Table 7.1: Review of expert opinion survey

Construction procurement selection model (DSS)	
Criteria	**Expert opinion**
General view	• Since the procurement selection practice is rather un-structured and ad hoc, development of a systematic and consistent model is well appreciated • It will assist building clients in initial decision making • It is construction procurement specific, therefore, will perform its superior function to industry practice. • The 'help' menu of the system assists the end user who are not experienced in IT, how to use this system
Suggestions	• Model should be flexible enough to include the further selection criteria and new procurement options to keep up with new developments in procurement. • Inclusion of possible indication on cost solutions for each procurement systems may further improve the efficiency of the model. • Improve prototype to fully functional software.
Application of Research Methodology	
Delphi	• Delphi is suitable techniques to achieve the defined objectives of the author.
MAUT	• Since procurement system is overall managerial approach, MAUT is a relevant tool to make the rather subjective matters of management into objective matters.

The author in consideration of certain views expressed by such experts makes following comments.

- Model will be updated at regular time intervals to keep it up-to-date to overcome tendencies of isolation.
- Although public sectors organizations cannot adopt this model due to policies imposed on procurement by the government, still it can be used as a base to improve or modify procurement polices.

- Model was designed, evaluated and developed based on results obtained by surveys and case studies conducted in actual construction projects. Therefore, model is more suitable for construction clients or their consultants/principal advisors.
- Although development of model to fully functional software is not an issue of this research, enhancing the model up to that extent, will provide more benefits to construction industry.
- The cost aspects of selected procurement system are out of the scope of the research due to time limitations.

7.7. Conclusion

DSS allows users to make intelligent and informed decisions on selection of procurement routes for various building projects. DSS development herein is restricted to a scaleable prototype, which is only used for demonstration purposes of a real system. Evaluated model was enhanced to DSS with integration of new technology in two development phases, which includes database and interfaces development. DSS was developed using relational database and operates in menu driven mode. Microsoft Access for databases and Java (Net Beans IDE 3.6) for system interfaces were used as development tools.

Expert opinion survey was conducted to validate the model through series of semi-structured interviews, demonstrations and discussions. Results indicate that the DSS provides assistance to all types of building clients of the construction industry in initial decision-making on project procurement selection. Since this DSS is a prototype, most interfaces are saddled with default outputs. DSS can be effectively used by the industry clients only through further development of a fully functional system.

CHAPTER EIGHT

Conclusions, Limitations, and Further Development

8. CONCLUSIONS, LIMITATIONS AND FURTHER DEVELOPMENT

8.1. Main Findings and Conclusions

This study highlighted the dominance of separated procurement systems in Sri Lanka from year 1977-2003. Among the variants of separated system, Measure and Pay had the highest share. It ranged from 50-72% of the total. The popularity of Measure and Pay is mainly due to the Government influence on the construction industry of Sri Lanka. Government as a major client and the regulator neglected the development of alternative procurement methods. Bureaucratic red tape of the Government created a barrier for the growth of alternative procurement methods in the name of accountability and transparency of public work projects. In addition, it was found that the combination of national culture and organizational culture of construction has created an environment that did not favor the use of new procurement methods. The organizational culture of construction in Sri Lanka is characterized by the separation of design and construction from the Colonial days. The culture of construction professionals is marked by a high power distance with very strong uncertainty avoidance. The construction professionals are found to be collectivists and feminine. Therefore, this culture mix does not challenge the status quo. Thus, there is no room for new procurement methods to be experimented in the Sri Lankan construction industry. As a result, the Measure and Pay became institutionalized and never being challenged.

However, economic growth has favored some of the alternative methods to emerge in Sri Lanka. Design and Build is one such method, which became popular mainly due to the industrial growth of the country. Industrial buildings were mainly procured using Design and Build method. Joint venture arrangements became popular due to the involvement of international Contractors in Sri Lanka.

With respect to the future procurement trend, there is a clear sign of increase in the use of Design and Build. With a larger role for private sector in infrastructure provision and increased foreign involvement, systems such as Joint Venture and Concession Contracts (BOT, BOO, BOOT) will become popular in the future. Construction companies will seek collaboration to provide entire

project services with horizontal integration, strategic alliances, joint ventures or consortia to combine strength to become single problem solver to the client.

Selection of appropriate procurement system for a particular construction project is influenced by several factors from the project's internal as well as external environment. Therefore, investigation of significant factors from both environments is critical to the successful decision making on procurement selection and thus, for the achievement of project success. A set of exclusive selection criteria at macro level has been established from this study based on the Sri Lankan context. This study has adopted the Delphi technique to establish the set of selection criteria and for obtaining the utility values for each selection criteria against various procurement systems. The Delphi techniques have been demonstrated to be powerful and appropriate technique to achieve these tasks by deriving objective pinions in a rather subjective area. This study has focused on the selection criteria in terms of client requirements, project characterizes, and external environment, thus selection criteria has been focused at macro level. It has been found that the factors from clients' characteristics & requirements and project characteristics significantly influence the selection together with the external environment. This portrays that selection of procurement system should address the factors at macro level and considering all the macro level factors in the selection process, will ultimately lead to the success of the project and assure the value for money to the construction clients. The results of factor analysis revealed nine significant factors from client requirements, six factors from project characteristics and five factors from external environment.

Selection of most suitable procurement systems is a difficult task, as each project is owned by different clients and possesses unique characteristics. A Systematic and realistic approach for the selection of best procurement system is critical to the success of any project thus to achieve the clients' ultimate goals. This study has adopted the Delphi technique together with MAUT to develop a multiple decisive factor model for the selection of best procurement system in construction. The Delphi technique was used to derive the utility values for each factor against various procurement systems. The special feature of this model is the inclusion of a set of selection criteria at macro level and a wide range of procurement systems. The final selection model consists of a set of selection criteria in terms of clients' requirements, project characteristics & external environment, a set of utility values for each selection criteria, a categorization of procurement options and relative importance weightings for each criteria.

This is useful for the constriction clients and his/her consultant/principal as they often involves in procurement selection by the quickest and ad hoc methods without being fully aware of the factors and various procurements options. As envisaged, the model is to make clients and his/her consultant/principal adviser aware of the needs to take into account multiple factor and various procurement options before selecting a procurement option and a set of selection criteria at macro level is specifically defined to achieve that. The application of the model seeks to overcome any inconsistency in the effective decision making process due to the influence of individuals and other external factors and has the potential to assist the clients/his consultants. The implementation of this model to aid procurement selection is advocated to place the client in best possible position to select correct method of procurement for his project at a particular circumstance.

Finally, the evaluated model was enhanced into s Decision Support System (DSS) to provide a user-friendly guide to project procurement selection. Decision Support System was developed using relational database and operates in menu driven mode. Microsoft Access for databases and Java (Net Beans IDE 3.6) for system interfaces were used as development tools for DSS. It was to help designed to construction clients and their consultants/principal advisors, especially those who often involves in procurement selection by ad hoc methods without fully considering the significant factors and alternative procurements systems available. It is modeled to assists them to obtain a ranked list of best procurement systems and a report which includes description, procedure, contractual arrangements, merits & demerits and its suitability to various buildings on selected procurement system. Expert opinion survey targeted to verify the contents of the model, its applicability & efficiency reveals that the development of such model is a good attempt and it assists the clients in initial decision making on appropriate procurement selection. Further, the methods adopted in this research were recognized as appropriate to achieve the objectives of the study.

8.2. Limitations

Several difficulties were encountered in carrying out this research. Difficulties were mainly arisen from conducting Delphi survey and case studies. Further, this section addresses the limitations to the model development.

8.2.1 Difficulties in conducting the Delphi

The following difficulties were encountered in conducting the four rounds of Delphi survey.

First, the successful rounds of Delphi techniques were extremely time consuming, as it consists of four rounds, the completion of which took about 20 weeks. Turnaround times for the questionnaire survey conducted among panelists were longer than expected. For each round of Delphi questionnaires, it was very difficult to get the response from industry practitioners, as they are always busy in their work. Always reminder calls and revisits to the organizations had to be made to the non-respondents. Chan et al (2001) experienced similar difficulty in his research study that is similar to the nature of this study.

Second, the selection of the panel of experts is central to the success of the Delphi method. Panel members must be 'willing' and 'able' (Robinson, 1991). It is important that panel members treat the work seriously, and devote the time necessary to provide thoughtful and reasoned responses to the questions. Third, as with all Delphi studies, the wording of the questions and the presentation format of the survey were extremely important (Robinson, 1991). In this study, a lot of effort was made to make the questionnaire simple and yet sufficient to convey the objectives of the study to the panel of experts.

Moreover, Corotis *et al.* (1981) reported that the principal difficulties were in maintaining the high level of response and in reaching and implementing a consensus. It is very important to keep the whole panel of experts responding to each round of Delphi. Any drop out of the panel of experts would be very undesirable for the Delphi techniques. Because of the extensive commitment the experts needed to spend over the four rounds of questionnaires, there is a relatively high tendency for the respondents to withdraw in the successive rounds of the Delphi (McKenna, 1994). Few respondents dropped out from round two and that have not make any major impact on the success of the survey. This study was undertaken with the success rate at each round (Refer Table 5.24). The relative success response rate of 90% was achieved. Other Delphi studies in the medical and health fields have recorded a response rate ranging from 57.65% to 80.36%: 57.65% in Procter and Hunt's (1994) survey, 78.75% in Lindeman's (1975) survey, 78.97% in Bond and Bond's (1982) survey, and 80.36% in Sleep *et al.*'s (1995) survey. The 90% response rate achieved in this study is relatively very high and considered to be acceptable for the purposes of this research.

Finally, there was a problem of indirect communication with the experts. The respondents had to interpret the questionnaires, and incorrect interpretation had occurred. No respondent has been found to be familiar with all the selection criteria and their influence on various procurement systems. The respondents requested further verbal explanations for the utility values, and clarifications on the criteria also were needed.

8.2.2 Difficulties in conducting case studies

Case studies were targeted to verify the applicability and practical use of the model. Therefore, it is important to select the respondents who are being as either project client or his/her representative in case where an inexperienced client is found. The major difficulty was in finding the project clients and obtaining the client's priority weightings for each factor. Further verbal explanations and clarifications on the criteria also were needed. Getting responses was a time consuming process.

8.2.3 Limitations to model development

This DSS is subjected to following constraints and limitations:

1. Model contents restricted to nineteen selection criteria and twelve types of procurement systems, which were identified through the comprehensive Delphi survey conducted among experts in construction industry.
2. Model development restricted to a scaleable prototype, which only used for demonstration purposes of a real system. Therefore, most interfaces are saddle with default outputs.
3. Model provides reports on best procurement systems, but there is no flexibility for a user to query reports, as they preferred.
4. The cost aspects of the selected procurement systems were not incorporated in this model due to time constraints.

Although, inability of adoption of this model in public sector is not a limitation of this research, due the policies imposed on procurement by the government, it can used as a base to improve the procurement polices for public sector projects.

