INVESTIGATION ON QUALITY OF COST DATA INPUT IN LIFE CYCLE COST (LCC) ANALYSIS IN MALAYSIA

Mohd Fairullazi Ayob and Khairuddin Abdul Rashid

International Islamic University Malaysia

Abstract:
Commentators often pointed out the main focus of the local practitioners and scholars on LCC in the Malaysian construction industry is considerably on the LCC conversion which includes the methodology and models of computing LCC, but very little emphasis is given on the availability, accessibility, currency and reliability of the data as inputs into the process of generating reliable LCC analysis. This paper presents the application of modified Delphi as a fieldwork approach to investigate the current state and practice of LCC in the Malaysian construction industry with specific reference to data inputs of LCC. A three-round modified Delphi process was implemented to obtain consensus of expert opinion regarding the availability, accessibility, currency and reliability of data as inputs into the process of generating reliable LCC analysis. The results establish that the majority of modified Delphi panellists agreed there are several data sources that are categorized as very current and very reliable for LCC analysis. However, the majority of panellists reached consensus there is no single data source that is readily available and accessible for LCC analysis. The study verified the problem of getting quality data inputs for producing a comprehensive and reliable LCC analysis is crucial. It has been identified as one of the significant factors that impose constraints to the implementation of LCC practice for building works in the Malaysia construction industry.

Keywords- Life cycle cost, data inputs, building, and consensus.

INTRODUCTION

Life Cycle Cost (LCC) is an economic assessment technique that uses mathematical method to produce outputs, which will give useful cost information to the clients' organization and cost estimators in facilitating them to develop better decision in the process of determining the most optimum total ownership costs of an asset or in comparing the most cost-effective of mutually exclusive alternatives. The LCC analysis process can be categorized into three main phases, i.e. data inputs, conversion and outputs. The outputs of LCC can be used to provide valuable and quality recommendation to the clients to attain potential cost saving and demonstrate the best value for money procurement on the investment of buildings [34]. Most clients and consultants in the Malaysian construction industry are aware on the concept and the practice of LCC, there exist several models and techniques on how to apply LCC for building works and yet LCC is unsatisfactorily practiced [1-3, 9, 10, 11]. Apart from that, it is uncertain whether a standard procedure or framework has been established to trace, collect and improve the quality of data which can facilitate the LCC estimators to carry out a comprehensive and reliable LCC analysis for building works in the Malaysian construction industry. The literature study has identified the following as the key quality of data input requirements required for producing reliable LCC outputs:

i Availability of cost data is defined as data certainty for LCC analysis (Gross and AEA, 2008; NATO Research and Technology Organisation, 2009; BS ISO 15686-5, 2008)

ii Accessibility of cost data is defined as the ease of access to obtain cost data for generating LCC analysis (Ren and Zhang, 2007; Schade, 2007; BSI, 2008; Ashworth, 2010)

iii Currency of cost data is defined as recent cost data used as inputs for producing reliable LCC analysis. Current data is frequently updated on a certain period of basis (i.e. monthly, quarterly or yearly) (www.statistic.gov.my; Khairani, 2009; DSM, 2010)

iv Reliability of cost data is defined as data consistency or data accuracy for LCC analysis (Annex 31, 2001; Creswell and Clark, 2007; King, 2007; CRES and Kikira, 2009; Giannarakis et al., 2011)

OBJECTIVE AND MOTIVE OF THE STUDY

The objective of this paper is to present the application of modified Delphi technique as a fieldwork approach to investigate the current state and practice of LCC in the Malaysian construction industry with specific reference to data inputs. This paper focuses only on cost data inputs of LCC. A modified Delphi is chosen as a fieldwork approach to evaluate the availability, accessibility, currency and reliability of the existing data in the Malaysian construction industry as inputs into the process of generating reliable LCC analysis. The study being reported herein is drawn from a three-year programme of research carried out by the author to purposely enhance the quality of LCC data input requirements for building projects in

Malaysia. This paper follows the other six papers that have been presented elsewhere by the author (Mohd Fairullazi and Khairuddin, 2011a[1], 2011b[2], 2011c[3], 2012[4], 2013[5], 2013[6], 2014).

METHODOLOGY DESIGNED FOR THE STUDY

There are three types of research strategies, namely quantitative, qualitative and mixed methods research [4, 5]. Many research works in the past have chosen qualitative research as the strategy designed for LCC studies, i.e. King [12], Masoud [8], Muhammad Zuhry, [9], Joyce and Poppert [13] and Iyer [14]. King [12] and Joyce and Poppert [13] commented that the qualitative research is more appropriate for LCC studies rather than the quantitative and mixed method researches because the nature of research in LCC data inputs is subjective which requires the researcher to examine the data inputs and behaviours based on the opinions, ideas, views and perceptions from the panellists that have knowledge, skills and expertise in LCC.

