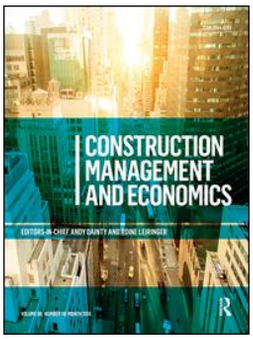

Routledge
Taylor & Francis Group

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

Application of Delphi method in selection of procurement systems for construction projects

Albert P. C. Chan , Esther H. K. Yung , Patrick T. I. Lam , C. M. Tam & S. O. Cheung

To cite this article: Albert P. C. Chan , Esther H. K. Yung , Patrick T. I. Lam , C. M. Tam & S. O. Cheung (2001) Application of Delphi method in selection of procurement systems for construction projects, Construction Management and Economics, 19:7, 699-718, DOI: 10.1080/01446190110066128

To link to this article: https://doi.org/10.1080/01446190110066128

Published online: 21 Oct 2010.

Submit your article to this journal

Article views: 2504

View related articles

Citing articles: 58 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=rcme20

Construction Management and Economics (2001) **19**, 699–718

Application of Delphi method in selection of procurement systems for construction projects

ALBERT P. C. CHAN[1]*, ESTHER H. K. YUNG[1], PATRICK T. I. LAM[1], C. M. TAM[2], and S. O. CHEUNG[2]

[1]*Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Hong Kong, PR China*

[2]*Department of Building and Construction, City University of Hong Kong, PR China*

Received 8 November 2000; accepted 10 May 2001

A number of procurement selection systems have been developed over the last decade. The use of multi-attribute decision analysis has been considered the foremost technique for examining client needs and the weightings of preferences from experts for each procurement system in the most objective way available. However, the major difficulty of these selection models lies in the lack of consensus among the experts on the utility factor of the selection criteria. To overcome these deficiencies, a Delphi technique was adopted to develop a multi-attribute model. Four rounds of Delphi surveys were conducted. A statistically significant consensus on the weighting of the utility factors for each procurement system was obtained from eight experts. The results vividly reveal that the Delphi method is a powerful and appropriate technique for deriving objective opinions in a rather subjective area such as the multi-attribute model for the selection of procurement system.

Keywords: Procurement system, multi-attribute selection model, Delphi method

Introduction

It is claimed that the correct choice of a building delivery method will lead to the success of a building project (Bennett and Grice, 1990; Chan, 2000). Hence selecting an appropriate procurement system is an essential step in any construction project process. If a client makes a wrong choice, the penalty may be time and cost overrun and general dissatisfaction. Despite considerable research into the choice of appropriate procurement systems for construction projects, no generally applicable solutions have been found (Skitmore and Marsden, 1988; Bennett and Grice, 1990; Chan, 1995; Love *et al.*, 1998). It appears that the appropriate solution is in each case largely a function of various factors (NEDO, 1985; Brandon *et al.*, 1988; Masterman, 1992; Chan *et al.*, 1994; Liu, 1994; Dell'Isola *et al.*, 1998; Franks, 1998). Love *et al.* (1998) state that the use of multi-attribute decision analysis (MADA) in a procurement selection system has been seen as the foremost technique for examining client needs and for weighting the preferences from experts for each procurement system in the most objective way available. The MADA approach utilizes a score or utility factor, which is determined by industry experts for each criterion (client need, project characteristic, risk allocation, etc.) for each procurement system. The utility factors are in effect a relative measurement of the suitability of a certain procurement path for a given criterion (Fellows and Langford, 1980). This provides a more objective analysis to alleviate the inconsistency and subjectivity in the decision-making process due to emotional or environmental conditions.

Several procurement selection systems have been developed over the last decade, varying from simple rating systems to more complex multi-attribute and matrix-based systems (Tucker and Ambrose, 1999). Some of the systems available and their basic methodology are given in Table 1 (Tucker and Ambrose,

*Author for correspondence. e-mail: bsachan@polyu.edu.hk

Construction Management and Economics
ISSN 0144–6193 print/ISSN 1466-433X online © 2001 Taylor & Francis Ltd
http://www.tandf.co.uk/journals
DOI: 10.1080/01446190110066128

1999). All these systems have attempted to provide a mechanism that allows procurement systems to be assessed against a set of possible client needs, by rating how well the procurement system can satisfy those needs. Some have also included limited project-specific characteristics and weighting systems to emphasize particular requirements (Tucker and Ambrose, 1999).

In most of these systems, three to five experts were asked to subjectively assess the utility factor; there lies always a problem of consistency in adopting this technique to obtain the utility factors for the multi-attribute model. The results were averaged and recorded as the utility factors for the corresponding criteria. Solely averaging the selected experts' utility factors to obtain a reasonable level of consistency amongst these factors is questionable. Previous research on procurement selection (Ireland, 1985; Love *et al.*, 1998) has mentioned the major difficulties associated with the procurement selection model. First, there has been no consensus found amongst 'experts' that easily systemizes procurement selection (Love *et al.*, 1998; Skitmore and Marsden, 1988). Second, there has not been a mutually exclusive set of criteria that uniquely and completely determines the appropriate procurement method for a specific project (Ireland, 1985).

To overcome these shortcomings, a Delphi technique was adopted to develop a multi-attribute model. Four rounds of Delphi surveys were conducted. The iterations of the Delphi exercise allowed the experts to modify their weighting of the utility factors and project them beyond their own subjective opinions. A more reliable result could be achieved. A statistically significant consensus on the weighting of the utility factors for each procurement system was obtained from eight experts. The aim of this paper is to report how the Delphi technique was used first to generate a list of selection criteria and second to derive a consensus on the weighting of the utility factors. The effectiveness of the Delphi method will be evaluated and the difficulties in conducting a Delphi survey will be discussed. Finally, a procurement selection model is developed based on the criteria and utility factors derived from the Delphi survey.

Research method: the Delphi technique

The Delphi technique is being increasingly used in many complex areas in which a consensus is to be reached. Some of these areas included the development of residential areas (Anatharajan and Anataraman, 1982), theory and design application (Corotis *et al.*, 1981), and bridge condition rating and effects of improvements (Saito and Sinha, 1991). Moreover, the Delphi method is a highly formalized method of communication that is designed to extract the maximum amount of unbiased information from a panel of experts. Therefore, it would be appropriate to adopt the Delphi technique for obtaining a set of universal utility factors for the selection model for procurement systems.