8.3. Further development

The following issues have been identified as the areas for further development

1. It should be pointed out that the research was conducted in Sri Lanka only for building projects and therefore the conclusions drawn here would have its limitation or even some biases. It is suggested that a larger scale Delphi survey that captures a number of civil and infrastructure projects could be conducted in Sri Lanka and this model could be enhanced for use by other clients who often involve in civil and infrastructure projects.

2. Enhancement of DSS to web based user guides allowing broader access. Although this is not a research issue, by enhancing prototype to fully functional software (real time system) will be benefited to construction industry. In addition, incorporation of online procurement of projects in conjunction with IT service providers will be more benefited.

3. Incorporation of value based framework for assessment of cost aspects of selected procurement system could be evaluated and the model could address the cost saving of ranked list of procurement systems suggested through the system. A solution for cost of procurement is one important issue to the project clients, since clients can make sure that they achieve best value for their investment by selecting suitable procurement systems. Addressing such issue was out of the scope of this research and therefore, it is recommended that the model can be further developed to that extent which may assist the clients to obtain an indication of cost saving by choosing the particular system the recommended through the model.

4. Application of value management for the selection of best procurement system in construction is one of the further directions to this research. Value management could be applied as one of the technique in each type of procurement system and benefits of such applied techniques could be evaluated for further development.

REFERENCES

9. REFERENCES

1. Adhikari, R., 1995. Adopting OO Languages? Check Your Mindset at the Door, *Software Magazine*, November, 49-59.

2. Alhazmi, T. and Mccaffer, R., 2000. Project procurement systems selection model. *Journal of Construction Engineering and Management*, 126(3), 176 - 183.

3. Ambrose, M. D. and Tucker, S. N., 2000. Procurement system evaluation for the construction industry. *Journal of Construction Procurement*, 6 (1).

4. Ambrose, M.D. and Tucker, S.N., 1999. Matching a procurement system to client and project needs: a procurement system evaluator, *Proceedings: Customer Satisfaction: A Focus for Research and Practice in Construction*, P.A. Bowen and R.D. Hindle (eds), Cape Town, South Africa, University of Cape Town, 280-288.

5. Ashworth, G., 1988. ELSIE, the QS's thinking friend. *Building*, 17, 97.

6. Azis, A.A. and Ofori G., 1996. Developing World Beating Contractors through Procurement Policies: The Case of Malaysia, In Taylor, R. G. (Ed.,) *CIB W92 'North Meets South' Procurement System Symposium Proceedings*, Durban, South Africa, 1-10.

7. Babbie, E., 1998. The practice of social research, 8th ed., Belmont: Wadsworth.

8. Barclay, J., 1994. A comparison between traditional and non-traditional forms of contracting for the procurement of building projects, B.Sc. thesis, School of Construction Management, Queensland University of Technology.

9. Bennett, J. and Flanagan, R., 1983. For the good of the client. *Building*, 1 April, 26–7.

10. Bennett, J. and Grice, A., 1990. In Brandon, P.S. (Ed.), Procurement Systems for Building, Quantity Surveying Techniques: New Directions, Oxford: BSP Professional Books.

11. Bond, S., 1982. A Delphi survey of clinical nursing research priorities. *Journal of Advanced Nursing*, 7(6):565-75.

12. Brandon, P. S., Basden, A., Hamilton, I. W. and Stockley, J. E., 1988. Application of Expert Systems to Quantity Surveying, London: Royal Institution of Chartered Surveyors.

13. Central Bank of Sri Lanka; 2005. Central Bank Annual Report, Colombo, Central Bank of Sri Lanka.

14. Chan, A. P. C., 1995. Towards an expert systems on project procurement. *Journal of Construction Procurement*, 1(2), 124–49.

15. Chan, A. P. C., Tam, C. M., Lam, K. C., and So, A. T. P., 1994. A multi-attribute approach for procurement selection: an Australian model. In *Proceedings of the Tenth Annual Conference of the Association of Researchers in Construction Management*, Loughborough University of Technology, September, 621–30.

16. Chan, A. P. C., Wong, F. K. W., Chan, E. H. W. and Ho, D. C. K. , 2000. A survey of project participants' view on design and build projects. In *Proceedings of the CIB W89 International Conference on Building Education and Research*, May, Atlanta, GA, 21–31.

17. Chan, A., 1998. Towards an Expert System on Project Procurement, School of Building & Planning, University of South Australia.

18. Chan, A.P.C., Yung, E.H.K., Lam, P.T.I., Tam, C.M., and Cheung, S.O., 2001. Application of Delphi method in selection of procurement systems for construction projects, *Construction Management and Economics*, 19, 699–718.

19. Chang, C.Y. and Ive, G., 2002. Rethinking the Multi Attribute Utility Approach based procurement route selection technique, *Construction Management and Economics*, 20, 275-84.

20. Chege L.W., 2001. Private financing of construction projects and procurement system: An Integrated Approach, *CIB World Building Congress*, New Zealand.

21. Chen, S.E., 2000. Project performance: a complexity perspective, unpublished PhD thesis, University of Newcastle, Newcastle.

22. Cheung, S., Lam, T., Leung, M. and Wan, Y., 2001. An analytical hierarchy process based procurement selection method, *Construction Management and Economics*, 19, 427–437.

23. Construction Industry Institute. 2001. Owner's Tool for Project Delivery and Contract Strategy Selection, Austin, Texas.

24. Corotis, R., Fox, R. and Harris, J., 1981. Delphi methods: theory and design load application. *Journal of the Structural Division*, ASCE, 107(6), 1095–105.

25. Cox, A. and Townsend, M., 1998. Strategic Procurement in Construction: Towards Better Practice in Management of Construction Supply Chain, Thomas Telford.

26. Crowly, L.G. and Karim, M. A., 1995. Conceptual Model of Partnering, *Journal of Management in Engineering*, 11(5), 33-39.

27. Dalkey, N.C., 1969. *Delphi Method: An Experimental Study of Group Opinion*, The Rand Corporation, Chicago, IL

28. Darlington, R.B., 1973. Factor Analysis (online), Available form : www.albany.edu [Accessed Date: 4th April 2005]

29. De Valance, G. and Huon, N., 1999, Procurement Strategies, In Best R. and De Valence, G. (Ed.), Building in Value: Pre Design Issues, London: Arnold, 13-21.

30. De Valence, G., 1999. Procurement trends and implications for construction economists. *AIQS Refereed Journal*, 3(1), 15-24.

31. Delbecq, A., Van de Ven, A. and Gustafson, D., 1975. Group guide to nominal group and Delphi processes, Glenview, IL: Scott, Foresman and Co.

32. Dell'Isola, M. D., Licameli, J. P. and Arnold, C., 1998. How to form a decision matrix for selecting a project delivery system. *Design-Build Strategies*, 4, 2.

33. Dunham, R.B., 1998. The Delphi Techniques (online), Available from: http://instruction. bus.wisc.edu/ obdemo/readings/delphi.htm (Accessed Date: 3rd January 2005).

34. Egan, J., 1998. Rethinking Construction. Department of the Environment, Transport and the Regions, HMSO, London.

35. Fellows, R. F., Langford, D., Newcombe, R. and Urry, S., 1983, *Construction Management in Practice*, New York: Longman.

36. Franks, 1990. Building Procurement Systems, Chartered Institute of Building, Ascot.

37. Franks, J., 1998. *Building Procurement Systems: A Client's Guide*, 3rd Ed., London: Addison Wesley Longman and Chartered Institute of Building.

38. Gibb, A.G.F. and Isack, F., 2001. Client drivers for construction projects: implications for standardization, Engineering, *Construction and Architectural Management*, 8 (1), 46-58.

39. Goldstein, N., 1975. A Delphi on the future of the steel and ferroalloy industries. In The Delphi Techniques and Applications, Addison Wesley, Reading, MA, 210–26.

40. Gordon, C.M., 1994. Choosing appropriate construction contracting method, *Journal of Construction Engineering and Management*, ASCE, 120 (1), 196-210.

41. Gunaydin, H.M.., 2004. The Delphi method (online), Available from : http://www.iyte.edu.tr/~muratgunaydin/delphi.htm [Accessed Date : February 2005]

42. Helmer, O., 1983. *Looking Forward: A Guide to Futures Research*, Beverley Hills: Sage Publications.

43. Hewitt, R.A., 1985. The procurement of buildings. Proposals to improve the performance of the industry, Project Reports submitted to the College of Estate Management for RICS diploma in Project Management.

44. Hofstede, G.H., 1980. Culture's Consequences: International Differences in Work Related Values, Sage Publications, London.

45. Hofstede, G.H., 1984. Cultural Dimensions in Management and Planning, *Asia Pacific Journal of Management*, 1(2), 81-99.

46. Holsti, O.R., 1969. Content Analysis for the Social Science and Humanities Reading, Mass, Addison-Wesley.

47. Hsiao, C., 2003. Analysis of Panel Data, 2nd ed., UK: Cambridge University Press.

48. Hughes, W., 1989. Identifying the environments of construction projects, *Construction Management and Economics*, 7, 29-40.

49. Kumar, R., 1996. *Research methodology – A step by step guide for beginners*, Malaysia: Longman, 17.

50. Kumaraswamy, M. and Dissanayaka, S., 2001. Developing a decision support system for building project procurement, *Building and Environment*, 36 (3), 337-349.

51. Kumaraswamy, M.M., 1994. New Paradigms for procurement protocols, CIM 92 "East meets West" *Procurement systems symposium*, Hong Kong, CIB Publication No.175 (ed.S.Rowlinson) 143-148 and 399-400.

52. Kumaraswamy, M.M., and Dissanayake, S.M., 1998. Linking procurement system to project priorities, *Building Research and Information*, 26 (4), 223-238.

53. Lahdenpera, P. J., Sulankivi, K. K., and Nykanken, V. E., 1999. Procurement Systems Shares and Trends in Finland, In Ogunlana, S. O. (Ed.,) *Profitable Partnering in Construction Procurement*, London:E & FN Spon, 265-272.

54. Latham, M., 1994. Construction the Team: Final Report of the Joint Government / Industry Review of Procurement and Contractual Arrangements in U. K. Construction Industry, HMSO, London.

55. Leedy, P.D., 1997. What is research? – Practical research: Planning and Design, 6th ed., Prentice Hall, New Jersey.

56. Lindeman, C.A., 1975. Delphi survey of priorities in clinical nursing research, *Nursing Research*, 24 (6), 434-41.

57. Linstone, H. and Turoff, M., 1975. *The Delphi Method: Techniques and Applications*, Addison Wesley, Reading, MA, 3–12.

58. Liu, A.M.M., 1994. From act to outcome: a cognitive model of construction procurement'', in Rowlinson, S. (Ed.), *CIB W92 Proceedings: East Meets West Procurement Systems Symposium*, 4-7 December, Hong Kong, 169-78.

59. Lonnie E.M. & David M.B., 1997. *Microsoft Office 97*, 2nd ed., New Delhi: BPB publications.

60. Love, P.E.D., 1996. Fast building: an Australian perspective, In *Proceedings of CIB-W92 Procurement Systems Symposium*, North Meets South, Developing Ideas, Durban, South Africa, 14 - 17 January, 329- 43.