The qualitative research is more appropriate for LCC data input study rather than the quantitative and mixed method researches because the data of LCC in the Malaysian construction industry are relatively limited, not current and inaccessible [6, 7]. Besides, the adoption and application of LCC techniques in the Malaysian construction industry is still embryonic [1-3, 9]. No evidence was found from the review of literature that indicates that the LCC techniques have already been practiced in the national context of strategic advancement issues in the Malaysian construction industry [1]. Furthermore, no evidence was found from the literature to support that a satisfactorily large number of respondents had knowledge about LCC did practiced LCC techniques to estimate total ownership costs of the building in the Malaysian construction industry. These factors have become major hurdles that impose constraints to the implementation of the quantitative and mixed method researches in the present study.

The literature study has identified several researchers which have used qualitative research in the past to study methodology, concepts and data inputs of LCC based on the analysis of opinions and perception from a group of respondents, i.e. Muhammad Zuhry (2010), Masoud (2009), King (2007), Ahmad Nazib (2005), Joyce et al. (1992) and Iyer (1999). Three of the researchers, namely Muhammad Zuhry (2010), Masoud (2009) and Ahmad Nazib (2005) applied the qualitative research to investigate the practice of LCC analysis and its data inputs in the context of the Malaysian construction industry.

FIELDWORK APPROACH OF THE STUDY

The literature review has found several scholars which have used Delphi technique as a fieldwork approach to collect primary data in LCC studies, i.e. King [12], Joyce and Poppert [13] and Wilkinson [15]. The scholars used Delphi technique to generate primary data by collecting, synthesizing and analysing quality opinions and valuable judgements from the group of panellists through rounds of Delphi questionnaire. The first scholar, King [12] performed a qualitative research strategy using the modified Delphi approach to develop a framework of best practices for controlling and reducing the total ownership cost (TOC/LCC). The second scholar, Joyce and Poppert [13] carried out the qualitative research strategy using the basic Delphi approach to develop the LCC analysis model for Phillips Laboratory and AFIT engineering group's second stage booster designs. Whilst, the third scholar, Wilkinson [15] executed a mixed methods research in combination with the modified Delphi approach to collect expert opinions for the development of a life cycle costing forecasting methodology for U.S. Air Force heating plants and the translation of the resulting cost estimating relationships (CERs), algorithms, and data into a Heating Plant Cost Analysis Model. The genuine application of the basic Delphi approach is a non face-to-face interaction that uses electronic devices for collecting responses from the panellists. However, several scholars suggested there is a need to modify the current basic approach [12, 17]. The first round of modified Delphi questionnaire is suggested to be conducted through a face-to-face interview in purposely to improve the response rate and to provide a solid grounding in the previously developed work [17] The modified Delphi also is more constructive than the basic approach as it initiates the process with a set of carefully selected items which derive from various sources including related competency profiles of panellists, synthesized reviews of literature, and interviews with the selected panel of experts [16].

Based on the literature study, there are several factors that have strongly convinced the authors to adopt a modified Delphi as the best fieldwork approach rather than other primary research approaches, i.e. surveys, case studies, action research and focus group discussion. Several scholars advocated that the modified Delphi approach is more appropriate than other typical research approaches in a situation where the existing data of the research are affluent and profound [18, 10]. The complexity of the domain research has made other typical research approaches relatively difficult and expensive to be conducted in providing explicit, precise and reliable data for the research questions [21]. Besides, the modified Delphi approach has been acclaimed as the best known qualitative, structured and indirect interaction futures

method [12]. There are many high impact publications that indicated the Delphi technique as a reliable and valid research approach to procure primary data for the research. Based on the report from Gordon [20, 35], from the assessment made on the Scopus database in September, 2008, more than 15,000 peer-reviewed professional journals from 4,000 various publishers indicated the Delphi technique as a chosen fieldwork approach to identify and forecast data for the research. Skulmoski et al. [21] reported that more than 280 dissertations and theses adopted Delphi as one of the primary approaches to generate primary data for the research. Nevertheless, it is very limited number of literatures currently available that indicated Delphi technique as a fieldwork approach in the research area of construction and built environment [22].

