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The Implementation of Life Cycle Costing towards Private Client's Investment: The Case of Malaysian Construction Projects

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Abstract

Life-cycle Costing (LCC) is a technique used to estimate the total cost of ownership. It allows comparative cost assessments to be made over a specific period of time, taking into account relevant economic factors both in terms of initial capital costs and future operational and asset replacement cost. The implementation of LCC in construction industry is rapidly increasing. However, in the Malaysian construction industry, LCC has not been implemented extensively. This paper explored LCC implementation in construction projects in Malaysia from the client's perspective as well as benefits and barriers to implementing LCC. A quantitative approach involving questionnaire survey distributed to private clients in the Malaysian construction industry. More than half of the surveyed respondents indicated they were ready to invest in future costs and about 37% were currently implementing LCC or a similar costing principle. The inability of LCC to meet expectations of organisation in managing costs, lack of familiarity with LCC and the market not requiring the use of LCC were the main reason why organisations who had used LCC in the past discontinued the use of LCC. Influencing future costs in the design stage, greater emphasis on achieving a better 'value for money' in projects and improving awareness of total cost of projects were the three major benefits of implementing LCC while lack of a procurement and contract award incentives to use LCC, lack of a standard method of LCC, and clients' unwillingness to pay for LCC were identified as the main barriers to implementing LCC. Correlation analysis demonstrated that implementation of LCC during 'investment planning', 'scheme/concept design', 'detail/final design', 'construction and commission', and 'operation and maintenance' stages had statistically significant relationship with 'quality performance', while implementing LCC 'investment planning', 'scheme/concept design', 'detail/final design', and 'operation and maintenance' stages significantly correlated with 'overall project performance'. The importance of LCC in various project stages, the study concludes by emphasizing the need to create more awareness and implementation methodology to promote the adoption of LCC in the Malaysian construction industry.

Keywords: client, construction industry, life cycle costing, Malaysia

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INTRODUCTION

A "client" means a person for whom a project is carried out, in the course or furtherance of a trade, business or undertaking, or who undertakes a project directly in the course or furtherance of such trade, business or undertaking. The client is the person or company, with the controlling interest in the project. Generally, the client will retain a significant level of control over the assessment and appointment of designers and contractors for a project (Health and Safety Authority, 2009). Usually, the client's requirements are to get construction needs translated into a design that specifies characteristics, performance criteria and conformance to specifications, as well as to get the facilities built within cost and time (Kangari et al, 1995). One of the reasons is due to difficulties in preparing estimates for maintenance and operation works. Ali et al. (2013) noted that preparing estimates for maintenance cost allocation is complex and difficult. The factors that need to be considered in decision making for maintenance cost of existing and new buildings significantly vary. LCC is a tool to assist in assessing the cost performance of construction work, aimed for facilitating choices where there are alternative means of achieving the client's objectives and where those alternatives differ, not only in their initial costs but also in their subsequent operational costs. It allows these alternatives to be compared on the same basis. Whole life costing (WLC) has a broader scope than LCC as it can include costs (and incomes) associated with the provision of the construction works that are not included in the client's costs (RICS, 2016). Dell'Isola and Kirk (1981) define LCC as an economic assessment of competing design alternatives, considering all significant costs of ownership over the economic life of each alternative, expressed in terms of equivalent dollars. Life cycle costs are those associated directly with constructing and operating the building; while whole life costs include other costs such as land, income from the building and support costs associated with the activity within the building.

By identifying the LCC in the initial stage, a sum of money for the project will be saved. Blanchard (1978) studies on cost committed in LCC in 5 different life cycle phases, which are 'investment planning', 'scheme/concept design', 'detail/final design', 'construction and commission', and 'operation and maintenance'. Blanchard (1978) further notes that the highest cost committed throughout the life cycle phases is at the end of the phases, which are the cost for operations and maintenance. This is supported by Klaus (1986), who notes that to optimize the total costs of a system, it is therefore essential to pay attention to the very early phases of the system.