61. Love, P.E.D., Skitmore, M. and Earl, G., 1998. Selecting a Suitable Procurement Method for a Building Project, *Construction Management and Economics*, 16, 221-233.

62. Luu, S.D.T., Ng, T., and Chen, S., 2003. Parameters governing the selection of procurement system, Engineering, *Construction and Architectural Management*, 10 (3), 209-218.

63. Masterman, J. and Gameson, R., 1997. Client characteristics and needs in relation to their selection of building procurement systems. *The Building Economics*, 19-25.

64. Masterman, J. W. E., 1992. *An Introduction to Building Procurement Systems*, E & FN Spon: London.

65. Masterman, J.W.E. and Duff, A.R., 1994. The selection of building procurement systems by client organizations, *10th ARCOM*, 14-16 September, Loughborough, UK.

66. Masterman, J.W.E. and Gameson, R. 1994. Client characteristics and needs in relation to their selection of procurement systems, *Proceedings: East Meets West – Procurement Systems Symposium*, CIB Publication 175, 4-7 December, Hong Kong, S. Rowlinson (ed.), 79-87.

67. Matthews, J., Rowlinson, S. P., Phua, F. T. T., McDermott P. and Chapmen T., 1999. In Ogunlana, S. O. (Ed.,) *CIBW92 & TG23 Proceedings: Profitable Partnering in Construction Procurement*, E & FN Spon, 247 –256.

68. Mcdermott, P. and Rowlinson, S., 1999. *Procurement systems. A guide to best practice in construction.* London: E & FN Spon.

69. McDermott, P., 1999. Strategic and Emergent issues in Construction Procurement, In Rowlinson, S. and McDermott, S. (Ed.,), Procurement Systems : A Guide to Best Practice in Construction, CIB Documentation, E & FN Spon, 3-26.

70. McKenna, H.P., 1994. The Delphi technique: a worthwhile research approach for nursing?. *Journal of Advanced Nursing*, 19, 1221-5.

71. Molenaar, K.R., 1999. Selecting appropriate projects for design-build procurement, in Ogunlana, S.O. (Ed.), *Proceedings: Profitable partnering in Construction Procurement Joint Symposium of CIB W92 (Procurement Systems) and CIB TG 23 (Culture in Construction)*, London: E&FN Spon, 349-60.

72. Moor, R. F., 1984. Response to Change: The Development of Non–traditional Forms of Contracting: Occasional Paper 31, Ascot: CIOB.

73. Moshini, R.A., 1993. Knowledge-based design of project procurement process, *Journal of Computing in Civil Engineering*, ASCE, 7(1), 107-122.

74. Mukalula, P., 1996. The Effectiveness of the Structural Adjustment Programme (SAP) on Maintenance Procurement Contracts, (Zambia case), In Taylor, R. G. (Ed.,) *CIB W92 'North Meets South' Procurement System Symposium Proceedings*, Durban, South Africa, 419-429.

75. Mustapha, F. H., Nauom, S. G. and Aygun, T., 1994. Public Sector Procurement Methods used in Turkey, In Rowlinson, S. (Ed.,) *CIB W92 'East Meets West' Procurement Systems Symposium Proceedings*, Hong, Kong, CIB Publication No. 175, 221-227.

76. Naoum, S.G., 1994. Critical analysis of time and cost of management and traditional contracts, *Journal of Construction Engineering and Management*, 120 (4), 687-705.

77. National Economic Development Office (NEDO), 1983. Faster Building For Industry, London: HMSO.

78. NEDO, 1985. Thinking about building, Report by Building, Design Partnership for National Economic Development Office, Building EDC, HMSO.

79. Ng, S.T., Luu, D.T., Chen, S.E. and Lam, K.C., 2002. Fuzzy membership functions of procurement selection criteria, *Construction Management and Economics*, 20 (3), 285-96.

80. Ng, W. F., 1994. Procurement Methods for Rural Housing Projects in the Poverty Stricken areas of Guangxi in the People Republic of China, In Rowlinson, S. (Ed.,) *CIB W92 ' East Meets West' Procurement Systems Symposium Proceedings*, Hong, Kong, CIB Publication No. 175, 251-258.

81. Nkado, R.N., 1999. Competencies required of Quantity Surveyors, Unpublished MBA Report, Johannesburg: University of the Witwatersrand.

82. NWPC, 1990. No Dispute: Strategies for Improvement in Australian Building and Construction Industry, *National Public Works Conference*, Canberra, Australia.

83. Ofori, G. and Pin, T., 1996. Linking Project Procurement to Construction Industry Development, In Taylor, R. G. (Ed.,) *CIB W92 ' North Meets South ' Procurement System Symposium Proceedings*, Durban, South Africa, 473-182.

84. Ofori, G., 1990. *The Construction Industry: Aspects of its Economics and Management*, Singapore University Press, National University of Singapore.

85. Outhred, G.P., 2001. The Delphi method: a demonstration of its use for specific research types, *Proceeding of the RICS Foundation*, Construction & Building.

86. Presidential Policy Statement, 1996. Sri Lanka: Presidential Secretariat.

87. Procter, S and Hunt, M., 1994, Using the Delphi survey technique to develop a professional definition of nursing for analysing nursing workload , *Journal of Advanced Nursing*, 19(5), 1003-1014.

88. Rameezdeen and De Silva, 2002. Trend of Construction Procurement Systems in Sri Lanka, *Journal of Built Environment Sri Lanka*, 2(1), 2-9.

89. Rameezdeen, R. and Gunarathna, 2003. Organization Culture in Construction: An Employee Perspective, *The Australian Journal of Construction Economics and Building*, 3 (1), 19-30.

90. Rameezdeen, R. and Welaratne, 2001. International Contractors Operating in Developing Countries: The Case of Japanese Contractors in Sri Lanka, *Proceedings of the 57th Annual Sessions of the Sri Lanka Association of Advancement of Science*, Colombo, Sri Lanka.

91. Rameezdeen, R., 2004. Ethic Culture and its Impact on Construction, *Proceedings of Conference on Sri Lanka: Challenges Offer Society in Transition*, 16-18 December, Colombo.

92. Robinson, J.B.L., 1991. Delphi technology for economic impact assessment, *Journal of Transportation Engineering*, 117(3), 28–32.

93. Rogge, T., 2003. Transparency of Procurement and Ethical Conduct: "Two sides of a coin", *CICA/IFI/IO Conference*, 14-15 Oct, Egypt, Rogge Group of Companies.

94. Rowlinson, S., 1999. Definition of Procurement Systems, In Rowlinson, S. and McDermott, S. (Ed.), *Procurement Systems: A Guide to Best Practice in Construction*, CIB Documentation, London: E & FN Spon, 27-53.

95. Rowlinson, S., 1999. Selection Criteria, In Rowlinson, S. and McDermott, S. (Ed.,), *Procurement Systems: A Guide to Best Practice in Construction*, E & FN Spon., Routledge, 27-53.

96. Rubenstein, M.E. and Firstenberg, I.R., 1995. *Patterns of problem solving*, 2nd ed., Englewood Cliffs, NJ:Prentice Hall.

97. Rwelamila, P.D. and Meyer, C., 1999. Appropriate or default project procurement systems, *Cost Engineering*, 41(9), 40-4.

98. Sackman, H., 1975. *Delphi critique*, USA : Lexington books, Lexington, Massachusetts.

99. Sackman, H., 1975. *Delphi Critique: Expert Opinion, Forecasting and Group Process*, D.C. Heath, Lexington, MA.

100. Sackman, H., 1975. Summary evaluation of Delphi, Policy Analysis, 1 (4), 693-718.

101. Saito, T., 1994. The Comparative Study of Procurement Systems in UK and Japan, In Rowlinson, S. (Ed.,) *CIB W92 ' East Meets West' Procurement Systems Symposium Proceedings*, Hong, Kong, CIB Publication No. 175, 389-398.

102. Sanvido, V.E., and Konchar, M.D., 1998. Project Delivery Systems: CM at Risk, Design-Build, Design-Bid-Build, Construction Industry Institute, Austin, Texas.

103. Scott, M. M., 1971. *Management Decision System: Computer based support for decision-making*, Boston: Harvard University Press.

104. Sharif, A. and Morledge, R., 1994. The procurement systems model by the functional approach, in Skitmore, R.M. and Betts, M. (Eds), *Proceedings:10th Annual ARCOM Conference*, Loughborough University of Technology, Association of Researchers in Construction Management, Leicestershire, 14-16 September, 2, 660-71.

105. Sheath, D.M., Jaggar, D. and Hibberd, P., 1994. Construction procurement criteria: a multi-national study of major influencing factors, in Rowlinson, S.(Ed.), *CIB W92 Proceedings: East Meets West, Procurement Systems Symposium*, 4-7 December, Hong Kong, 361-70.

106. Shen, Q., Lo, K. K. and Wang, Q., 1998. Priority setting in maintenance management: a modified multi-attribute approach using analytical hierarchy process. *Construction Management and Economics*, 16(6), 693–702.

107. Singh, S., 1990. Selection of appropriate project delivery system for construction projects, in *Proceedings of CIB W-90 International Symposium on Building Economics and Construction Management*, Sydney, Australia, 469- 80.

108. Skitmore, R.M. and Marsden, D.E., 1988. Which procurement system? Towards a universal procurement selection technique, *Construction Management and Economics*, 6, London : E & F.N. Spon Ltd, 71-89.

109. Tan, W., 2002. *Practical Research Methods*, Singapore: Prentice Hall, Pearson Education Asia Pte Ltd.

110. Taylor, D. A., 1990. *Object-Oriented Technology: A Manager's Guide*, Addision-Wesely, Reading, MA.

111. Turner, A., 1990. *Building Procurement*, London: Macmillan.

112. Turoff, M. 1975. The Policy Delphi, In Linstone, H.A. and Turoff, M. (Eds.), *The Delphi methods: Techniques and applications*, Addison-Wesley, reading, MA, 84-100.

113. Valance, K. and Akintoye, A., 1996. Building Procurement Systems Selection and Flexibility, In Taylor, R. G. (Ed.,) *CIB W92 ' North Meets South ' Procurement System Symposium Proceedings*, Durban, South Africa, 602-613.

114. Walker, A., 1989. *Project Management in Construction*, 2nd ed., Oxford: BSP Professionals Books.

115. Walker, A., 1996. *Project Management in Construction*, 3rd ed., Oxford: Basil Blackwell.

116. Weber, R.P., 1990. *Basic Content Analysis*, 2nd ed., Newbury Park, Calif: Sage.

117. Wicklein, R. C., 2000. Identifying critical issues and problems in technology education using a modified-Delphi Technique, [Online]. Available from http://scholar.lib.vt.edu/journals/JTE/v5n1/wicklein.jte-v5n1.html [Accessed Date : 5th January 2005]

118. World Bank, 1995. World Bank Procurement Guidelines

ANNEXURE

QUESTIONNAIRE SURVEY: ROUND 1

CRITERIA ADOPTED FOR SELECTION OF PROCUREMENT SYSTEM IN CONSTRUCTION

1. GENERAL INFORMATION

Research Topic	:	STUDY OF FACTORS AFFETCING THE AFFETCING THE SELECTION OF PROCUREMENT SYSTEMSIN CONSTRUCTION : A MULITPLE CRITERIA DECESIVE FACTOR MODEL
Objectives	:	1. Identify the various types of procurement systems used in the Sri Lankan Construction Industry. 2. Identify and analyse the significant factors affecting the selection of procurement systems in terms of; ➢ Clients' requirements ➢ Project Characteristics ➢ External Environment 3. Establish a set of selection criteria for the procurement selection. 4. Develop a multiple decisive factor model to assist the clients/consultants in initial decision making on selecting best procurement system for different types of projects. 5. Enhance the model to Decision Support System (only prototype) that provides a user-friendly environment for procurement selection.