Limitations of modified Delphi and mitigation strategies

Limitations

It was a great challenge for the authors to identify appropriate level of panellists that possess the required skills, knowledge and expertise in the field of LCC environment. The competency of the panellists and the quality of responses are some of the crucial factors in the Delphi approach [22]. The competency and experience of the panellists are beyond the control of the authors. The process of Delphi may consume large time as it involves multi-round of questionnaires to explore the research problems, gathering data and finally to achieve consensus of opinion amongst the panellists [23]. Hence, it may affect concentration of the panellists to provide full commitment throughout the long Delphi process.

Mitigation strategies

A very careful and inflexible selective process was implemented to choose the right panellists that are competence and capable to diagnose problems and to design constructive solutions in the field of LCC environment [17]. In the process of identifying suitable people to be invited to become panellists in the modified Delphi study, a specified list of criteria was used. One of the important requirements is the panellist must be able to provide valuable answers inconsistently in every round of questionnaire [24]. A letter of informed consent was sent out to every individual of panellist in the initial stage of the modified Delphi process in purposely to acquire agreement from the panellists to become panellists in the modified Delphi study. The informed consent letter provides information about the purpose of the study, procedures to be followed, specified time frame for the panellists to return the completed questionnaire, and the contact details of the researcher if the panellists desire to get further information.

The panellists were identified through the practice, literature searches, and recommendations from the institutions and experts in the field of LCC environment (12, 4). To ensure maximum numbers of participants can be attained in the modified Delphi process, all panellists were contacted individually either by fax, e-mail or phone call. Continual reminders were made to the non-responders in notifying the importance of each panellists' contributions to the Delphi process [25]. The use of electronic devices in the modified Delphi process provides effective interaction amongst the panellists as the devices enable the information to flow more quickly and reduce time delay between rounds of questionnaires [25]. The questionnaires were piloted and validated with the research supervisor, recognized LCC experts and related peers in purposely to ensure the questions and the presentation formats are designed in sharp and answerable.

Administrating modified Delphi questionnaire

The modified Delphi process consists of four essential elements, i.e. (i) sequential questionnaires, (ii) reiteration and controlled feedback, (iii) anonymous responses and (iv) statistical group response [26]. A three-round modified Delphi process was decided to be carried out in the study to move the panellists toward consensus of opinion. The researcher decided to get between 10-18 participants in each round, following the recommendation from Delphi literature (27, 28, 29). In every round, the panellists were required to answer the questions independently and anonymously. The anonymity of Delphi panellists was maintained throughout the three-round modified Delphi process in order to avoid open debate and dishonest opinion. The value is specified based on the quality of the opinions rather than who proposed the idea [23]. The controlled feedbacks of group responses were only disseminated to the panellists who completed the previous rounds of modified Delphi study [26].

Round 1: The questions in this round were developed and structured in broad and open-ended in purposely to obtain a wide range of responses from the panellists [32]. The panellists were required to provide their background information and to indicate their expertise and competency in relation to the subject of the research [18]. The authors decided to conduct the first round questionnaire through an oral interview with every individual of panellists in purposely to provide adequate information about the scope

and objectives of the research, to improve understanding on the questions, and to provide added explanations about any area of disputation with regard to the questionnaire, scope and objectives of the study [30]

Round 2: The questions were developed in close-ended based on the results of the first round questionnaire [33]. The second round questionnaires were disseminated to the panellists using the electronic device, i.e. e-mail [12]. The panellists were required to complete the questionnaire by rating their answers on a 5-point Likert-type scale based on the responses obtained from the first round questionnaire [26]. The significant advantage of using the 5-point Likert-type scale is it can avoid unbiased sentiments of survey respondents. Moreover, the 5-point Likert-type scale has a nice midpoint to estimate the mean weighted average for a standard point of comparison [12]. The hierarchical answers collected from the second round questionnaire were analysed with descriptive group statistical analysis techniques, i.e. the measure of central tendency (median) accompanied by a measure of dispersion (standard deviation) [31]. The panellists were encouraged to contact the authors to reduce the potential of fear they may encounter in interpreting the questions. The contact information is provided in the questionnaire form and the panellists should be able to contact the authors if further clarification is required. SMS reminders were sent out regularly to notify the non-responders to complete and return the completed questionnaire before the timeline.