The LCC implementation in construction industry is rapidly increasing (Kirkham, 2005). This is supported by Olubodun et al. (2010) who found higher levels of LCC application being experienced than originally envisaged. Luay et al (2018) note that LCC is gaining much attention particularly within the context of sustainable construction. However, the life cycle costing application in the construction sector is rather limited and faces practical problems. Imperfect understanding of life cycle costing method and application is considered one of the key barriers to a widespread application of LCC in the construction industry. Luay et al (2018) further emphasise that life cycle costing is a powerful tool that allows cost quantification for a relatively long period of time considering price changes. The technique has been theoretically explained by many authors in previous literature. In addition, Renata (2017) notes that LCC used by investors for supporting decision-making in the early building design stages continues to be met with many difficulties. The implementation of LCC associated with many difficulties such as obtaining the required cost variables, particularly, if the analysis is conducted to develop life cycle budgets in the nominal terms, in which future inflation and deflation rates for the different cost elements could not be disregarded. Moreover, the availability of reliable data, diverging LCC standards, and the disparity between design information availability and the real importance of the design stage for decisions have also been identified as some of the difficulties with LCC implementation.

In the Malaysian construction industry, LCC has not been implemented extensively. At present the practitioners in Malaysia implement LCC in the construction industry is still at its early stages and not widely used. This is due to implementation barriers especially on the lack of awareness of the benefits and cost data management. Olubodun et al. (2010) associates this with uncertainties involved in the LCC stages, which raises questions about the benefits of LCC calculations. Mohamed et al (2007) and Mazlan (2010) highlighted that the techniques for LCC were seldom applied in Malaysian construction industry even though most developers and consultants are aware of the technique. While Fairullazi and Abdul (2011) found that concentration has been only on the initial cost with very seldom consideration of the future cost for operation, maintenance and replacement when a project or building development is proposed. Meanwhile, the study by Nor-Azizah and Zainal (2012) indicated that LCC concepts and practices seem to be unrecognized by practitioners.

Hence, the main objective of this paper is to explore the client's level of agreement on the importance of LCC implementation towards his investment. The benefits and barriers to implement LCC in the Malaysian construction industry are also investigated.

LITERATURE REVIEW

Life Cycle Costing Implementation in the Construction Industry

The concept of LCC was born in 1965 when the United States Logistics Management Institute used the term LCC in a military related document. After this document, the U.S. Department of Defence published three guidebooks in the early 1970s (Kenji, 2001). LCC was originally designed for procurement purposes in the US Department of Defence (White & Ostwald, 1976) and it is still used most commonly in the military sector as well as in the construction industry (Woodward, 1997). LCC is a technique used to estimate the total cost of ownership. It allows comparative cost assessments to be made over a specific period of time, taking into account relevant economic factors both in terms of initial capital costs and future operational and asset replacement costs. Life cycle costs are the total cost estimates in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span (DOE, 1995). LCC technique is a technique that may help clients in decision making when a client has a selection for his project. The main purpose of an LCC estimate is in helping to select the best option from a number of competing proposals (Ashworth, 1996). LCC provides basis for contrasting initial investments (design, professional fees, construction cost) with future costs over a specified period (usually building life). LCC also is used to compare the cost of alternative building components or systems over their economic or technical life (Renata, 2013). LCC is a mathematical method used to support a decision making on the option for a selection of material and equipment for a project and it is financially auditable (Bull, 1993).

The adoption of life cycle thinking has been very slow in other industries (Lindholm & Suomala, 2007). Public sector has also been a relevant promoter for LCC calculations (Woodward, 1997). LCC was originally designed for procurement purposes, i.e. to be used from a point of view of the client. Many of the most prominent LCC methods (Fabrycky & Blanchard, 1991; Woodward, 1997) are intended to be used to support design decision making, but nevertheless from a client's perspective. Since 1992, the concept of LCC has been accepted as a standard in the UK (BS 3843, 1992). The definition of LCC was revised in 2000 and incorporated in standard ISO 15686 Part 1 Service Life Planning. In 1999, Whole-Life Cost Forum was founded and WLC Comparator Tool was created. Then, in 2001, a task group, TG4, was former under the framework of the Working group for sustainable construction for drafting a report on LCC in construction and to make recommendations on how to integrate LCC into the European policy making. The last major initiative is A Common European methodology for LCC (2007). Research on LCC implementation in the construction industry has been considerably reported, although there is no consensus on the extent of LCC implementation in the construction industry across different regions. Some studies have indicated that LCC implementation is being considerably undertaken (Kirkham, 2005; Olubodun et al., 2010), while other studies have shown slow and minimal adoption of LCC implementation (Higham, Fortune and James, 2015). Fortune and Cox (2005) found from a survey of quantity surveying firms in the UK that among the non-traditional costing models in use, LCC was the most used costing model with 68% of the surveyed respondents indicating that they implemented LCC. In another study of construction companies and professionals in the UK, Olubodun et al. (2010) found that about half of the surveyed construction companies and professionals implemented LCC and identified lack of understanding of the technique and the absence of a standardized methodology as major factors affecting wide adoption of LCC implementation. Higham et al. (2015) using questionnaire survey and interview to the construction professionals found that LCC has not been widely used by built environment professionals in the UK. The study further identified that the major hindrance for LCC adoption was the need of clients for budgeting on short-term horizons. Other factors included were lack of awareness of the tool by practitioners and clients, unreliability of data into the long term and the overriding need for commercially driven projects to achieve maximum return on investment. Aouad et al. (2001) argued that recent developments in Web, virtual reality (VR), and object-oriented technologies as well as mathematical and computational modelling techniques are catalysts for helping in tackling issues associated with LCC costing techniques and proposed a conceptual framework for LCC model with database and virtual reality environment integration for desing, construction, operation and maintenance of buildings. Bakis et al. (2003) proposed a similar LCC model that relied on a computer-integrated environment to provide a framework or mechanism for collecting and retaining LCC data.