Delphi background

The Delphi concept was developed from the American defence industry. Project Delphi was the name of a

Table 1 Existing procurement selection systems (adopted and expanded from Tucker and Ambrose, 1999, p.103)

Author	Year	Description
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.
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.
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.
Dell'Isola *et al.*	1999	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.

study undertaken by the Rand Corporation for the US Air Force in the early 1950s concerning the use of expert opinion (Robinson, 1991). The objective of the study was to 'obtain the most reliable consensus of opinion of a group of experts by a series of intensive questionnaires interspersed with controlled opinion feedback' (Linstone and Turoff, 1975). It was originally developed for market research and sales forecasting purposes (Goldfisher, 1992).

The Delphi method can be characterized 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 complex problems. Delphi is primarily a communication device, which is applied when the consensus of experts on an uncertain issue, often intangible, is desired (Linstone and Turoff, 1975). It is conducted by rounds interspersed with group opinion and information feedback in the form of relevant statistical data. Delphi is an iterative forecasting procedure characterized by three features (Dickey and Watts 1978): anonymity; iteration with controlled feedback; and statistical response.

Panel members remain unknown to one another and respond to a series of questionnaires. The iterative nature of the procedure generates new information for panelists in each round, enabling them to modify their assessments and project them beyond their own subjective opinions. It can represent the best forecast available from a consensus of experts (Corotis *et al.*, 1981).

The Delphi approach offers an additional advantage in situations where it is important to define areas of uncertainty or disagreement among experts. In these instances, Delphi can highlight topics of concern and evaluate uncertainty in a quantitative manner. Group evaluation of belief statements made by panel members is an explicit part of Delphi (Robinson, 1991). Goldstein (1975) correctly points out that, although the group view has a higher probability of being correct than an individual, its success depends principally on the careful selection of the panel and the formulation of questions. The major difficulties of Delphi, however, lie in maintaining the high level of response and in reaching and implementing a consensus (Robinson, 1991).

Format of Delphi rounds

The Delphi method adopted in this research consisted of four rounds. In the first and second rounds of Delphi questionnaire, it was intended to gather a set of exclusive selection criteria for the procurement system in the Hong Kong construction industry. The respondents were asked to provide a minimum of five criteria for the selection of the most appropriate procurement system in the first round Delphi. The second round of the questionnaire dealt with all the criteria provided in the first round, and experts were asked to state the importance of each criterion. In the third round of questionnaire, a list of criteria with corresponding questions was presented, and the respondents were requested to assess the suitability of each procurement system against each selection criterion.

While analysing the data, the focus should be on the opinion of the group rather than that of individuals. Therefore a concordance analysis, which measures the consistency of the experts' responses over successive rounds of the Delphi, was adopted. In the fourth round of the Delphi, respondents were provided with results from round three. They were asked to reconsider the scores of the utility factors and see whether they would adjust them. The consistency of the results over the last two rounds were analysed and compared. The questions asked in the four rounds of the Delphi survey are detailed in Appendices A, B, C and D, respectively.

Selection of the expert panel

The success of Delphi method depends principally on the careful selection of the panel. A group of experts was selected to provide opinions on the suitability of a certain procurement path for a given criterion. Since the information solicited requires in-depth knowledge and sound experience about the various procurement options, a purposive approach was adopted to select this focused group of experts (Bryman, 1996; Morgan, 1998; Edmunds, 1999). The following criteria were devised to correctly identify eligible participants for the Delphi surveys.

1. Practitioners to have extensive working experience in the construction industry in Hong Kong.
2. Experts to be currently, recently or directly involved in the management of construction projects in Hong Kong.
3. Experts to have a detailed knowledge of all the procurement options.

In order to obtain the most valuable opinions, only practitioners who met all the sampling criteria were selected. The ten members of the panel represent a wide distribution of professional people, with four from public client organizations, three from private consultant groups, and three who were academics in the universities in Hong Kong. The composition of this group of experts provides a balanced view for the Delphi survey. A list of the panel members and their positions in the corresponding companies is given in Table 2, although the names of the experts and their organizations are faked to respect their anonymity.

Table 2 List of the panel of experts for the Delphi method

Name	Position	Sector	Organizations currently work for
1.Mr. A	Assistant director (quantity surveyor)	Public	AA Department
2.Mr. B	Principal assistant secretary	Public	BB Bureau
3.Mr. C	Assistant director, (architectural services)	Public	AA Department
4.Dr. D	Executive manager (capital works)	Public	CC Authority
5.Mr. E	Director	Private	DD Quantity Surveyors
6.Mr. F	Project director	Private	EE HK. Ltd.
7.Mr. G	General manager and Director	Private	FF Properties Ltd.
8.Dr. H	Associate professor	Academic	The University of GG
9.Dr. I	Associate professor	Academic	The University of GG
10.Dr. J	Acting head and Associate professor	Academic	The HH University

Delphi round one: identifying the selection criteria

Format

The first round of Delphi questionnaire, accompanied by an invitation letter, was sent to the panel members. The letter explained the purpose of the research, and the experts were informed that there would be four rounds of questionnaires. In the first round of Delphi, experts were asked to provide at least five major criteria that they considered to influence the selection of a procurement system in the construction industry of Hong Kong. In the questionnaire (Appendix A), a list of nine criteria that had been found from previous research studies and literature were also included for their reference. These were: time; time certainty; cost certainty; price competition; flexibility to changes; complexity of project; quality; responsibility; and risk avoidance.

Results and analysis

The criteria suggested by the experts were carefully analysed and a list of criteria was formed. Table 3 shows all the criteria provided by experts in the round one Delphi questionnaire. Altogether 23 criteria were identified. Also there were some criteria which had not been suggested by the panel of experts but were identified as a result of the literature survey. They were included in the list of the important factors in the selection of most appropriate procurement system. These criteria are shown in Table 4. Criteria, which conveyed similar meanings were combined and rephrased. For example, availability of expertise was rephrased and combined with availability of competent contractors; overlapping of design and construction was combined with responsibility; nature of the project was combined with complexity; value for money, public accountability, source of finance, authority, and state of market were rephrased and combined with price competition. Sixteen criteria were consolidated to form a list of criteria for the second round of Delphi. Their frequencies were recorded and the criteria were categorized into four groups as indicated in Table 5.