2. QUESTIONNAIRE

Name of Respondent : .....

Organization : .....

Designation : .....

Experience in the industry : .....

1. Would you please list criteria, which you believe are the major criteria in the selection of a procurement system for a construction project in the Sri Lankan Construction industry?

Client Requirements	Project Characteristics	External Environment

Note: The following Table lists out the factors which have been identified from the literature and previous research studies as the reference.

FACTORS AFFECTING THE SELECTION AT MACRO LEVEL	
CLIENT REQUIREMENTS	
Cost	**Quality**
• Capital Cost • Maintenance Cost • Completion with in budget (Cost overrun) • Financial Risk • Price competition • Prequalification cost	• Design durability and reliability • Aesthetic appearance • Flexibility • Design innovation • Suitability for the intend users (functionality) • Building system workmanship
Time	**General**
• The Early start of construction and completion on time • Speed of construction. • Construction time • Planning and designing on time • Tendering and evaluation time • Minimizing of activities interference • Time overruns • Quick responses to the clients new requirements (Extra works and variations)	• Allocation of responsibilities • Professional team performances • Parties involvement Availability of competent consultants and contractors • Accountability • Transparency • Risk Avoidance (Safety) • Corporation and motivation • Existing building operation • Familiarity • Tender evaluation criteria • Clear express of end user's requirements

FACTORS AFFECTING THE SELECTION AT MACRO LEVEL	
PROJECT CHARACTERISTICS	**EXTERNAL ENVIRONMENT**
• Project Type • Project Size • Project Cost • Degree of Flexibility • Degree of Complexity • Project Site Location • Site Risk Factors • Payment Method • Integration of Design and Construction of the project • Project Funding Method • Building Construction Method • Time Constraints	• Market competitiveness • Technological feasibility • Regulatory Environment • Availability of Experience Contractors • Education of Contractors • Material Availability • Weather and Natural Disaster • Cultural Differences • Political Constraints • Mode of finance • Economic condition of the country • Information Technology • Institutional Bodies • Industrial Actions • Objection from neighbours

Thank you very much for your co-operation.

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QUESTIONNAIRE SURVEY: ROUND 2

CRITERIA ADOPTED FOR SELECTION OF PROCUREMENT SYSTEM IN CONSTRUCTION

1. GENERAL INFORMATION

Research Topic	:	STUDY OF FACTORS AFFETCING THE AFFETCING THE SELECTION OF PROCUREMENT SYSTEMSIN CONSTRUCTION : A MULITPLE CRITERIA DECESIVE FACTOR MODEL
Objectives	:	1. Identify the various types of procurement systems used in the Sri Lankan Construction Industry. 2. Identify and analyse the significant factors affecting the selection of procurement systems in terms of; ➢ Clients' requirements ➢ Project Characteristics ➢ External Environment 3. Develop of selection criteria for the procurement selection. 4. Develop a multiple decisive factor model to assist the clients/consultants in initial decision making on selecting best procurement system for different types of projects. 5. Enhance the model to Decision Support System (only prototype) that provides a user-friendly environment for procurement selection.

2. QUESTIONNAIRE

Name of Respondent : .....

Organization : .....

Designation : .....

Experience in the industry : .....

Guidance on completion of this Questionnaire

The following are the criteria for the selection of procurement system which include the criteria that you have provided in the round one questionnaire and the analyzed set of criteria, which were suggested by other experts/practitioners from the industry. We would like you to reconsider the criteria which you provided in the round one. Please put tick in the appropriate box to indicate to what extent you think those the criteria that were suggested by the all respondents influence the selection of procurement system.

A	Client Requirements	To what extent do you think the criterion influence the choice of procurement system in Sri Lanka?		
		Very Important	*Important*	*Not Important*
1	**Cost Requirements** *How well the following cost related requirements influence the choice of procurement system?*			
	Capital Cost			
	Maintenance Cost			
	Prequalification and tendering cost			
	Financial Risk			
	Price competition			
	Completion with in the budget			
2	**Time Requirements** *How well the following time related requirements influence the choice of procurement system?*			
	Planning and designing time			
	Tendering and evaluation time			
	Construction time			
	The Early start of project			
	Speed of construction			
	Time overruns			
	Quick responses to the clients new requirements (Extra works and variations)			
	Maximizing of activities interfacing			
	Stage completion			

A	Clients' Requirements	To what extent do you think the criterion influence the choice of procurement system in Sri Lanka?		
		Very Important	*Important*	*Not Important*
3	**Quality Requirements** *How well the following Quality related requirements influence the choice of procurement system?*			
	Design Reliability			
	Aesthetic appearance of the building			
	Workmanship			
	functionality (Suitability for the intend users)			
	Design innovation			
4	**General Needs** *How well the following general requirements influence the choice of procurement system?*			
	Allocation of responsibilities			
	Professional team performances			
	Parties involvement			
	Accountability			
	Transparency			
	Safety requirements			
	Corporation and motivation			
	Existing building operation			
	Familiarity (Client awareness of construction procurement system)			
	Tender evaluation criteria			
	Clear express of end user's requirements			
	Flexibility			
	Consultant attitude towards the client			
	Type of clients			

B	Project Characteristics	To what extent do you think the criterion influence the choice of procurement system in Sri Lanka?		
		Very Important	*Important*	*Not Important*
1	**Project Type** *Does the type of project affect to selection of procurement system?* (E.g. Residential, Social, Industrial, Commercial, Infrastructure....etc.)			
2	**Project Size** *How Does the project size affect in terms of GFA (Gross Floor Area) or contract sum, selection of procurement system?*			
3	**Project Cost** *How does the firm project cost effect the selection of procurement system at the beginning of the project?* Low cost (Less than 20 million) Medium cost (In Between 20 million and 800 million) High cost (Greater than 800 million)			
4	**Degree of Flexibility** *Do any expected project changes in design and construction phases' affect the procurement system selection?* (This deals with whether scope of work of the project flexible or rigid)			
5	**Degree of Complexity** *How do the complex project procedures affect the procurement system selection?* (This deals with the project requirements like advanced technology, number of phases, nature of services and employees required).			
6	**Time Constraints** ***Is there a tight time schedule for the project?***			
7	**Payment Method of the project** *How does the method of payment affect the selection of procurement system?* ***(E.g. for Payment methods: Measure and Pay, Lump Sum, Fixed fee...etc.)***			

	External Environmental Factors	To what extent do you think the criterion influence the choice of procurement system in Sri Lanka?		
		Very Important	*Important*	*Not Important*
1	**Market's Competitiveness** *Existing market competitiveness for the project*			
2	**Technological Feasibility** *The degree of technology required and its feasibility*			
3	**Regulatory Feasibility** *Involvement of the regulatory bodies in implementing the procurement methods*			
4	**Availability of Experienced Contractor** *How important to have competent contractors for the procurement system*			
5	**Education of Contractors** *Extent to which the Education of builders influences the procurement system*			
6	**Material Availability** *a) Availability of materials at site and its influence* *b) Scarcity of natural materials*			
7	**Weather and Natural Disaster** *Extent to which the monsoons and weather influence the procurement system*			
8	**Cultural Differences** *Influences of the cultural difference between, organisations, parties involved in the project*			
9	**Political Constraints** *a) Government as a policy maker* *b) Government as a major client*			
10	**Finance for the Project** *c) Donors: Extent to which the donors influence the procurement system* *d) Aids: Extent to which the procedures regarding the aids influence the procurement system*			

	External Environmental Factors	To what extent do you think the criterion influence the choice of procurement system in Sri Lanka?		
		Very Important	*Important*	*Not Important*
11	**Economic Condition of the Country** *Extent to which the economic condition of the country influences the procurement system*			
12	**Information Technology** *Development of information technology and its influences on the procurement system*			
13	**Intuitional Bodies** *The influence of the intuitional bodies in use & development of the procurement system*			
14	**Industrial Actions** *The influence of industrial actions on the procurement method (e.g. labour strike)*			
15	**Objections from Neighbours / Public** *Extent to which the influence of neighbours affect the procurement system*			
16	**Civil War Condition** *Extent to which the influence of Civil War Condition affect the procurement system*			
17	**Environmental Issues** *Extent to which the influence of Environmental Issues affect the procurement system*			
18	**Good Will of the Contractor** *Extent to which the influence of Good will of the contractor affect the procurement system*			

Thank you very much for your co-operation.

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QUESTIONNAIRE SURVEY: ROUND 3

UTILITY VALUES FOR DIFFERENT PROCUREMENT SYSTEMS

(Suitability of each factor against each procurement system)

1. Results from the Delphi Round 02 questionnaire

From the Delphi round 02, there were 25 factors out of 34 related to Clients' requirements, 11 factors out of 13 related to Project characteristics and 14 factors out of 18 related to External environment selected. All these factors were assigned mean rating of higher than the neutral point 2 and each of them maintained a Severity Index between 65% - 95%. Then the selected factors were grouped using Rotated component matrix. Factor analysis revealed 9 factor categorizes of Clients' requirements, 6 factor categories of Project characteristics and 5 categorizes of External environmental factors. These factor categories were used to carry out the round 3 Delphi survey to obtain the utility values for each factor against a wide range of procurement systems.

2. Guidance on completion of Questionnaire

The Table 1 of this questionnaire is designed for you to assess performance of each procurement system in relation to each main criterion which includes "Clients' requirements", "Project characteristics" and "External environment". Please enter a score from 10 (least favourable) to 110 (Most favourable) to indicate the suitability of each factor against each procurement system. (Please note that Zero is eliminated to avoid any possible imbalances)

The following is an example for the criterion "Familiarity". If you believe that the traditional measure and pay is more familiar system to the construction industry in Sri Lanka, you may enter a score say, 100. Where partnering which is one of the variants of collaborative system, provide least familiarity, there fore you may enter a score around 20.

Table 1: Example

A	Selection Criteria Client Requirements	PROCUREMENT ARRANGEMENTS											
		Utility Values (suitability of each criterion against each procurement system)											
		Separated			Integrated					Management Oriented		Collaborative	
		Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
9	**Familiarity** Extent to which, the Client wants to choose a system which is familiar to him	100	85	65	60	40	45	30	35	30	35	20	20

Note: Concise description of each procurement systems is attached herewith.

Thank you very much for your participation. Please kindly return the questionnaire within ONE WEEK time.