Benefits of the implementation of Life Cycle Costing

LCC promises benefits to clients and the project as a whole. Previous research has mentioned the benefits of LCC. Amongst the benefits of implementing LCC are transparency and sustainability of future construction costs. Alex (2013) states that LCC offers a clear technique with the choices based on financial and environmental criteria and improves forecasting since it allows more accurate forecasting of future expenditure to be applied to long-term costing assessment. The lifetime quality and the cost effectiveness of buildings would be improved by using LCC in the early stage of design (Schade, 2007). Influencing future costs in the design stage is also one of LCC's benefits. LCC is normally used as a method for comparing various options at an early stage in the life of a project to enable a balance decision to be made on which option should be preferred (Alex, 2013). Evaluation of design alternatives (buildings or components), assessment of a compromise between the technical parameters of the project and the cost (substitution of materials, technologies etc), greater emphasis on achieving a better "value for money" in projects and improving awareness of total cost of projects are some of the benefits associated with LCC implementation. Other than that, LCC assists the decision maker in identifying total cost involved, which in turn leads to effective and economic investment policy. LCC also can be used as a guide for maintenance of the building. As stated by Auoad et al (2001), an effective LCC management system provides economic maintenance policies during the operation of the building. It aids in selecting different maintenance systems that can be adopted, the maintenance cycles and their frequencies, to make repairs/replacement decisions, improvements, alterations or refurbishment decision and to decide on the maintenance budget.

Barriers to implementing LCC

Despite numerous benefits associated with the LCC implementation, previous studies have shown that even in developed countries, the adoption of LCC as a tool for early stage project evaluation had been slow and not at such pace attributable to the numerous benefits associated with LCC (Aouad et al., 2001; Bakis et al., 2003; Fortune and Cox, 2005). Olubodun et al. (2010) however reported that 51% of 46 surveyed construction companies and professionals in the North West of England indicated they frequently used LCC, indicating an upturn in the adoption of LCC. Higham et al. (2015) on the other hand found that of the 49 construction industry professionals surveyed, which included quantity surveyors, architects, project managers and engineers, 55%, 48%, 57%, 78%, 77%, 50%, and 22% rarely used LCC for housing, health, education, industrial, commercial, highway infrastructure projects and other projects respectively. The discrepancies demonstrated in some of these appear to be evident of the numerous issues surrounding the wide-spread uptake and application of LCC in the construction industry. In the view of Bull (1993) the fact that the construction industry is fragmented in nature makes is difficult to implement LCC. Bull (1993) argues that because the planning, building or maintenance phases of construction process are considered separate, an approach that is at odds with the very principles of LCC needed. On the other hand, Cole and Sterner (2000) note that bureaucratic structures such as the separation of capital spend and ongoing revenue budgets of public funds ensure that decisions are made in isolation. They argue that this does not align with the philosophy of LCC, thus severely restricting the use of LCC on their projects. Olubodun et al. (2010) found that lack of understanding of the LCC technique, an absence of a standardized methodology for LCC, complex process of LCC analysis, perceived inaccuracy of LCC results, and artificiality of the LCC process were the factors limiting the adoption of LCC in UK construction projects. Attempts to establish a standardized LCC methodology led to the development of the BS-ISO15686-5, however, Higham et al. (2015) found that construction industry professionals in the UK, at least the ones interviewed in the study, were not aware of the existence of this standard. In the same study, Higham et al. (2015) reported that short term horizons, lack of awareness of the benefits of LCC, lack of interest from clients, lack of expertise and length of required payback period were the five main factors limiting life cycle costing implementation. In a recent study, Saridaki and Haugbølle (2019) used a combination of literature review and case study of a Danish architectural firm to identify barriers to LCC implementation, classifying them as primary, secondary, tertiary and quaternary contradictions in the activity system of design practices. The study found that generally, lack of understanding of LCC definitions and methods, difficulties in accessing reliable data, lack of knowledge on sustainability issues, difficulty implementing LCC with available tools, limited collaboration between LCC practitioner and the rest of the project team, lack of standardized methodology for managing and exchanging life-cycle data, difficulty integrating design models with new technologies such as building information modelling (BIM) were some of the challenges associated with LCC adoption and implementation. Table 1 is a summary of the barriers to implement LCC in construction industry.