Table 3 Criteria provided by the panel of experts in round one Delphi

Criteria	Frequency of criterion by experts
Familiarity	20 %
Distrust of new system	10 %
Test problem which give rise to less problem	10 %
Size of the project (GFA, Contract sum)	20 %
Nature of the project	20 %
Complexity	40 %
Availability of expertise	20 %
Flexibility for changes	30 %
Responsibility	20 %
Risk management	40 %
Price competition	80 %
Public accountability	60 %
Value of money	20 %
Time available	70 %
Time predictability	70 %
Certainty of cost	70 %
Quality	50 %
Overlapping of design and construction	10 %
Client involvement	10 %
Peer relationships	10 %
Source of finance	10 %
Authority	10 %
State of market	10 %

Delphi round two: refining the selection criteria

Format

The experts were asked to indicate the relative importance of these 16 criteria that had been identified in round one of the Delphi survey, using a simple 3-level

Table 4 Criteria identified from literature survey

Criteria	Criteria question	Explanation
Ability to state clear end user's requirements (Deakin, 1999)	Is the client able to state his or her requirements precisely at the tender stage?	If a very precise and clear end user's requirement is prepared before tender, design and build system can be used. Whereas, if the end user's requirement is not very clear, management contracting system can be used.
Availability of competent contractors (Chan *et al.*, 1999)	Is there a plentiful supply of competent contractors to work for the procurement system in question?	If this were an important criterion for the client, traditional sequential system would have the most plentiful supply of competent contractors. On the other hand, there would be less supply of competent contractors for management contracting and design and build systems.

scale: very important, important and not important. The total frequency distribution of the experts who suggested the criteria in round one and a percentage of the experts for each criterion were also stated. Moreover, experts were also classified as public or private group, and the corresponding frequencies were shown as well. The result of round one was also attached to the questionnaire in graphical form. The round two Delphi questionnaire is presented in Appendix B.

Results and analysis

Table 5 shows the indication of relative importance of each criterion by the ten experts. Criteria that attracted only 50% agreement or below in the category of 'very important' or of 'important' were removed in the round three Delphi survey. As a result, only 14 criteria were included in the round three study.

Table 5 Delphi round two results: frequency distribution and percentage

Criteria	% of experts who stated the criterion as either very important or important.	Very important	Important	Not important
Criteria which are included in the next round of Delphi	100%	7	3	–
1. Price competition	100%	7	3	–
2. Time available	100%	5	5	–
3. Time predictability	100%	4	6	–
4. Availability of competent contractors	90%	–	9	1
5. Quality	90%	4	5	1
6. Ability to state clear end user's requirement	80%	6	2	2
7. Complexity	80%	2	6	2
8. Certainty of cost without fluctuation	80%	1	7	2
9. Flexibility for changes	80%	1	7	2
10. Risk management	80%	1	7	2
11. Client's involvement	80%	1	7	2
12. Size of project	70%	2	5	3
13. Responsibility	70%	-	6	4
14. Familiarity	60%			
Criteria which were excluded in the next round of Delphi				
15. relationship				
16. Distrust of new system	40%	3	1	6

Delphi round three: utility factors obtained from experts

Format

In the round three Delphi method, experts were asked to enter a utility factor against each procurement system in a table. The utility factor is a factor to indicate the degree of suitability of each procurement system against each criterion (Skitmore and Marsden, 1988; Chan, 1995). Respondents were asked to enter a score from 10 to 110 to eliminate the occurrence of zero. The ten experts were asked to complete the questionnaire in two weeks. However, only three experts did so within this stipulated time. A reminder letter was sent to all the experts who had not returned the questionnaire. Two weeks later a final letter, which stated a deadline for returning the questionnaire, was sent to the non-respondents. Follow-up of the non-respondents to this round indicated that the primary reason for their non-responses was a lack of time to complete the questionnaire. Finally, eight responses were collected and two experts withdrew. The two dropouts were Mr. D and Mr. G. The main reason for their dropping out was the heavy commitment of their current workload, and hence they were unable to complete the Delphi survey.

Appendix C gives a sample model used in the round three questionnaire to ask the experts to assess the suitability of each procurement system against each selection criterion.

Results and analysis

An analysis was performed of the eight questionnaires received in which the mean of utility factor for the set of criteria was computed. A preliminary procurement selection model was developed based on the mean of the utility factors advocated by the eight experts. It was measured using a score between 10 and 110, with 10 representing 'low suitability' and 110 representing 'high suitability' of each procurement system against each criterion.

If the scores provided by the experts were insufficiently consistent, the results could simply be due to chance. To obtain a measure of consistency, a statistical test was applied involving the calculation of a coefficient of concordance (W) for the utility factors provided by the experts (Siegel and Castellan, 1988; Chan and Yeong, 1995; Chan, 2000) using the SPSS computer package. A concordance coefficient of 1 indicated that the eight experts all ranked the procurement paths identically. Table 6 shows the utility factors of ten criteria were sufficiently consistent at 0.05 level of significance or smaller.

Delphi round four: refining the utility factor

Format

For the round four survey, the experts were provided with feedback of the results obtained in round three. The average of the utility factors of the eight experts for each procurement system against each criterion and

Table 6 Concordance coefficient of the utility factors in round three

Selection criteria	Average utility factors							
	Traditional sequential	Traditional accelerated	Competitive D&B	Enhanced D&B	Novation	Mgt. contracting	Kendall coefficient (W)	α
Significant level < 0.05								
1. Price competition	87.5	67.5	92.5	87.5	77.5	55	0.524	0.001
2. Time availability	50	76.3	86.3	76.3	76.3	87.5	0.405	0.006
3. Competent contractors	92.5	80	66.3	67.5	65	52.5	0.375	0.01
4. Clear user's requirement	93.8	72.3	88.8	95	95	56.3	0.527	0.001
5. Complexity	69.4	57.5	72.5	85	85	83.1	0.294	0.038
6. Certainty of cost	74.4	48.8	93.8	88.8	88.1	40	0.751	0.00
7. Flexibility	64.4	61.3	48.8	53.8	53.8	89.4	0.407	0.006
8. Risk management	76.3	60	90	82.5	82.5	55	0.540	0.001
9. Responsibility	67.5	61.3	100	93.75	89.4	58.1	0.707	0.00
10. Familiarity	97.5	60	81.25	76.3	47.5	51.3	0.658	0.00
Significant level > 0.05								
1. Time predictability							0.242	0.084
2. Quality							0.056	0.812
3. Client's involvement							0.180	0.206
4. Size of the project							0.100	0.55

the respondent's own score in the round three were shown. The actual questionnaire was as in Appendix D. The respondents were asked to re-assess their score in the light of the average values scored by the eight experts. A table with the same format as provided in the round three questionnaire was attached, with the corresponding respondent's scores. The final round questionnaire was distributed to the eight experts with a ten day requested response time. A request for interviews was made to the experts for feedback and clarification on any matters regarding the research model. Only one expert agreed to have an interview. Six experts returned the questionnaire on time. Reminder calls were made to the non-respondents. The last response was collected three weeks after the initial request.

Results and analysis

Eight questionnaires were received from the experts, and there was no further drop out from the round three Delphi. Most of the experts had reconsidered their utility factors provided in the previous round and had made adjustments to their scores. The consistency of the experts' utility factors was again computed using the SPSS package to calculate the Kendall coefficient of concordance. The results were summarized and compared as shown in Table 7.