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Table 2: Description for each procurement system adopted to the survey

Procurement System	Description
Separated Systems	**The key characteristics of these systems are the rigid separation of design and construction phases and lack of integration across this boundary**
Measure and Pay	*Contractor is paid according to amount of work done as measured after the physical completion*
Lump Sum	*Contractor agrees to perform the work for one fixed price, regardless of the ultimate cost*
Prime Cost	*Contractor receiving only what spent plus and agreed amount to cover profits and overheads (Ex. Cost plus contacts, target cost contract, fee contracts)*
Integrated Systems	**The key feature of these system is the rigid integration of design and construction phases**
Design & Build	*The contractor provides the design and construction under one contract*
Package Deal	*The contractor provides the design and construction under one contract, but there is a implication that building provided will be of a standard or semi standardized type*
Turnkey	*The client has an agreement with one single administrative entity ,who provides the design and construction under one contract, and frequently effects and land acquisition, financing, leasing, etc.*
Private Finance Initiative	*PFI is a means where by the private sector can contribute to the provision of what has been regarded, traditionally as a public service. The promoter designs, builds, finances and operates the facility on behalf of the (public) client. (ex. BOOT,BOT)*
Management Oriented Systems	**The basic feature of these arrangements is the separation of management function from the design and construction**
Construction Management	*The construction manager is appointed at early stage to provide a planning ,management and co- ordination function*
Management Contracting	*Engaging a single contractor early to provide planning, management and co- ordination of construction who then sub contracts the work in normal manner.*
Collaborative Systems	**The basic principle of these systems is the collaboration between two or more parties to achieve successful project objectives through fair dealings ,commitment and shared investment**
Partnering	*A concept where organizations agree to work together for a period of time ,perhaps unspecified, on a basis of mutual trust and with common objectives there by optimizing each partner's strength*
Joint Venture	*A joint venture is the pooling of the assets and liabilities of two or more firms for the purpose of accomplishing a specific goal and on the basis of sharing profits or losses.*

Name of Respondent: .....
(Please enter a score from 10 to 110 for the utility value)

SELECTION CRITERIA		PROCUREMENT ARRANGEMENTS												
		Utility Factors (suitability of each factor against each procurement system)												
		Separated			Integrated					Management Oriented		Collaborative		
A	Clients' Requirements	Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture	
1	**Risk Management** Extent of the risk avoidance (shifting of risk) or risk minimization in terms of cost (specially financing risk), time, quality, design liability, ect. requirements of the project													
2	**Time Availability and Predictability** Requirement of time frame work for planning and designing, tendering and evaluation, speeding up the construction and minimizing time overruns of the project. (Requirement of early start of the project also deals with this)													
3	**Price Certainty** Awareness of the capital cost and maintenance cost requirement at the early stage of the project and completion with in the budget.													
4	**Price Competition** Requirement for open and fair competition to select the builder to achieve a lower contract sum													
5	**Accountability and Transparency** Extent of the accountability and the transparency requirement by client, consultants, contractors and other parties involved in the project													
6	**Flexibility for Changes** Extent to which, the system allows frequent changes in design & construction, and quick responses can be obtained to those changes according to clients specific requirements													

SELECTION CRITERIA		PROCUREMENT ARRANGEMENTS												
		Utility Factors (suitability of each factor against each procurement system)												
		Separated			Integrated					Management Oriented		Collaborative		
A	**Clients' Requirements**	Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture	
7	**Quality of Work** Extent of the requirement for design reliability, design innovation, workmanship, functionality and professional performance of the project													
8	**Responsibility and Parties Involvement** Extent to which the responsibility for completion of the programme, design and construction, is essential through the parties involved or performance of the professionals (or a single point responsibility is required)													
9	**Familiarity** Extent to which, the Client wants to choose a system which is familiar to him													
Project Characteristics														
1	**Project Cost and Funding method** This represents the total cost of the project and the funding method for the project													
2	**Project Complexity** This represents whether the project involves highly specialized, advanced technology, number of phases, highly serviced, nature of employee and employers required and size of project in terms of gross floor area													
3	**Project Type** This represents whether the project type is residential, social, industrial, commercial or infrastructure and its construction method along with degree of innovative technology involvement													

SELECTION CRITERIA		PROCUREMENT ARRANGEMENTS												
		Utility Values (suitability of each factor against each procurement system)												
		Separated			Integrated					Management Oriented		Collaborative		
B	**Project Characteristics**	Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture	
4	**Time Constrains** This represents need to have a tight time schedule for the woks of the project.													
5	**Degree of Flexibility** This represents whether the scope of the project is flexible or rigid and the integration of design & construction phases are allowed or not.													
6	**Payment Modality of the Project** This represents the payment modality of the project, such as measure and pay, lump sum, cost reimbursement, etc.													
C	**External Environment**													
1	**Market Condition for the project** This representing the market condition and its influences, which includes the market competitiveness, availability of experienced contractor, and the material availability.													
2	**Economic Condition & Fiscal Policy** The economic condition and its influences which includes the economic condition of the country, Aid, Donors, the position of the Government as a major client as well as a policy maker.													

SELECTION CRITERIA		PROCUREMENT ARRANGEMENTS												
		Utility Values (suitability of each factor against each procurement system)												
		Separated			Integrated					Management Oriented		Collaborative		
C	External Environment	Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture	
3	**Technology** This examines the technological capability and the influence of the Information Technology towards required for the project completion													
4	**Socio-cultural suitability** Socio cultural aspects which examines the social and the cultural impacts on the procurement selection. This includes the cultural difference, Education of the builders and the environmental issues influencing the project													
5	**Regulatory Environment** Influence of Regulatory environment in terms of government, government regulatory bodies as well as institutional bodies on selection process													

Annexure 3.4

QUESTIONNAIRE SURVEY: ROUND 4

RE ASSESSING THE UTILITY VALUES FOR DIFFERENT PROCUREMENT SYSTEMS

(Suitability of each factor against each procurement system)

Name of Respondent: .....

The following table shows the 'average' of the utility values provided by the 25 experts and your score provides in round 3 were also showed. Please enter a 'reconsidered' score in the following table if it is different from 'Your score'. Otherwise, please give a tick (✓) to indicate that the utility value remains the same.

Note: w = Kendall coefficient of concordance (the larger the w, the better the consistence among experts)
α = Significant level

A	Selection Criteria Client Requirements		PROCUREMENT ARRANGEMENTS											
			Utility Values (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
1	**Risk Management** Extent of the risk avoidance (shifting of risk) or risk minimization in terms of cost (specially financing risk), time, quality, design liability, ect. requirements of the project **(w = 0.1444, α = 0.000)**	Average	62.83	81.74	55.06	77.83	69.57	81.43	57.83	57.17	61.09	63.48	71.30	69.57
		Your score	80.00	70.00	50.00	70.00	80.00	80.00	50.00	70.00	80.00	60.00	50.00	50.00
		Reconsidered score												

A	Selection Criteria Client Requirements		PROCUREMENT ARRANGEMENTS											
			Utility Values (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
2	**Time Availability and Predictability** Requirement of time frame work for planning and designing, tendering and evaluation, speeding up the construction and minimizing time overruns of the project. (Requirement of early start of the project also deals with this)	Average	58.53	60.00	65.00	82.17	81.30	84.13	61.96	54.35	63.09	63.50	57.78	56.52
		Your score	85.00	60.00	60.00	90.00	100.0	90.00	60.00	60.00	60.00	50.00	60.00	50.00
		Reconsidered score												
3	**Price Certainty** Awareness of the capital cost and maintenance cost requirement at the early stage of the project and completion with in the budget.	Average	66.41	95.43	43.70	82.83	76.71	86.96	58.48	54.35	60.43	5857	50.57	52.74
		Your score	80.00	110.0	60.00	100.0	90.00	85.00	60.00	65.00	60.00	60.00	60.00	65.00
		Reconsidered score												
4	**Price Competition** Requirement for open and fair competition to select the builder to achieve a lower contract sum	Average	93.26	82.83	69.57	64.57	62.35	51.74	49.45	42.96	64.13	59.57	42.61	58.04
		Your score	90.00	100.0	60.00	70.00	70.00	60.00	60.00	50.00	70.00	70.00	50.00	60.00
		Reconsidered score												
5	**Accountability and Transparency** Extent of the accountability and the transparency requirement by client, consultants, contractors and other parties involved in the project	Average	89.13	76.30	84.57	57.17	56.52	51.09	57.70	54.48	72.98	70.13	69.78	70.26
		Your score	110.0	110.0	80.00	60.00	60.00	60.00	60.00	60.00	80.00	80.00	60.00	70.00
		Reconsidered score												

A	Selection Criteria Client Requirements		PROCUREMENT ARRANGEMENTS **Utility Values** (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
6	**Flexibility for Changes** Extent to which, the system allows frequent changes in design & construction, and quick responses can be obtained to those changes according to clients specific requirements	Average	95.43	38.70	78.70	51.96	50.87	38.48	56.30	51.30	71.70	68.48	70.22	66.04
		Your score	110.0	10.00	70.00	90.00	50.00	50.00	60.00	50.00	90.00	90.00	80.00	80.00
		Reconsidered score												
7	**Quality of Work** Extent of the requirement for design reliability, design innovation, workmanship, functionality and professional performance of the project	Average	77.61	72.17	67.00	67.78	64.57	59.70	62.74	57.57	78.35	78.35	75.82	76.30
		Your score	80.00	70.00	60.00	70.00	65.00	60.00	70.00	60.00	80.00	90.00	80.00	70.00
		Reconsidered score												
8	**Responsibility and Parties Involvement** Extent to which the responsibility for completion of the programme, design and construction, is essential through the parties involved or performance of the professionals (or a single point responsibility is required)	Average	67.87	70.13	60.43	72.90	67.39	74.35	68.91	68.08	70.57	69.74	69.35	71.09
		Your score	80.00	70.00	70.00	80.00	70.00	80.00	70.00	60.00	70.00	70.00	80.00	70.00
		Reconsidered score												
9	**Familiarity** Extent to which, the Client wants to choose a system which is familiar to him	Average	97.83	90.00	73.17	72.61	57.61	59.13	54.83	47.10	43.04	42.09	33.48	36.74
		Your score	100.0	100.0	80.00	90.00	70.00	70.00	60.00	90.00	70.00	60.00	40.00	40.00
		Reconsidered score												