Table 1: Barriers to implement LCC

Barriers	References
Construction industry is fragmented in nature.	Bull (1993)
Bureaucratic structures and the decision made in isolation.	Cole and Sterner (2000)
Lack of understanding of the LCC technique.	Olubodun et al. (2010), Saridaki and Haugbølle (2019)
Lack of expertise on LCC.	Higham et al. (2015)
Absence of a standardized methodology for LCC.	Olubodun et al. (2010), Saridaki and Haugbølle (2019)
Lack of awareness of the benefits of LCC.	Higham et al. (2015)
Complex process of LCC analysis.	Olubodun et al. (2010)
Professionals in the UK were not aware of the existence of LCC standard.	Higham et al. (2015)
Limited collaboration between LCC practitioner and the rest of the project team.	Saridaki and Haugbølle (2019)
Difficulties in implementing LCC with available tools.	Saridaki and Haugbølle (2019)
Difficulty integrating design models with new technologies such as building information modelling (BIM).	Saridaki and Haugbølle (2019)
Difficulties in accessing reliable data.	Saridaki and Haugbølle (2019)
Perceived inaccuracy of LCC results.	Olubodun et al. (2010)
Lack of interest from clients.	Higham et al. (2015)
Lack of knowledge on sustainability issues.	Saridaki and Haugbølle (2019)
Length of required payback period.	Higham et al. (2015)
Artificiality of the LCC process.	Olubodun et al. (2010)

RESEARCH METHODOLOGY

The objectives of this research are to identify the level of agreement among private client on the importance of LCC in construction industry and to examine the barriers in implementing LCC. In this study, the client refers to private developers. A quantitative approach was adopted and questionnaire survey was utilised for data collection. A total of 210 private developers were identified from the Star Publication (M) Berhad, a property developer website, to form the population for the study. According to Krejcie and Morgan (1970), the minimum sample size required for the population is 136. A set of questionnaires was sent to 150 private developers. The non-probability purposive sampling technique was used to distribute the questionnaire to developers. The questionnaires were distributed in 2 approaches, which were self-administrated by postal and during the real estate conference held in Kuala Lumpur. The list of the private developers who attended the conference was obtained from the conference organiser. A total of 59 questionnaires were received giving a response rate of 43 percent from both approaches. The questionnaire was designed in 3 parts. The first part contained questions about the demographic profile of the respondents. The second part was related to LCC implementation and the third part of the questionnaire was related to barriers, benefits and importance of LCC implementation. A 5-point Likert scale (1=strongly disagree; 5=strongly agree) was used in the questionnaire to identify the importance, benefit and barriers of the LCC implementation in construction project. The five-point scale used in the questionnaires was then transformed to mean readings to determine the ranks of each variable, following the procedure used by Egbu (1994). Data was analysed using frequency distributions, mean, standard deviation and correlation analysis.

RESULTS

Demographic profile of respondents

Table 2 shows the demographic characteristics of the respondents. The demographic profile describes the job designation of the respondents, their gender, age and work experience in the construction industry. Analysis on the job title shows most of the respondents (65.8%) indicated 'other', which include engineers, architects, QS, senior planner, and project executive. Whereas the analysis on the gender of the respondents, 46.6% were male while 53.4% were female, accounting for a slight majority. In terms of age, majority of the respondents (59.1%) indicated they were 31 to 40 years old, followed by those 41 to 50 years (20.1%). A slight majority (45.1%) said they have worked in the construction industry for 6 to 10 years, followed by 21.9% who said they have been working in the construction industry for more than 15 years. In total, more than 88% of the respondents indicated they have experience of more than 6 years working in the construction industry.