Round 3: In this round, the questionnaire consists of all consolidated responses which obtained from the previous rounds. The second round feedbacks were provided to the panellists in a form of median Likert-type scale accompanied by a measure of dispersion (standard deviation) of other panellists. Opportunity was given to the panellists to re-rate their proposed scores in the second round questionnaire. The standard deviation score of the item response is defined as the measurement level of consensus achieved, which also indicates the amount of disagreement within the panel. The mean score was calculated to determine which item responses are categorized as very important items to be included in the answer set of the respective question [17]. However, if the panellists decide to re-rate their score, they are encouraged to provide two rational reasons of why they do so. The consolidated reasons are significant to facilitate the researcher to determine significant of the questions. By doing this, the authors can observe what factors that make the panellists judge, think and view differently than the majority of group [12]. However, if the panellists decide to retain their score, they do not need to amend the answers, but they are required to proceed to the following questions. The third round questionnaire is decided to be the final round of the modified Delphi study. The reason of this is the consensus of expert opinion has become more stable and consistent and the general agreement amongst the panellists is expected to achieve, following the recommendation from Delphi literature (32, Parsons et al., 2008). The outputs of the study are statistical distribution of the responses which include the consensus of expert opinion regarding the availability, accessibility, currency and reliability of data in the Malaysian construction industry as inputs into the process of generating reliable LCC analysis.

RESULTS AND DISCUSSIONS

The main results were generated from the three-round modified Delphi process. In the first round, 42 panellists completed the questionnaire (100% response rate), second round 22 panellists (52.4% response rate), and the third round 20 panellists (90.9% response rate, based on the total participants in the second round). These response rates are considered adequate and satisfactory to report the results of the study, following the recommendation from the literature [35, 36]. The results also reveal a large part of the group of panellists disclosed that their professional qualification or/and expertise have significant connection to LCC. The participated panellists are not sharing similar characteristics and do not have expertise in each specific indicator area. The heterogeneous group of panellists was maintained throughout the three-round of modified Delphi process. On the basis of panellists' profiles, it is not misconception to state that the participated panellists in the modified Delphi study satisfactorily meet the specified criteria of expert panel and sufficient to report the research findings.

The standard deviation of each item response was calculated to identify the amount of disagreement within the panel and to indicate the measurement level of consensus achieved. The decision criteria used are shown in Table 1. The mean score is calculated to determine which item responses can be categorized as very important items to be included in the answer set of the respective questions. The decision criterion used is a 'cut-off' mean of 3.75 on the 5-point Likert scale or 75% of all individual ratings at the 3.75 level or higher. The results reveal that the standard deviation (SD) scores of all item responses in Round 2 are less than 1.5 and 1.00, which indicate the "reasonable or fair level of consensus" and "high level of consensus achieved in the second round. However, in the third round (final), 2 panellists decided to re-rate the previous scores of four item responses, which include the items 60, 2090,

2110 and 2150. Eventually, the scores of the revised items have to be re-calculated to ascertain the new revised median and standard deviation group responses. The new results reveal that the standard deviation scores of the revised items are slightly decreased by 0.02 to 0.13, however the scores are lower than their corresponding items in the second round. Table 2 presents the new scores of the revised items and the changes values of the standard deviation and median group responses. The reductions of the standard deviation scores show that the consensus of expert opinion has improved overtime. Nevertheless, the median scores of the respective items are remained unchanged. The reductions of the standard deviation scores also demonstrate that a greater consensus of expert opinion is achieved in the final round of modified Delphi study.

There are total 6 questions with respect to the LCC data inputs. The first question asks opinion about what costs should be included in the LCC analysis of a building. Based on the analysis of the third round responses, the initial capital costs, operation costs, maintenance and replacement costs, financial costs, salvage costs, and asset appreciation/depreciation costs have achieved "high level of consensus" because the estimated SD scores are less than 1.00. The mean scores of these 6 item cost components are ranked as the top six very critical items based on the hierarchy of mean scores. The second question asks about the three main difficulties, where the panellists think could hinder the application of LCC analysis in the Malaysian construction industry. The results reveal that three item responses obtained the highest mean score with the lowest SD value, i.e. no available system for data record keeping, data are not readily available as inputs for LCC analysis, and lack of enforcement from related parties (i.e. Public Works Department , Construction Industry Development Board) to make LCC compulsory in the building development projects. The third and fourth questions ask opinion about the degree of data availability and accessibility for LCC analysis. The results of the third round show that no data sources can be categorized as available and accessible data degrees because no item response obtained mean score more than 3.75. The fifth and sixth questions ask opinion about the degree of data currency and reliability for LCC analysis. The results show that many item responses of these two questions (Question 5 and 6) obtained mean score more than 3.75, and these items are considered satisfactory to be categorized as very important items of current and reliable data degrees. Table 3 shows the summary of data sources achieved in the modified Delphi study as highly available, highly accessible, very current and very reliable that that can be used as inputs into the process of generating LCC analysis.