The concordance analysis shows that the consistency of the experts' ranking for procurement systems against each criterion had improved over the successive round. The coefficients of concordance for all the criteria (except for flexibility) improved from 0.69% to 23.7%. In this round of the Delphi, eleven criteria were considered to be sufficiently consistent (compared with ten in the previous round). The criterion time predictability was also consistent at the 0.05 significance level.

The results show that the experts had some difficulty in assessing the quality criterion ($\alpha = 0.755$), the client's involvement ($\alpha = 0.135$) and the size of the project ($\alpha = 0.240$) in relation to the procurement system with significance level greater than 0.05. This implies that the experts had a rather different view on the utility factors of these criteria. Therefore these criteria were removed from the selection model.

The multi-attribute model

By the application of the Delphi method, a set of sufficiently consistent utility factors was obtained after the final round of Delphi questionnaire. The set of selection criteria and the corresponding utility factors were used to develop a procurement selection model: a multi-attribute model consisting of the following set of client's criteria, which are re-phrased as priority questions.

1. *Price competition*: How important is it to choose your project team by price competition, so increasing the likelihood of a low price?
2. *Time available*: How important is early completion to the success of your project?
3. *Time predictability*: To what extent do you require a specific completion date at the start of the project?
4. *Availability of competent contractors*: How important is it to have a plentiful supply of competent contractors to work for the procurement system?

Table 7 Concordance coefficient of utility factors in round four

Selection criteria	Coefficient of concordance (W)			Significance level	
	Round 3	Round 4	% improvement	Round 3	Round 4
Significant level < 0.05					
1. Price competition	0.524	0.539	0.78 %	0.001	0.001
2. Time availability	0.405	0.417	2.96 %	0.006	0.005
3. Availability of competent contractors	0.375	0.422	12.5 %	0.01	0.005
4. Ability to state clear end user's requirement	0.527	0.575	8.4 %	0.001	0.000
5. Complexity	0.294	0.363	23.7 %	0.038	0.013
6. Certainty of cost	0.751	0.759	1 %	0.00	0.000
7. Flexibility	0.407	0.389	—	0.006	0.008
8. Risk management	0.540	0.571	5.7 %	0.001	0.000
9. Responsibility	0.707	0.790	11.7 %	0.00	0.000
10. Familiarity	0.658	0.691	5 %	0.00	0.000
11. Time predictability	0.242	0.489	10.2 %	0.084	0.002
Significant level > 0.05					
1. Quality	0.056	0.066	17.9 %	0.812	0.755
2. Client's involvement	0.180	0.210	3 %	0.206	0.135
3. Size of the project	0.100	0.169	0.69 %	0.55	0.240

5. *Clear end user's requirements*: How capably is the client able to state his or her requirements clearly and precisely at the tender stage?
6. *Complexity*: Is the project highly specialized, technologically advanced or highly serviced?
7. *Certainty of cost without fluctuation*: How important is a firm price at the beginning of construction?
8. *Flexibility for changes*: To what extent do you expect the project to have frequent changes in the design and construction once the work has begun on site?
9. *Risk management*: To what extent do you need risk avoidance in the event of time, cost, design liability and quality slippage?
10. *Responsibility*: To what extent do you wish to have a single point of responsibility for the completion of the design and construction of the project?
11. *Familiarity*: How important is it for the client to choose a familiar system to deliver the project?

The priority questions allow the users to prioritize the criteria according to a specific project and the user's specific requirements (Skitmore and Marsden, 1988; Bennett and Grice, 1990; Chan, 1995; Love *et al.*, 1998). For example, if an inexperienced client wishes to develop a large complex project of a specialized nature, and he prefers to transfer the risks to other parties as far as possible and at the same time to obtain a quicker project time, he may specify a high priority for criteria like time available, time predictability, complexity, risk management, and responsibility. Then he might specify a middling priority for criteria like price competition, flexibility for changes, and certainty of cost without fluctuation, and specify a low priority for criteria like availability of competent contractors, clear end user's requirements, and familiarity.

Figure 1 shows the multi-attribute model with the mean values of the utility factors for the each procurement system against each selection criterion. The results indicate that competitive design and build method provides the best price competition (mean utility factor 91.9) and time predictability (mean utility factor 93.8). In addition, it also provides the best certainty of price (mean utility factor 93.8) and best risk avoidance (mean utility factor 90) and responsibility (mean utility factor 100). The management contracting system is the speediest (mean utility factor 86.3) and the most flexible (mean utility factor 88.1). The enhanced design and build and the novated design and build are the most appropriate options if the client is able to state the employer's requirement precisely at the tender stage (mean utility factor 95). They are also the most suitable methods to be adopted if the project is complex (mean utility factor 85.6). The traditional sequential method is found to be the most familiar procurement system (mean utility factor 92.5), which has a plentiful supply of competent contractors to work for the system (mean utility factor 96.3).

Use of the selection model

The selection model can be applied by following the following procedures (Chan and Yung, 2000).

1. The user reads all the priority questions and enters the relative importance of each criterion in the table on a scale of 1 to 5, 1 being the least important, and 5 being the most important. The prioritization exercise enables the users to specify their requirements according to the project needs and circumstantial factors.
2. Each priority rating is taken in turn and multiplied by each of the utility factors, the results being entered into the appropriate columns. These are compared for all the criteria.
3. The totals of each of the result columns, under each procurement path, are calculated, and ranked in descending order. The most appropriate procedure should have the highest total result.

Difficulties in conducting the Delphi techniques

Several difficulties were encountered in conducting the Delphi technique. First, the successful rounds of Delphi techniques were extremely time consuming. The completion of the four rounds of Delphi questionnaires took about five months. For each round of Delphi, reminder letters were sent to the non-respondents and sometimes further reminder calls had to be made. Robinson (1991) experienced similar difficulty in his research study for the economic impact assessment. He stated that the turnaround times for the questionnaire by panelists were longer than expected. 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 the current study, a lot of effort was made to make the questionnaire simple and yet sufficient to convey the objectives of the study