Table 2: Demographic profile of respondents (n=59)

		Percent	**Cumulative Percent**
Job title	Director	5.4	5.4
	General manager	6.8	12.2
	Project manager	11.0	23.3
	Senior manager	11.0	34.3
	Other	65.8	100.0
	Total	100.0	
Gender	Male	46.6	46.6
	Female	53.4	100.0
	Total	100.0	
Age	30 years or less	8.4	8.4
	31 to 40 years	59.1	67.5
	41 to 50 years	20.1	87.6
	51 to 60 years	11.0	98.6
	More than 60 years	1.4	100.0
	Total	100.0	
Period of working in construction industry	5 years or less	11.5	11.5
	6 to 10 years	45.1	56.6
	11 to 15 years	21.5	78.1
	More than 15 years	21.9	100.0
	Total	100.0	

Life Cycle Cost implementation

Organisation's readiness to invest for future costs

The respondents were asked about their organisation's readiness to invest in future costs. As shown in Table 3, 67.1% of the respondents indicated their organisation was ready to invest in future costs, while 32.9% indicated their organisation was not ready.

Table 3: Organisation ready to invest for future costs (n=59)

	Valid Percent	**Cumulative Percent**
Yes	67.1	67.1
No	32.9	100.0
Total	100.0	

Current use of LCC on projects

On whether their organisation was currently using LCC, majority of the respondents (37%) said they were not sure, while 26% said their organization was not using LCC as can be seen in Table 4. Only 15.1% indicated that LCC was well established in their organisation, while 19.2% said their organisation recently started implementing LCC but not fully. 2.7% said their organisation uses a costing principle with similar characteristics to LCC.

Table 4: Organisation currently using LCC (n=59)

	Valid Percent	**Cumulative Percent**
Not sure	37.0	37.0
Organisation does not use LCC	26.0	63.0
Organisation recently started implementing LCC but not fully implementing it	19.2	82.2
LCC is well established in our organisation	15.1	97.3
Organisation uses LCC, or a costing principle with similar characteristics	2.7	100.0
Total	100.0	

Benefits of LCC to client

In Table 5, the results regarding the benefits of LCC to client are shown. Influencing future costs in the design stage was indicated by the respondents as the number one benefit of LCC (mean = 4.05), followed by 'greater emphasis on achieving a better **'**value for money**'** in projects' (mean = 4.04; SD = 0.818), and then 'improving awareness of total cost of projects' (mean = 4.04; SD = 0.835).

Table 5: Benefits of LCC to client (n=59)

	Mean	Std. Deviation
Influencing future costs in the design stage	4.05	0.680
Greater emphasis on achieving a better 'value for money' in projects	4.04	0.818
Improve awareness of total cost of projects	4.04	0.835
Evaluation of design alternatives (buildings or components)	4.00	0.782
Ability to plan for future expenditure associated with the ownership of buildings	3.99	0.819
Assessment of a compromise between the technical parameters of the project and the cost	3.99	0.731
Transparency and sustainability of future construction costs	3.99	0.672

Importance of LCC implementation in various project stages.
Table 6 shows the importance of project stages for LCC implementation, ranked in order of descending means. The respondents indicated 'investment planning' stage as the most important (mean = 4.23), followed by 'scheme/concept design' (mean = 4.20), and 'detail/final design' also requires (mean = 4.18). The result shows that LCC is considered to be of predominant importance during pre-construction stage.

Table 6: LCC implementation in various project stages (n=59)

	Mean	Std. Deviation
Investment Planning	4.23	0.930
Scheme/Concept Design	4.20	0.827
Detail/Final Design	4.18	0.817
Construction and Commission	4.14	0.911
Operation & Maintenance	4.03	0.950

Impact of LCC implementation in various project stages.
As can be seen in Table 7, 'client expectations for project' was ranked the highest in changes caused as a result of LCC implementation (mean = 3.87. This was followed by 'project features and functions that client value' (mean = 3.78), and 'projected construction cost' (mean = 3.76). Changes in 'projected maintenance cost' was ranked the lowest, followed by 'projected operation cost', and 'number of design changes after construction start' with mean scores of 3.32, 3.34, and 3.36 respectively. The results imply that LCC implementation is considered by the respondents to have more impact in the pre- and during-construction stages of the project. This results highlight the importance of LCC implementation in various project stages.