Table 1: Standard deviation versus level of consensus reached (Grobbelaar, 2007, pg.14)

Standard deviation (SD)	Level of consensus achieved
$0 \leq X < 1$	High level of consensus
$1 \leq X < 1.5$	Reasonable/ fair level of consensus
$1.5 \leq X < 2$	Low level of consensus
$2 \leq X$	No consensus

Table 2: Consensus improvement

Question number (Category)	Code	Responses collected	Round 2		Round 3		Changed value	
			Median	SD	Median	SD	Median	SD
Question 1 (cost to include in LCC)	60	Asset appreciation/ depreciation costs	4	0.87	4	0.85	-	-0.02
Question 4 (highly accessible data for initial capital costs)	2090	Specific material cost (internal data)	4	1.37	4	1.35	-	-0.02
Question 4 (accessible data for initial capital costs)	2110	Contract documents	4	1.20	4	1.16	-	-0.04
Question 4 (accessible data for initial capital costs)	2150	Manufacturer	4	1.23	4	1.20	-	-0.03

Table 3: Consolidated item responses that achieved consensus in the modified Delphi study with regard to the state of data for LCC analysis of building

	Initial capital costs	Financial costs	Operation costs	Maintenance and replacement costs	Salvage costs
Highly available data	-nil-	-nil-	-nil-	-nil-	-nil-
Highly accessible data	-nil-	-nil-	-nil-	-nil-	-nil-
Very current data	Suppliers, Manufacturers, Quantity surveyors, Contract documents, Public Works Department (PWD), Consultants, The Valuation and Property Services Department (JPPH), Clients/ Developers, Contractors, Subcontractors, Valuers	Bank Negara, Financial institutions, Ministry of Finance, Statistics Department	Facility Management contract, Facility Managers, Annual cost report	Consultants	Facility Management contract
Very reliable data	Suppliers, Manufacturers, Construction Industry Development Board (CIDB) cost data, Quantity Surveyors, RISM, PWD, Contract documents, Consultants, Local government/ Public projects	Bank Negara, Financial institutions, Ministry of Finance	Facility Management contract (Annually base), Facility Managers	Facility Management contract (Annually base), Annual cost report, PWD published data	Market value, Facility Management contract (Annually base)

CONCLUSION AND RECOMMENDATION

This paper presents the fieldwork method to investigate the availability, accessibility, currency and reliability of data as inputs into the process of generating reliable LCC analysis in the Malaysian construction industry. The modified Delphi technique and the application of it in the LCC studies have been discussed in the paper. The modified Delphi technique was chosen because the technique has been recognized as a reliable and valid method to procure and evaluate experiences, understandings, views, opinions and judgements from the collective intelligence panellists in the field of LCC environment. The modified Delphi study involves a structured group communication process that procured responses through a number of sequential questionnaires from a group of panellists, following by synthesizing and analysing opinions and ideas to establish the consensus of expert opinion. The consensuses of expert opinions was established in the three rounds of modified Delphi questionnaire in effort to generate primary data for the study. The results revealed that all the panellists in the modified Delphi study have agreed there are several data sources that are satisfactorily categorized as very current and very reliable for LCC analysis, however, the majority of them have the same opinion there is no single data source in that is readily available and accessible as inputs for producing a comprehensive LCC analysis for building works in the Malaysian construction industry. So, based on the results of the study, it can be generally stated that all the panellists in the modified study have reached consensus there is limited availability and accessibility of current and reliable cost data inputs for LCC practice in the Malaysian construction industry. Apart from that, the results have verified there is no model, system or guideline has been established in the Malaysian construction industry to trace, define, collect and manage cost data inputs of building to provide cost data to the clients and estimators in facilitating them to carry out a comprehensive and reliable LCC analysis for building works. The study is limited by constrains in finding suitable panellists that have accessibility expertise in the field of LCC environment, and the routine of Delphi process is long and time-consuming. Accordingly, appropriate mitigation strategies were carried out to mitigate the limitations of the modified Delphi approach in the study. Further research is encouraged to identify appropriate procedures and strategies in making the data more available, accessible, current and reliable as inputs into the process of generating reliable LCC analysis. Due to the complexity of the domain research, the modified Delphi technique is recommended as a chosen fieldwork approach to identify and generate consensus of expert opinion about the appropriate procedures and strategies in making the data more available, accessible, current and reliable as inputs for the LCC analysis.

Notes

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