Selection Criteria	Utility Factors													
	Traditional system					Integrated system						Management		
	Client's Priority Rating	Sequential		Accelerated		Competitive design & build		Enhanced design & build		Novation		Management contracting		
W significant at 0.05 level		U.F.	Score	U.F.	Score	U.F.	Score	U.F.	Score	U.F.	Score	U.F.	Score	
1. **Price Competition** • How important is it to choose your project team by price competition, so increasing the likelihood of a low price?		85.6		68.1		91.9		88.1		76.3		55		
2. **Time Available** • How important is early completion to the success of your project?		51.9		76.3		84.4		75.6		76.3		86.3		
3. **Time Predictability** • To what extent do you require a specified completion date at the start of the project?		77.5		70.6		93.8		86.9		87.5		71.3		
4. **Availability of Competent Contractors** • How important is it to have a plentiful of supply of competent contractors to work for the procurement system?		92.5		83.8		66.9		68.1		65.6		51.3		
5. **Ability to State Clear End user's requirements** • How capable is the client able to state the employer's requirements precisely at the tender stage?		93.8		75		87.5		95		95		56.3		
6. **Complexity** • Is the project highly specialized, technologically advanced or highly serviced?		70		55		73.1		85.6		85.6		83.1		
7. **Certainty of Cost without Fluctuation** • How important is a firm price at the beginning of construction is needed?		73.8		46.9		93.8		88.1		87.5		41.3		
8. **Flexibility for Changes** • To what extent do you expect frequent changes in design and construction once the work has begun on site?		66.3		65.6		50.6		55.6		55.6		88.1		
9. **Risk Management** • To what extent do you need risk avoidance in the event of time, cost, design liability, and quality slippage?		75.6		59.4		90		82.5		82.5		58.1		
10. **Responsibility** • To what extent do you wish a single point of responsibility for the completion of the programme, design and construction of the project?		66.9		57.5		100		93.8		89.4		58.1		
11. **Familiarity** • How important is it for the client to choose a familiar system to deliver a building project?		96.3		60.6		80.6		75.6		46.9		51.3		
Total														
Order of preference														

Figure 1 Multi-attribute procurement selection model

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).

This study was undertaken with relative success in that a response rate of 80% 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 80% response rate achieved in this study is relatively 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. The respondents requested further verbal explanations for the utility factors, and clarifications on the criteria questions also were needed.

Conclusion

To obtain a set of exclusive criteria for procurement system selection has been a continuous concern in previous researches (Ireland, 1985; Love *et al.*, 1998). To ensure that a consensus is reached for the utility factors provided by a panel of experts is an even more difficult task. The Delphi method is demonstrated to be appropriate for obtaining the utility factors for the procurement selection model in which a consensus has to be reached. However, the major difficulties lie in maintaining the high level of response for the series of rounds, and implementing a consensus in such a subjective area. Furthermore, the Delphi method is extremely demanding of resources, relying as it does on continuing close contact with the experts. Therefore it is not particularly suitable for use in projects with a restricted time frame.

Although the Delphi method has been used for a few decades in strategic planning, applications in the construction industry have come into use only recently. No documented use in procurement selection has been found as yet. The results of this research illustrate vividly that there is a significant improvement in the consistency of the utility factors over the successive Delphi rounds. Thus the Delphi technique is a useful tool for obtaining group opinions on the utility factors for the multi-attribute procurement selection model in which a consensus is to be reached. This echoes Lindeman's (1975) finding that the Delphi method is especially effective in difficult areas which can benefit from subjective judgments on a collective basis, but for which there may be no definitive answer.

Four Delphi rounds were conducted in this study. A set of exclusive criteria for the selection of procurement system was identified following the first two rounds of the Delphi. The last two rounds of the Delphi were to derive a statistically significant consensus on the weighting of the utility factors. A procurement selection model was developed based on the criteria and utility factors derived from the Delphi survey. As the model was developed locally in Hong Kong, future research should be conducted in other geographic locations to distinguish between general selection criteria in a given regional market and specific criteria to be used for an identified client with identified needs. An alternative approach for determining the value of utility factors for the selection criteria would be the analytical hierarchical method, using pairwise comparison. Future research may also be conducted by using two Delphi panels and comparing the results of the prediction in a real project.

Acknowledgement

The authors gratefully acknowledge the Hong Kong Polytechnic University for providing funding to support this research effort.

References

Anatharajan, T. and Anataraman, V. (1982) Development of residential areas: Delphi technique for decision making. *International Journal for Housing Science and Its Applications*, **6**(4), 329–41.

Bennett, J. and Grice, A. (1990) Procurement systems for buildings. In Brandon, P. S. (ed.), *Quantity Surveying Techniques: New Directions*, BSP Professional Books, Oxford.

Bond, S. and Bond, J. (1982) A Delphi survey of clinical nursing research priorities. *Journal of Advanced Nursing*, **7**, 565–75.

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

Bryman, A. (1996) *Quantity and Quality in Social Research*, Routledge, London.

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

Chan, A. P. C. (2000) Evaluation of enhanced design and build system: a case study of a hospital project. *Construction Management and Economics*, **18**, 863–71.

Chan, A. P. C. and Yeong, C. M. (1995) A comparison of strategies for reducing variations. *Construction Management and Economics*, **13**, 467–73.

Chan, A. P. C. and Yung, E. H. K. (2000) *Procurement Selection Model for Hong Kong*, Research Monograph, The Hong Kong Polytechnic University.

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, pp. 621–30.

Chan, A. P. C., Yu, A. T. W., and Tam, C. M. (1999) Enhanced design build: an innovative system to procure a hospital project. In *CIB W92 Procurement Systems Symposium*, 25–28 January, Chiang Mai, Thailand, pp. 405–15.

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.

Deakin, P. (1999) Client's local experience on design and build projects. In *Seminar Proceedings on Design and Build Procurement System*, Construction Industry Training Authority, Hong Kong, pp. 11–15.

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.

Dickey, J. and Watts, T. (1978) *Analytic Techniques in Urban and Regional Planning*. McGraw-Hill, New York.

Edmunds, H. (1999) *The Focus Group Research Handbook*. NTC Business Books.

Fellows, R. F. and Langford, D. A. (1980) Decision theory and tendering. In *Building Technology and Management*, Chartered Institute of Building, Ascot, pp. 36–9.

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

Goldfisher, F. (1992) Modified Delphi: a concept for new product forecasting. *Journal of Business Forecasting*, **11**(4), 10–1.

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

Ireland, V. (1985) The role of managerial actions in cost, time and quality performance of high rise commercial building projects. *Construction Management and Economics*, **3**(1), 59–87.

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

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

Liu, A. M. M. (1994) From act to outcome: a cognitive model of construction procurement. In *Proceedings of the CIB-W92 Procurement Systems Symposium*, Hong Kong, 4–7 December, pp. 169–78.

Love, P. E. D., Skitmore, M. and Earl, G. (1998) Selecting a suitable procurement method for a building project. *Construction Management and Economics*, **19**, 221–33.

Masterman, J. W. E (1992) *An Introduction To Building Procurement Systems*, E. & F. N. Spon, London.

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

Morgan, D. L. (1998) *The Focus Group Guidebook*, Focus Group Kit 1, Sage, Beverly Hills, CA.

NEDO (1985) *Thinking about Building*, National Economic Development Office, Building Design Partnership for NEDO, HMSO, London.