B	Selection Criteria Project Characteristics		PROCUREMENT ARRANGEMENTS											
			Utility Values (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
1	**Project Cost and Funding method** This represents the total cost of the project and the funding method for the project	Average	63.04	90.13	59.57	78.04	71.76	82.78	54.35	56.13	63.26	59.78	60.77	63.91
		Your score	70.00	90.00	80.00	70.00	70.00	80.00	50.00	55.00	60.00	60.00	60.00	60.00
		Reconsidered score												
2	**Project Complexity** This represents whether the project involves highly specialized, advanced technology, number of phases, highly serviced, nature of employee and employers required and size of project in terms of gross floor area	Average	66.47	55.87	61.83	67.00	63.04	50.60	74.00	68.20	81.35	78.04	74.73	81.87
		Your score	80.00	60.00	60.00	70.00	60.00	80.00	80.00	60.00	100.0	90.00	80.00	70.00
		Reconsidered score												
3	**Project Type** This represents whether the project type is residential, social, industrial, commercial or infrastructure and its construction method along with degree of innovative technology involvement	Average	75.90	66.30	65.65	72.83	63.91	58.70	75.13	60.65	76.26	75.39	68.61	70.78
		Your score	100.0	70.00	70.00	70.00	70.00	60.00	70.00	80.00	80.00	80.00	80.00	66.00
		Reconsidered score												
4	**Time Constrains** This represents need to have a tight time schedule for the woks of the project.	Average	49.78	61.96	79.13	83.04	77.87	75.65	70.65	66.70	66.52	62.70	60.78	64.78
		Your score	50.00	60.00	80.00	80.00	75.00	80.00	90.00	60.00	70.00	65.00	60.00	60.00
		Reconsidered score												

B	Selection Criteria Project Characteristics		PROCUREMENT ARRANGEMENTS											
			Utility Values (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
5	**Degree of Flexibility** This represents whether the scope of the project is flexible or rigid and the integration of design & construction phases are allowed or not.	Average	89.35	50.39	73.91	54.74	49.13	42.77	56.74	46.30	69.13	69.35	73.00	66.26
		Your score	90.00	40.00	70.00	60.00	50.00	50.00	70.00	50.00	70.00	80.00	70.00	70.00
		Reconsidered score												
6	**Payment Modality of the Project** This represents the payment modality of the project, such as measure and pay, lump sum, cost reimbursement, etc.	Average	77.50	77.22	78.00	72.22	69.43	51.30	65.48	53.70	69.83	69.57	68.04	66.74
		Your score	100.0	100.0	100.0	70.00	80.00	55.00	80.00	50.00	80.00	60.00	60.00	60.00
		Reconsidered score												
C	**External Environment**													
1	**Market Condition** This representing the market condition and its influences, which include the market competitiveness, availability of experienced contractor, and the material availability.	Average	73.61	68.87	59.13	77.00	68.39	70.78	67.20	65.64	59.78	58.83	54.57	57.61
		Your score	100.0	95.00	45.00	85.00	50.00	60.00	80.00	105.0	35.00	35.00	50.00	65.00
		Reconsidered score												

C	Selection Criteria External Environment		PROCUREMENT ARRANGEMENTS **Utility Values** (suitability of each criterion against each procurement system)											
			Separated			Integrated					Management Oriented		Collaborative	
			Measure & Pay	Lump Sum	Prime cost	Design & Build	Package Deal	Turn Key	Develop and Construct	Private Finance Initiative	Construction Management	Management Contracting	Partnering	Joint Venture
2	**Economic Condition & Fiscal Policy** The economic condition and its influences which includes the economic condition of the country, Aid, Donors, the position of the Government as a major client as well as a policy maker.	Average	55.57	69.13	55.78	69.03	53.88	55.57	56.87	66.51	64.57	63.92	71.56	73.04
		Your score	75.00	75.00	75.00	75.00	20.00	20.00	50.00	40.00	80.00	80.00	45.00	100.0
		Reconsidered score												
3	**Technology** This examines the technological capability and the influence of the Information Technology towards required for the project completion	Average	53.91	53.48	47.83	78.04	63.17	71.87	64.43	65.75	62.83	61.39	73.04	74.78
		Your score	40.00	40.00	40.00	70.00	80.00	85.00	35.00	50.00	35.00	25.00	90.00	105.0
		Reconsidered score												
4	**Socio-cultural suitability** Socio cultural aspects which examines the social and the cultural impacts on the procurement selection. This includes the cultural difference, Education of the builders and the environmental issues influencing the project	Average	54.65	53.70	61.87	50.22	49.13	49.04	45.00	58.61	59.57	60.04	59.30	61.43
		Your score	85.00	95.00	60.00	80.00	55.00	55.00	50.00	65.00	40.00	40.00	45.00	30.00
		Reconsidered score												
5	**Regulatory Environment** Influence of Regulatory environment in terms of government, government regulatory bodies as well as institutional bodies on selection process	Average	54.35	52.91	51.39	59.57	59.35	62.35	64.57	69.91	66.74	63.70	65.66	68.04
		Your score	90.00	100.0	60.00	95.00	70.00	75.00	55.00	45.00	40.00	45.00	55.00	50.00
		Reconsidered score												

Table : Overall results of Delphi round 02

Annexure 5.1

	Selection Criteria	To what extent do you think the criterion influence the choice of procurement system?			Total Frequency	Percentage %	Severity Index	Mean	Rank	Standard Deviation	COV	COV %
		VI	I	NI								
	Clients' Requirements											
	Cost Requirements *How well the following cost related requirements influence the choice of procurement system*											
1	Capital Cost	18	9	3	30	90.00%	83.33%	2.50	10	0.682	0.273	27.29%
2	Maintenance Cost	8	14	8	30	73.33%	66.67%	2.00	25	0.743	0.371	37.14%
3	Prequalification and tendering cost	5	17	8	30	73.33%	63.33%	1.90	27	0.662	0.348	34.83%
4	Financial Risk	20	8	2	30	93.33%	86.67%	2.60	6	0.621	0.239	23.90%
6	Price competition	14	15	1	30	96.67%	81.11%	2.43	14	0.568	0.234	23.36%
5	Completion with in the budget	23	6	1	30	96.67%	91.11%	2.73	1	0.521	0.191	19.05%
	Time Requirements *How well the following time related requirements influence the choice of procurement system*											
7	Planning and designing time	18	12	0	30	100.00%	86.67%	2.60	6	0.498	0.192	19.16%
8	Tendering and evaluation time	14	16	0	30	100.00%	82.22%	2.47	12	0.507	0.206	20.57%
9	Construction time	20	10	0	30	100.00%	88.89%	2.67	2	0.479	0.180	17.98%
10	The Early start of project	22	5	3	30	90.00%	87.78%	2.63	3	0.728	0.276	27.64%
11	Speed of construction	12	18	0	30	100.00%	80.00%	2.40	15	0.498	0.208	20.76%
12	Time overruns	16	13	1	30	96.67%	83.33%	2.50	10	0.626	0.250	25.04%
13	Quick responses to the clients' new requirements (Extra works and variations)	17	12	1	30	96.67%	84.44%	2.53	9	0.571	0.226	22.55%
14	Maximizing of activities interfacing	7	20	3	30	90.00%	71.11%	2.13	23	0.556	0.261	26.07%
15	Stage completion	4	16	10	30	66.67%	60.00%	1.80	32	0.664	0.369	36.91%

	Selection Criteria	To what extent do you think the criterion influence the choice of procurement system?			Total Frequency	Percentage %	Severity Index	Mean	Rank	Standard Deviation	COV	COV %
		VI	I	NI								
	Clients' Requirements											
	Quality Requirements *How well the following time related requirements influence the choice of procurement system*											
16	Design Reliability	19	11	0	30	100.00%	87.78%	2.63	1	0.490	0.186	18.61%
17	Aesthetic appearance of the building	7	13	10	30	66.67%	63.33%	1.90	14	0.759	0.399	39.94%
18	Workmanship	9	17	4	30	86.67%	72.22%	2.17	10	0.648	0.299	29.89%
19	Functionality (Suitability for the intend users)	11	14	5	30	83.33%	73.33%	2.20	8	0.714	0.325	32.47%
20	Design innovation	12	15	3	30	90.00%	76.67%	2.30	5	0.651	0.283	28.32%
	General Requirements *How well the following requirements influence the choice of procurement system*											
21	Allocation of responsibilities	15	14	1	30	96.67%	82.22%	2.47	4	0.571	0.232	23.16%
22	Professional team performances	18	12	0	30	100.00%	86.67%	2.60	3	0.498	0.192	19.16%
23	Parties involvement	20	9	1	30	96.67%	87.78%	2.63	1	0.556	0.211	21.12%
24	Accountability	10	19	1	30	96.67%	76.67%	2.30	5	0.535	0.233	23.26%
25	Transparency	8	21	1	30	96.67%	74.44%	2.23	7	0.504	0.226	22.57%
26	Safety requirements	5	16	9	30	70.00%	62.22%	1.87	15	0.681	0.365	36.51%
27	Corporation and motivation	5	16	9	30	70.00%	62.22%	1.87	15	0.681	0.365	36.51%
28	Existing building operation	2	10	18	30	40.00%	48.89%	1.47	19	0.629	0.429	42.87%
29	Familiarity	7	17	6	30	80.00%	67.78%	2.03	12	0.643	0.316	31.64%
30	Tender evaluation criteria	8	13	9	30	70.00%	65.56%	1.97	13	0.765	0.389	38.89%
31	Clear expression of end user's requirements	12	12	6	30	80.00%	73.33%	2.20	8	0.761	0.346	34.60%

	Selection Criteria	To what extent do you think the criterion influence the choice of procurement system?			Total Frequency	Percentage %	Severity Index	Mean	Rank	Standard Deviation	COV	COV %
		VI	I	NI								
Clients' Requirements												
32	Flexibility	8	19	3	30	90.00%	72.22%	2.17	21	0.592	0.273	27.33%
33	Consultant attitude towards the client	6	9	15	30	50.00%	**56.67%**	**1.70**	33	0.794	0.467	46.73%
34	Type of clients	5	16	9	30	70.00%	**62.22%**	**1.87**	29	0.681	0.365	36.51%
Project Characteristics												
	How well the following project characteristics influence the choice of procurement system											
1	Project Type	15	13	2	30	93.33%	81.11%	2.43	4	0.626	0.25729	25.73%
2	Project Size	12	14	4	30	86.67%	75.56%	2.27	7	0.691	0.30507	30.51%
3	Project Cost	18	10	2	30	93.33%	84.44%	2.53	3	0.629	0.24821	24.82%
4	Degree of Flexibility	11	18	1	30	96.67%	77.78%	2.33	6	0.547	0.23429	23.43%
5	Degree of Complexity	17	13	0	30	100.00%	85.56%	2.57	1	0.504	0.19637	19.64%
6	Time Constraints	18	11	1	30	96.67%	85.56%	2.57	1	0.568	0.22142	22.14%
7	Payment Method of the project	15	13	2	30	93.33%	81.11%	2.43	4	0.626	0.25729	25.73%
8	Integration of Design and Construction	11	15	4	30	86.67%	74.44%	2.23	9	0.679	0.30399	30.40%
9	Project Funding Method	9	15	6	30	80.00%	70.00%	2.10	10	0.712	0.33903	33.90%
10	Project Site Location	3	12	15	30	50.00%	**53.33%**	**1.60**	13	0.675	0.42167	42.17%
11	Site Risk Factors	6	16	8	30	73.33%	**64.44%**	**1.93**	12	0.691	0.35767	35.77%
12	Construction Method	9	20	1	30	96.67%	75.56%	2.27	7	0.521	0.22978	22.98%
13	Degree of Innovative Technology Involvement	7	19	4	30	86.67%	70.00%	2.10	10	0.607	0.28925	28.93%