Procter, S. and Hunt, M. (1994) Using the Delphi survey technique to develop a professional definition of nursing for analyzing nursing workload. *Journal of Advanced Nursing*, **19**, 1003–14.

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

Saito, M. and Sinha, K. (1991) Delphi study on bridge condition rating and effects of improvements. *Journal of Transportation Engineering*, **117**(3), 320–34.

Siegel, S. and Castellan, N. (1988) *Nonparametric Statistics for the Behavioural Sciences*, McGraw-Hill, New York.

Skitmore, M. and Marsden, D. E. (1988) Which procurement system? Towards a universal procurement selection technique. *Construction Management and Economics*, **6**, 71–89.

Sleep, J., Bullock, I. and Grayson, K. (1995) Establishing priorities for research in education within one college of nursing and midwifery. *Nurse Education Today*, **15**, 439–45.

Tucker, S. N. and Ambrose, M. D. (1999) Procurement system evaluation in a changing construction environment. In *Proceedings of the Construction Process Re-engineering Meeting*, 12 and 13 July, Sydney, pp. 97–109.

Appendix A

A survey of criteria adopted for selection of procurement system

Round 1: Questionnaire

Name of Respondent:_____

1. Would you please list five criteria, which you believe are the major criteria in the selection of procurement system for a building project in Hong Kong. (You are definitely welcome to provide more than five criteria.)

.....

.....

.....

.....

.....

Note:

The following are some of the criteria found in previous research studies and literature.

- Time
- Time certainty
- Cost certainty
- Price competition
- Flexibility to changes
- Complexity of the project
- Quality
- Responsibility
- Risk avoidance
- Value for money
- Public accountability

Appendix B

Criteria adopted for selection of procurement system

Delphi Round 2: Questionnaire

• Name of Respondent:_____

Guidance on completion: The following are the criteria for the selection of procurement system, which you have provided, in the round one questionnaire. We now also attached herewith the analyzed set of criteria, which were suggested by other experts. We would like you to reconsider the criteria, which you have included last time. Please also put a tick in the appropriate box to indicate to what extent do you think those criteria that were suggested by the nine experts influence the choice of procurement system.

Criteria you provided in round one:

- Time
- public accountability
- cost
- nature of project
- quality
- availability of expertise

Criteria	Frequency				To what extent do you think the criterion influence the choice of procurement system?		
	Public	Private	Total	% of experts	Very Important	Important	Not Important
• Criteria which were suggested by more than 50% of the experts:							
1. Price competition - open and fair competition/ public accountability Is price competition important in the selection of project team, thus enhancing a low price?	6	3	9	100	☐	☐	☐
2. Complexity Does the project have very special employer's requirement, very innovative design and special construction method or complicated phasing?	4	3	7	77.8	☐	☐	☐
3. Time available Is there a tight time schedule for the project ?	4	3	7	77.8	☐	☐	☐
4. Quality Does the client ask for superb quality in terms of aesthetic, workmanship, and functionality?	2	5	7	77.8	☐	☐	☐
5. Certainty of cost without fluctuation Is a firm price at the beginning of construction needed ?	4	1	5	55.6	☐	☐	☐
6. Time predictability Is a specific completion date required at the start of the project?	3	2	5	55.6	☐	☐	☐

Criteria	public	private	total	% of experts	Very Important	Important	Not Important
• Criteria which were suggested by 10% to 50 % of the experts:							
1. Familiarity How important is it for you to choose a familiar system to deliver a building project?	0	2	**2**	**22.2**	☐	☐	☐
2. Size of the project - GFA, Contract sum Is the building a large-scale project ?	1	1	**2**	**22.2**	☐	☐	☐
3. Flexibility for changes Does the project expect any changes in design and construction once the work has begun on site?	0	3	**3**	**33.3**	☐	☐	☐
4. Responsibility To what extent do you wish to have a single point of responsibility for the completion of the program, design and construction during the project ?	0	2	**2**	**22.2**	☐	☐	☐
5. Risk management To what extent do you need risk avoidance in the event of time, cost, design liability, and quality slippage?	0	3	**3**	**33.3**	☐	☐	☐
• Criteria which were suggested by less than 10% of the experts:							
1. Distrust of new system To what extent do you have confidence in adapting the procurement system?	0	1	**1**	**11.1**	☐	☐	☐
2. Client involvement Does the client wish to have maximum involvement, tight control over daily management or inspection in the building project?	0	1	**1**	**11.1**	☐	☐	☐
3. Peer relationships Is there any business relationship or prior working relationship between any of the parties?	0	1	**1**	**11.1**	☐	☐	☐
• Criteria suggested by literature							
1. Clear end user's requirements Is the client able to state his or her requirements precisely at the tender stage?	-	-	**0**	/	☐	☐	☐
2. Availability of competent contractors Is there a plentiful supply of competent contractors to work for the procurement system in question?	-	-	**0**	/	☐	☐	☐
• Other criteria which are not listed above:							
					☐	☐	☐

Please return:
Thank you very much for your participation. Please kindly return the questionnaire either by fax or by mail within two weeks time. If you have any queries, please contact me at xxxxxxxx.