	Selection Criteria	To what extent do you think the criterion influence the choice of procurement system?			Total Frequency	Percentage %	Severity Index	Mean	Rank	Standard Deviation	COV	COV %
		VI	I	NI								
	External Environment											
	How well the following factors from external environment influence the choice of procurement system											
1	Market Competitiveness	11	17	2	30	93.33	76.67	2.30	3	0.868	0.3775	37.75
2	Technological Feasibility	9	18	3	30	90.00	73.33	2.20	5	0.876	0.3983	39.83
3	Regulatory Feasibility	9	12	9	30	70.00	66.67	2.00	9	1.095	0.5477	54.77
4	Experienced Contractor Availability	14	13	3	30	90.00	78.89	2.37	1	0.930	0.3929	39.29
5	Education of Builders	7	21	2	30	93.33	72.22	2.17	6	0.785	0.3622	36.22
6	Material Availability	8	14	8	30	73.33	66.67	2.00	9	1.033	0.5164	51.64
7	Scarcity of natural Material	3	14	13	30	56.67	55.56	1.67	**17**	0.911	0.5465	54.65
8	Weather & Natural Disaster	3	7	20	30	33.33	47.78	1.43	**21**	1.006	0.7016	70.16
9	Cultural Differences	10	10	10	30	66.67	66.67	2.00	9	1.155	0.5774	57.74
10	Government as a policy maker	7	16	7	30	76.67	66.67	2.00	9	0.966	0.4830	48.30
11	Government as a major Client	8	17	5	30	83.33	70.00	2.10	8	0.928	0.4419	44.19
12	Finance For the Project : Donors	14	12	4	30	86.67	77.78	2.33	2	0.974	0.4173	41.73
13	Finance For the Project : Aid	12	14	4	30	86.67	75.56	2.27	4	0.962	0.4245	42.45
14	Economic condition of the country	11	13	6	30	80.00	72.22	2.17	6	1.030	0.4752	47.52
15	Information Technology	8	14	8	30	73.33	66.67	2.00	9	1.033	0.5164	51.64
16	Institutional Bodies	2	15	13	30	56.67	54.44	1.63	**18**	0.826	0.5055	50.55
17	Industrial Actions	6	11	13	30	56.67	58.89	1.77	**16**	1.099	0.6219	62.19
18	Objections from Neighbors / Public	3	8	19	30	36.67	48.89	1.47	**20**	0.997	0.6801	68.01
19	Civil War Condition	5	8	17	30	43.33	53.33	1.60	**19**	1.127	0.7042	70.42
20	Environmental Issues	7	16	7	30	76.67	66.67	2.00	9	0.966	0.4830	48.30
21	Good Will of the Contractor	6	15	9	30	70.00	63.33	1.90	**15**	0.989	0.5208	52.08

Correlation Matrix for Clients' Requirements

Annexure 5.2

	SC	CC	MC	FR	PC	CWB	PADT	TET	CT	ESOP	SC	TO	QRCNR	MAI	DR	Wsp	Func	DI	AR	PTP	PI	Acc	Trans	Fami	CEEUR	Fle
Correlation	CC	1.000																								
	MC	0.408	1.000																							
	FR	0.081	0.000	1.000																						
	PC	-0.133	-0.327	0.020	1.000																					
	CWB	-0.097	-0.178	0.618	0.171	1.000																				
	PADT	0.203	0.093	0.245	0.024	0.239	1.000																			
	TET	-0.199	0.000	0.175	0.351	0.357	0.082	1.000																		
	CT	0.105	-0.097	-0.116	0.042	-0.092	-0.144	-0.189	1.000																	
	ESOP	-0.243	-0.383	-0.015	0.386	-0.133	-0.209	0.006	-0.231	1.000																
	SC	-0.203	-0.280	0.200	0.341	0.292	0.111	0.191	0.144	0.114	1.000															
	TO	0.202	0.148	0.195	0.326	0.155	0.243	0.101	0.153	-0.179	0.420	1.000														
	QRCNR	0.088	0.000	0.039	0.326	0.147	-0.194	0.063	-0.084	0.160	0.194	0.199	1.000													
	MAI	-0.136	0.000	0.439	0.389	0.508	0.174	0.310	0.043	-0.048	0.448	0.353	0.051	1.000												
	DR	0.155	0.095	0.294	-0.029	0.279	0.226	0.018	0.049	-0.171	0.198	0.311	0.230	0.173	1.000											
	Wsp	0.429	0.143	-0.171	0.078	-0.170	0.107	-0.140	0.185	0.012	0.214	0.241	0.311	-0.016	0.199	1.000										
	Func	0.141	0.130	-0.124	0.204	0.056	0.232	0.019	0.101	0.040	0.058	0.031	0.406	0.243	0.118	0.224	1.000									
	DI	-0.272	-0.214	0.392	0.289	0.244	0.170	0.292	0.000	0.065	0.468	0.262	0.204	0.257	0.248	-0.123	0.015	1.000								
	AR	-0.177	-0.325	0.155	0.205	0.317	-0.048	0.293	-0.042	0.337	0.170	-0.006	0.056	0.058	-0.107	-0.124	0.017	-0.111	1.000							
	PTP	0.406	0.093	0.134	0.024	0.106	0.444	-0.191	0.000	-0.209	-0.028	0.133	-0.073	-0.075	0.226	0.214	0.039	0.170	-0.170	1.000						
	PI	0.318	0.083	-0.040	-0.025	0.008	0.199	0.016	0.431	-0.236	0.050	0.175	-0.123	0.152	0.249	0.271	0.191	-0.352	0.232	0.324	1.000					
	Acc	0.142	0.087	0.373	-0.102	0.173	0.336	-0.279	0.403	-0.186	0.181	0.113	-0.090	0.197	0.434	0.149	0.379	0.228	-0.135	0.336	0.267	1.000				
	Trans	0.351	-0.092	-0.022	-0.004	-0.280	0.110	-0.306	0.190	0.097	-0.110	-0.222	-0.208	-0.152	0.219	0.299	0.153	-0.221	-0.271	0.247	0.316	0.371	1.000			
	Fami	0.038	-0.069	-0.216	-0.130	-0.073	-0.373	0.156	-0.072	0.102	0.062	0.047	0.223	-0.374	0.144	0.146	-0.159	0.055	0.048	-0.166	-0.059	-0.222	-0.126	1.000		
	CEEUR	0.332	0.244	0.539	-0.128	0.487	0.491	0.107	0.094	-0.336	0.236	0.391	0.063	0.391	0.481	0.070	0.178	0.223	0.016	0.400	0.261	0.525	-0.126	-0.285	1.000	
	Fle	0.043	0.235	-0.094	-0.017	-0.075	0.117	0.077	-0.283	-0.067	0.117	0.171	0.442	0.087	0.574	0.285	0.245	0.045	-0.238	0.117	0.192	0.054	0.096	0.160	0.230	1.000

Annexure 5.3

Correlation Matrix for Project Characteristics

		PT	PS	PC	DF	DC	TC	PM	INDC	PFM	CM	DITI
Correlation	PT	1.000										
	PS	0.042	1.000									
	PC	0.181	0.137	1.000								
	DF	0.067	0.030	0.167	1.000							
	DC	0.069	-0.053	0.428	0.292	1.000						
	TC	-0.326	-0.047	-0.006	0.148	0.165	1.000					
	PM	0.208	-0.356	0.181	-0.134	0.178	0.061	1.000				
	INDC	0.160	-0.064	0.183	0.248	0.205	0.182	0.241	1.000			
	PFM	0.054	0.504	0.339	0.089	0.029	-0.145	0.132	0.307	1.000		
	CM	0.162	0.274	0.288	0.161	0.193	0.287	0.056	-0.085	0.298	1.000	
	DITI	0.245	0.016	0.036	0.312	0.034	0.130	0.154	0.276	0.056	0.349	1.000

Annexure 5.4

Correlation Matrix for External Environmental factors

		MC	TF	RF	ECA	EOB	MA	CD	GPM	GMC	FFD	FFA	ECC	IT	EI
Correlation	MC	1.000													
	TF	0.006	1.000												
	RF	0.425	0.219	1.000											
	ECA	0.253	0.121	0.360	1.000										
	EOB	0.028	0.203	0.188	0.598	1.000									
	MA	0.407	-0.123	0.425	0.228	0.047	1.000								
	CD	0.142	0.142	0.215	-0.020	0.215	0.165	1.000							
	GPM	0.015	0.015	0.032	-0.142	-0.534	0.140	-0.087	1.000						
	GMC	0.108	-0.015	0.326	0.142	-0.376	0.228	-0.142	0.709	1.000					
	FFD	0.273	0.273	0.434	0.004	-0.282	0.335	-0.004	0.519	0.721	1.000				
	FFA	0.273	0.273	0.514	0.106	-0.146	0.417	-0.004	0.423	0.625	0.915	1.000			
	ECC	-0.040	0.363	0.351	0.075	0.199	0.045	0.299	0.332	0.454	0.249	0.249	1.000		
	IT	0.343	0.239	0.444	0.237	0.273	0.225	0.443	-0.015	0.196	0.272	0.353	0.535	1.000	
	EI	0.136	0.136	0.091	0.538	0.497	0.017	0.253	-0.138	-0.108	-0.163	-0.053	0.141	0.285	1.000

Annexure 7.1 : More system interfaces for report and a sample report

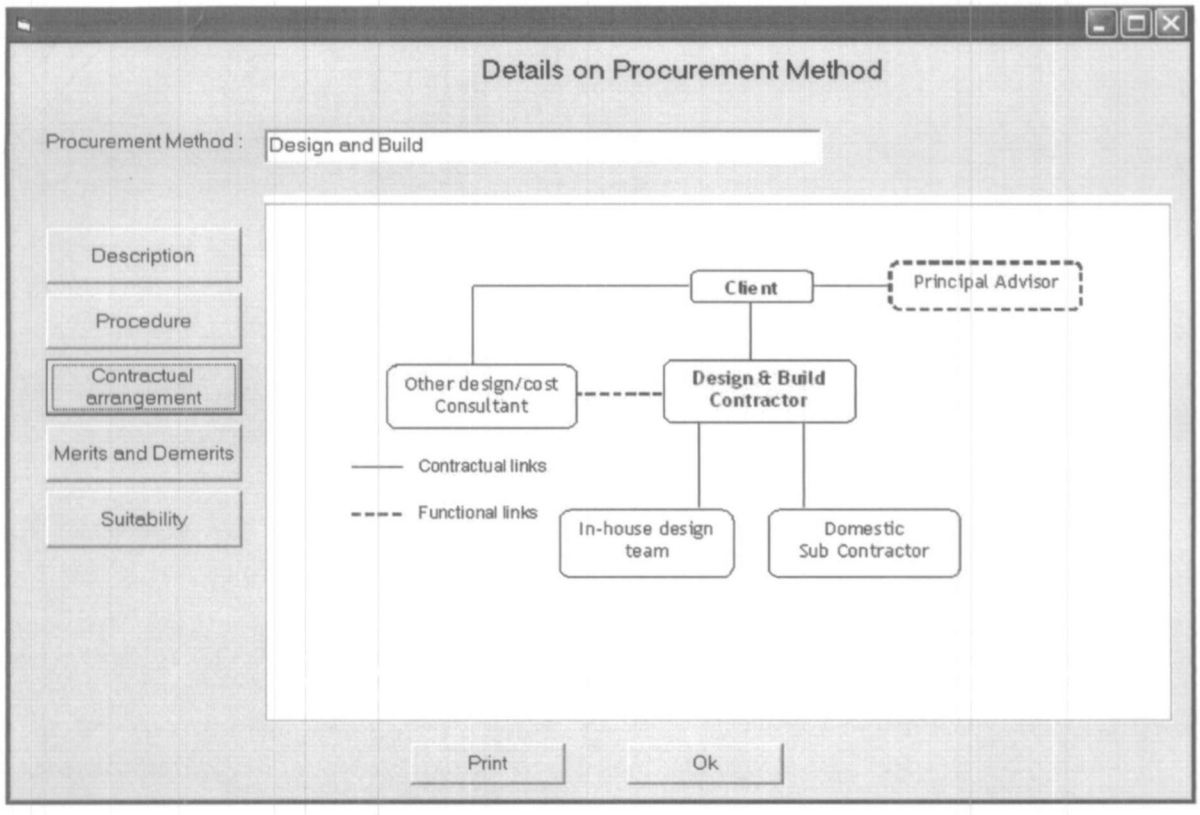


Figure: Report on selected procurement option – Contractual arrangements

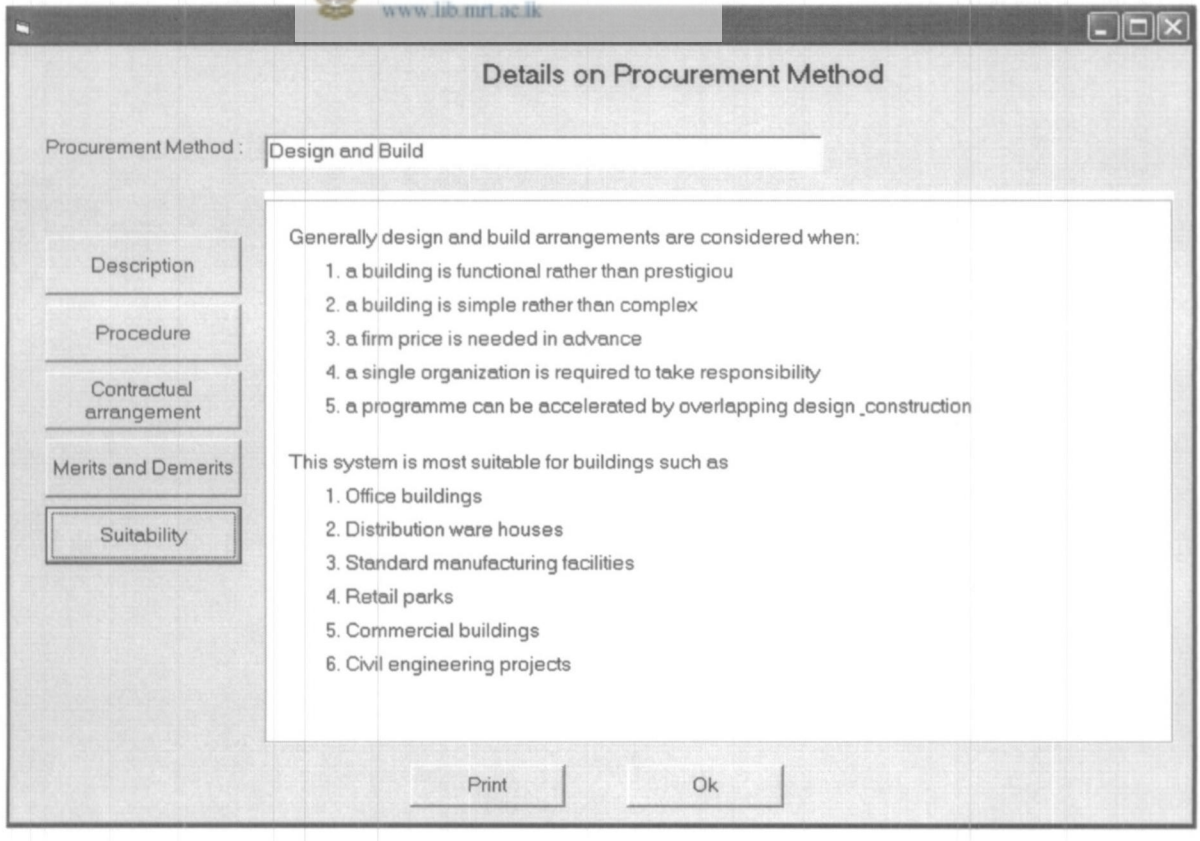


Figure: Report on selected procurement option – Suitability

DSS ~ CONSTRUCTION PROCUREMENT

Decision Support System for Construction Procurement Selection

Procurement Method: Design and Build

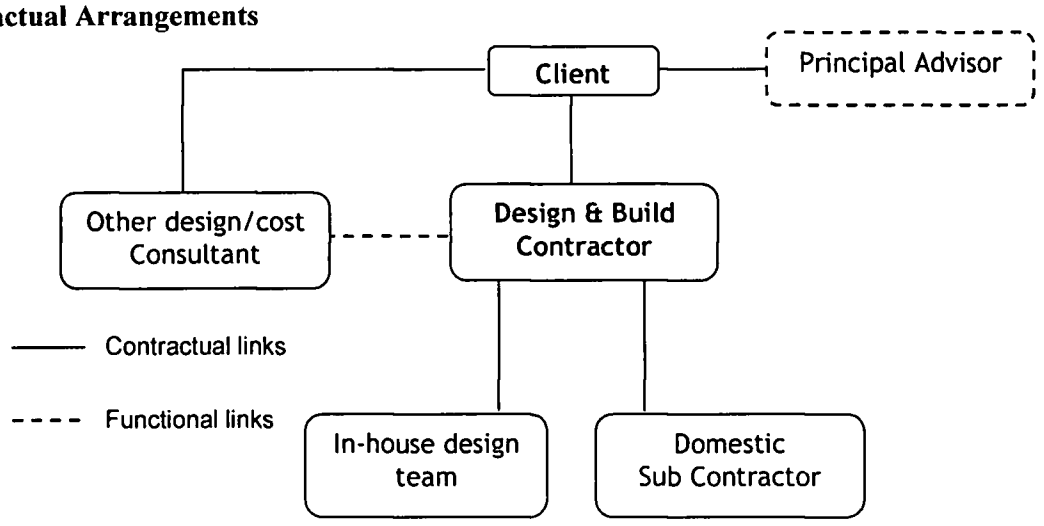
Description:

This system simply means that one contracting organization offers to undertake the sole responsibility of design and construction of a project normally on a lump sum fixed price basis. The key characteristics of the DB arrangements are the single point of responsibility offered to the client by contractor and the overlapping of design and construction phases. Although, the contractor assumes the overall responsibility for the project delivery, the client may appoint an independent advisor to monitor quality and cost. Preparation of concept design and performance specifications for the project, obtaining tenders, evaluation of the contractors' proposals, recommendation of most appropriate contractor are done by the independent advisor, who is often an design/cost consultant.

Procedure:

- Prepare tender document
- Call for open tenders on selected medium
- Evaluate of tenders (pre qualification, post qualifications)
- Prepare the technical report with financial evaluation
- Recommendation report to client
- Select suitable contractor based on evaluation
- Closing of singing the agreement
- Award of contract

Contractual Arrangements



12/11/06 *1*

DSS ~ CONSTRUCTION PROCUREMENT

Decision Support System for Construction Procurement Selection

Procurement Method: Design and Build

Merits:

- There is a single pint of responsibility
- Fixed priced bids are used
- Client's financial risk is minimal
- Design and construction ate integrated
- Total duration is reduced
- Time and cost overruns are less likely to occur
- Client's involvement can be minimized

Demerits:

- Lack of independent ant professional advice to client
- Low level of competition
- Requires a detailed client's brief
- Flexibility to changes is less and expensive
- Client's control of quality & functionality is minimized
- Tender price can be expensive to bidder

Suitability:

Generally design and build arrangements are considered when a:

- building is functional rather than prestigious
- building is simple rather than complex
- firm price is needed in advance
- single organization is required to take responsibility
- programme can be accelerated by overlapping design & construction

This system is most suitable for buildings such as

- Office buildings
- Distribution ware houses
- Standard manufacturing facilities
- Retail parks
- Commercial buildings
- Civil engineering projects

A DECISION SUPPORT SYSTEM FOR THE SELECTION OF APPROPRIATE SYSTEM IN CONSTRUCTION

Aim: The primary aim of the proposed comprehensive study on construction procurement is to investigate challenges associated with the development of Decision Support Model for the selection of best procurement system in construction. This model is developed to assist the clients in initial decision making on procurement selection and the model is capable of ensuring systematic approach and increasing the consistency in selection process.

This interview is conducted to obtain expert opinions on:

- Suitability of research methodology adopted
- Decision Support Model and software (prototype)
- Applicability of the model and its benefits
- Shortcomings, suggestions and improvements pertaining to thedeveloped model

GENERAL INFORMATION

Name of Researcher : Miss. Shiyamini Ratnasabapathy

Name of Supervisors : Dr.R.Rameezdeen and Prof.Chitra Weddikkara

1) Name of the respondent:

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2) Job title:

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3) Experience in the field :

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INTERVIEW GUIDLINES

1. DECISION SUPPORT SYSTEM

1) In general do you think this model will provide assistance to Clients or their consultants/principal advisors in procurement selection process?

Yes ☐ No ☐

a). If yes, state reasons for considering so (refer the following features)?

- ☐ A knowledge base on construction procurement selection
- ☐ A realistic and systematic approach for selection
- ☐ Assures the selection of best procurement system
- ☐ Decision support tool for construction procurement selection
- ☐ Reports on selected procurement method
- ☐ Others (please state in the space given below)

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b). If No, give reasons for not considering so?

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2) Do you consider this model provides good assistance for inexperienced clients in selecting an optimum procurement system for his project?

Yes ☐ No ☐

a). If yes, state reasons for considering so (refer the following features)?

- ☐ A knowledge base on construction procurement selection
- ☐ A realistic and systematic approach for selection
- ☐ Assure the selection of best procurement system
- ☐ Decision support tool for construction procurement selection
- ☐ Reports on selected procurement method
- ☐ Provide awareness of several influencing factors and alternative procurement methods and their applicability
- ☐ Others (Please specify in the given space)

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b). If No, give reasons for not considering so?

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3) What are the shortcomings associated with this model?

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4) What are the suggestions for the further improvement of this model?

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5) What is your opinion on enhancement of this model to a computer aided software tool?

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2. RESEARCH METHODOLOGY: Application of Delphi and MAUT

6) What is your opinion on applicability of

a) **Delphi** for obtaining utility values :

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b) **Multi Attributer Utility Techniques** (MAUT) to develop the procurement selection model:

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