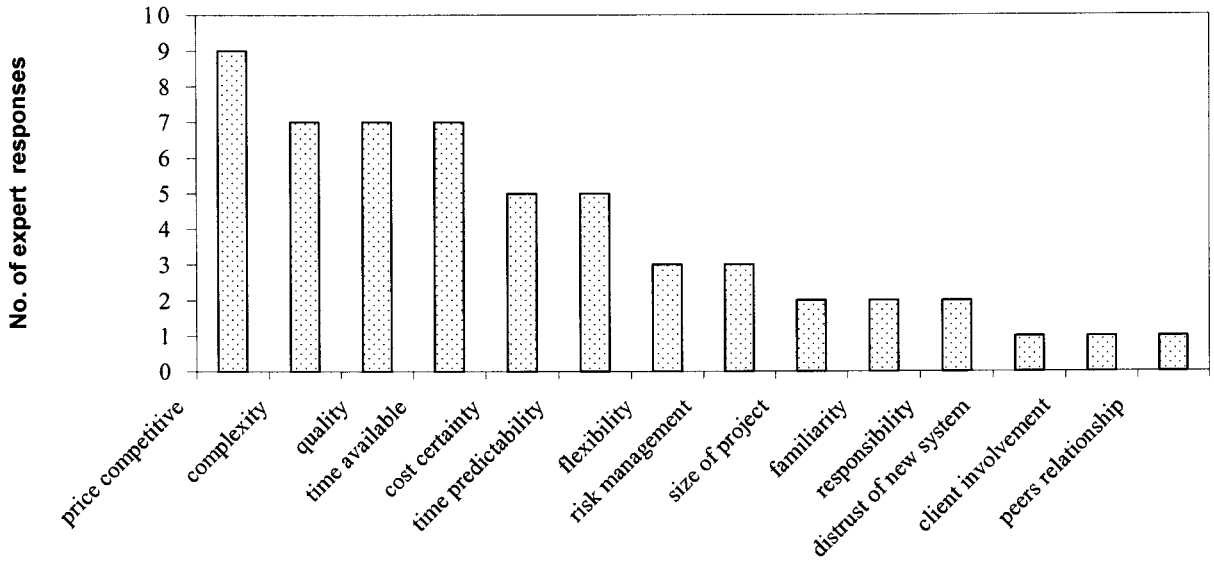

Figure 1 Criteria for the selection of procurement system

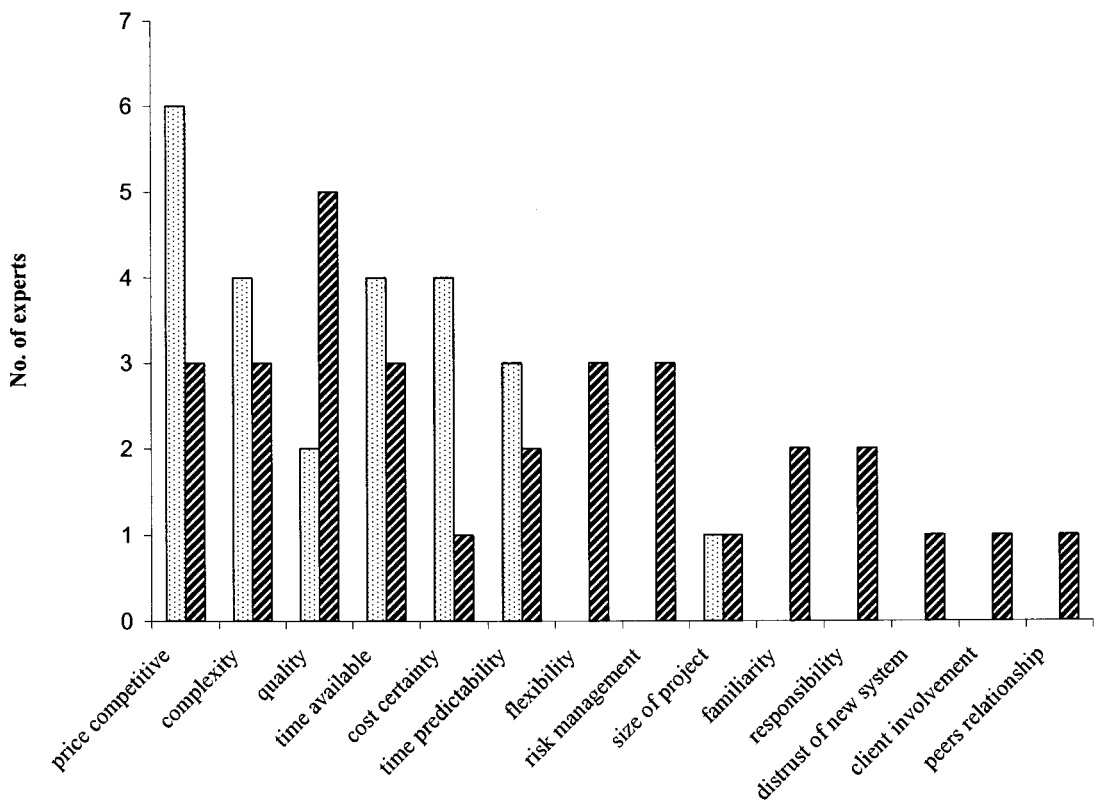

Figure 2 Distribution of criteria for the public and private sector. The left bar stands for the public sector, and the right bar for the private

Appendix C

Delphi Round 3 Questionnaire - Utility Factors for different procurement systems

Department of Building & Real Estate
The Hong Kong Polytechnic University

1. Results from Delphi Round 2 questionnaire

From the Delphi round two questionnaire, we have found that the criteria obtained were sufficiently consistent. Out of the list, eleven criteria were agreed by 80% or more experts as either very important or important. For the round three questionnaire, fourteen criteria, which were agreed by 60% or more experts, will be used to carry out the Round 3 Delphi method to obtain the utility factors for the procurement systems.

2. Guidance on Completion of questionnaire

A table on page 2 of this questionnaire is designed for you to assess the performance of each procurement system in relation to each criterion. Would you please enter a score from 10 (least favourable) to 110 (most favourable) to indicate the suitability of each criterion 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 traditional sequential system is a more familiar system for the construction industry in Hong Kong, you may enter a score say, 100. Whereas novation is the least well-known system, therefore you may enter a score around 20 .

Table. 1. Example

Selection Criteria	Utility Factors					
	Sequential traditional	Accelerated traditional	Competitive design & build	Enhanced design & build	Novation	Management contracting
1. **Familiarity** • It is very important for the client to choose a familiar system to deliver a building project.	100	90	70	65	20	55

3. Definition of procurement systems

Sequential traditional – client appoints an architect to produce the design, select the contractor and supervise the work through to completion. Contractor bid on completed design and cost documents.

Accelerated traditional – a contractor is appointed early on the basis of partial information, by negotiation or in competition, possibly on a two-stage basis.

Competitive D&B – documents are prepared by consultants to enable several contractors to offer designs and prices in competition. Contractor is responsible for the design and construction of the project.

Enhanced D&B – consultants are appointed to design the building to a partial stage, and the contractor is responsible for design development, working details and development.

Novation – consultants are appointed to design the building to a partial stage, than contractors complete and guarantee the design and prices in competition. The winning contractor is required to hire the client's design consultants.

Management contracting – management contractor works alongside the design and cost consultants, providing a construction management service on a fee basis. The design requirements are met by letting each element of the construction to specialist sub-contractors.

4. For Return

Thank you very much for your participation. Please kindly return the questionnaire either by fax at xxxxxxxxx or by mail within two weeks time.

Department of Building & Real Estate
The Hong Kong Polytechnic University

Delphi Round 3 Questionnaire - Utility Factors for different procurement systems

Name of Respondent:

(Please enter a score from 10 to 110 for the Utility factor.)

Selection Criteria (results from Round 2)	Utility Factors (suitability of each criterion against each procurement system)					
	Traditional system		**Integrated system**			**Management**
	Sequential	Accelerated	Competitive design & build	Enhanced design & build	Novation	Management contracting
1. **Price Competition** • open and fair competition/ public accountability. Price competition is important in the selection of the project team to enhance a lower price.						
2. **Time Available** • Time schedule of the project is tight.						
3. **Time Predictability** • Specified completion date is required at the start of the project.						
4. **Availability of Competent Contractors** • There is a plentiful of supply of competent contractors to work for the procurement system.						
5. **Quality** • Superb quality in terms of aesthetic, workmanship and functionality is requested.						
6. **Clear End user's Requirements** • Client is able to state the employer's requirements precisely at the tender stage.						
7. **Complexity** • The Project has a very special employer's requirement, very innovative design and special construction method or complicated phasing.						
8. **Certainty of Cost without Fluctuation** • A firm price at the beginning of construction is needed.						
9. **Flexibility for Changes** • Frequent changes in design and construction once the work has begun on site are expected.						
10. **Risk Management** • Risk avoidance in the event of time, cost, design liability and quality slippage is required.						
11. **Client's Involvement** • The client wishes to have maximum involvement, tight control over daily management or inspection in the building project.						
12. **Size of the Project** • The building is a large-scale project in terms of GFA and or contract sum.						
13. **Responsibility** • A single point of responsibility for the completion of the programme, design and construction during the project is needed.						
14. **Familiarity** • It is very important for the client to choose a familiar system to deliver a building project.						

• **Delphi Round 2 Results**

Criteria	% of experts who stated the criterion as either very important or important.
1. Price competition	100%
2. Time Available	100%
3. Time Predictability	100%
4. Availability of competent contractors	100%
5. Quality	90%
6. Clear end user's requirement	90%
7. Complexity	80%
8. Certainty of cost without fluctuation	80%
9. Flexibility for changes	80%
10. Risk management	80%
11. Client's involvement	80%
12. Size of project	70%
13. Responsibility	70%
14. Familiarity	60%

From the Delphi round two questionnaire, it was found that four out of sixteen criteria were 100% agreed by the panel of experts as either very important and important. Two criteria were agreed by 90% of the experts. Five criteria were agreed by 80% of the experts. Two criteria were agreed by 70% of the expert and 60 % of the experts agreed on the familiarity criterion. For the criteria which had a frequency of less than 60%, (Distrust of new system and peer relationship) would be excluded from our list of criteria.

Thus, the average percentage for the agreement of the fourteen criteria, which were suggested by the experts, was 84.29. This shows that these criteria are sufficiently reliable.

Appendix D

Department of Building & Real Estate
The Hong Kong Polytechnic University

Delphi Round 4 Questionnaire

Name of respondent:

The following table shows the "average" of the utility factors provided by the eight experts and your score provided 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 factor remains the same.

Note: *W = Kendall coefficient of concordance* (the larger the *w*, the better the consistency among the experts)
α = significant level

Selection Criteria	Utility Factors (suitability of each procurement system against each criterion)																				
	Traditional system						Integrated system												Management		
	Sequential			Accelerated			Competitive design & build			Enhanced design & build			Novation			Management contracting				
	Average	Your score	Reconsidered score	Average	Your score	Reconsidered score	Average	Your score	Reconsidered score	Average	Your score	Reconsidered score	Average	Your score	Reconsidered score	Average	Your score	Reconsidered score			
Criteria which are sufficiently consistent, α < .05																					
1. **Price Competition** • Price competition is important in the selection of the project team to increase the likelihood of a low price. **w=.521 α=.001**	87.5	50		67.5	30		92.5	100		87.5	80		77.5	60		55	40				
2. **Time Available** • Time schedule of the project is tight. **w=.405 α=.006**	50	40		76.3	60		86.3	100		76.3	80		76.3	60		87.5	60				
3. **Availability of Competent Contractors** • There is a plentiful supply of competent contractors to work for the procurement system. **w=.521 α=.001**	92.5	80		80	90		66.3	100		67.5	70		65	70		52.5	70				
4. **Clear End user's Requirements** • Client is able to state the employer's requirements precisely at the tender stage. **w=.527 α=.001**	93.8	90		76.3	40		88.8	90		95	80		95	70		56.3	70				
5. **Complexity** • The Project has a very special employer's requirement, very innovative design and special construction method or complicated phasing. **w=.294 α=.038**	69.4	75		57.5	60		72.5	90		85	80		85	70		83.2	75				
6. **Certainty of Cost without Fluctuation** • A firm price at the beginning of construction is needed. **w=.751 α=.000**	74.4	75		48.8	60		93.8	90		88.8	80		88.1	85		40	40				
7. **Flexibility for Changes** • Frequent changes in design and construction once the work has begun on site are expected. **w=.407 α=.006**	64.4	65		61.3	70		48.8	60		53.8	50		53.8	40		89.4	75				

Department of Building & Real Estate
The Hong Kong Polytechnic University

Delphi Round 4 Questionnaire

Note: *W = Kendall coefficient of concordance* *α = significant level*

Selection Criteria	Utility Factors																	
	Traditional system						**Integrated system**									**Management**		
	Sequential			Accelerated			Competitive design & build			Enhanced design & build			Novation			Management contracting		
	Average	**Your score**	**Reconsidered score**	**Average**	**Your score**	**Reconsidered score**	**Average**	**Your score**	**Reconsidered score**	**Average**	**Your score**	**Reconsidered score**	**Average**	**Your score**	**Reconsidered score**	**Average**	**Your score**	**Reconsidered score**
8. **Risk Management** **w=.540 α=.001** • Risk avoidance in the event of time, cost, design liability and quality slippage is required.	76.3	50		60	40		90	100		82.5	80		82.5	90		55	40	
9. **Responsibility** **w=.707 α=.000** • A single point of responsibility for the completion of the programme, design and construction during the project is needed.	67.5	60		61.3	50		100	100		93.8	90		89.4	95		58.1	75	
10. **Familiarity** **w=.658 α=.000** • It is very important for the client to choose a familiar system to deliver a building project.	97.5	60		60	60		81.3	80		76.3	70		47.5	50		51.3	60	
Criteria which are not sufficiently consistent, α > .05																		
11. **Time Predictability** **w=.242 α=.084** • Specific completion date is required at the start of the project.	78.1	65		68.8	50		90	100		83.1	85		83.8	70		67.5	60	
12. **Quality** **w=.056 α=.812** • Superb quality in terms of aesthetic, workmanship and functionality is requested.	77.5	90		71.3	70		72.5	50		75.6	55		76.9	55		75	70	
13. **Client's Involvement** **w=.180 α=.206** • The client wishes to have maximum involvement, tight control over daily management or inspection in the building project.	70.6	65		73.8	70		61.9	35		65.6	45		63.8	40		79.4	75	
14. **Size of the Project** **w=.100 α=.550** • The building is a large-scale project in terms of GFA and or contract sum.	79.4	75		72.5	80		73.8	70		81.9	75		80.6	65		76.9	85	