Table 7: Changes in project that may be caused by LCC implementation (n=59)

	Mean	Std. Deviation
Client expectations for project	3.84	0.882
Project features and functions that client value	3.78	0.716
Projected construction cost	3.76	0.841
Cost of materials	3.74	0.764
Overall project performance	3.72	0.868
Cost of project before construction	3.69	0.859
Time required for project start	3.58	0.759
The cost of owing the project through its life cycle	3.47	0.848
Number of design changes after construction start	3.36	0.918
Projected operation cost	3.35	0.928
Projected maintenance cost	3.32	0.926

Importance of LCC for decision making.
Regarding the importance of LCC for decision making in an organisation, Table 8 shows that 'improving understanding of the total cost of an asset' was ranked the most important by the respondents (4.07), followed by 'a tool for the financial assessment of alternative options' (mean = 4.07; SD = 0.746), and then 'instilling greater confidence in decision-making in a project' (mean = 4.07; SD = 0.849).

Table 8: Importance of LCC in organization for decision making (n=59)

	Mean	Std. Deviation
Improving understanding of the total cost of an asset	4.09	0.797
A tool for the financial assessment of alternative options	4.07	0.746
Instilling greater confidence in decision-making in a project	4.07	0.849
Helping to achieve an appropriate balance between initial capital costs and future costs	4.05	0.660
Facilitating effective choices	4.00	0.682
Public funded projects to invest in construction project have a particular requirement for value for money and financial efficiency using LCC	3.95	0.842
Assessing the design of buildings in terms of LCC is one of the ways to ensure meeting economy, efficiency and effectiveness for project	3.93	0.926
Assessing the total cost commitment of investing in and owning an asset over its complete life cycle or selected intermediate period	3.86	0.849
Helping to identify opportunities for greater cost effectiveness	3.86	0.926

Importance of common standard for life cycle costing in the construction industry.
The respondents were asked to indicate the importance of having a common standard for LCC. Table 9 shows that 'making LCC assessments and underlying assumptions more transparent and robust' was ranked by the respondents as the most important (mean = 4.14), followed by 'enabling the practical use of LCC so it becomes widely used in the construction industry' (mean = 4.09), and then 'enabling the application of LCC for wide range of procurement methods' (mean = 4.01).

Table 9: Importance of having common standard for LCC (n=59)

	Mean	**Std. Deviation**
Make the LCC assessments and underlying assumptions more transparent and robust	4.14	0.709
Enable the practical use of LCC so it becomes widely used in construction industry	4.09	0.762
Enable the application of LCC for wide range of procurement methods	4.01	0.767
Help to improve decision making and evaluation processes	3.97	0.891
Address concerns over uncertainties and risks to improve the confidence in LCC forecasting	3.96	0.851
Establish clear terminology and a common methodology for LCC	3.91	0.982

Barriers to implementing LCC

As shown in Table 10, the respondents identified 'lack of procurement and contract award incentives to use LCC' as the number one barrier to implementing LCC (mean = 3.84), followed by 'lack of a standard LCC method' (mean = 3.81; SD = 0.886), and then 'clients unwilling to pay for LCC' (mean = 3.81; SD = 0.989). Difficulty in obtaining appropriate relevant and reliable information of data was the fourth ranked barrier (mean = 3.78), with separation of capital/acquisition and running costs of most projects the fifth ranked barrier (mean = 3.73).

Table 10: Barriers to implementing LCC (n=59)

	Mean	**Std. Deviation**
Lack of procurement and contract award incentives to use LCC	3.84	0.844
Lack of a standard method of LCC	3.81	0.886
Clients are unwilling to pay for it	3.81	0.989
Difficulty in obtaining appropriate relevant and reliable information of data	3.78	0.880
Separation of capital/acquisition and running costs of most projects	3.73	0.969
Lack of fiscal measures that encourage clients' use of LCC	3.70	0.872
Insufficient time to carry it out	3.66	1.037
Incompatibility with client's intangible or non-financial objectives and needs	3.62	0.917
LCC skills are unavailable	3.61	0.948
Clients do not request it	3.59	1.019
Results are difficult to interpret and not directly useful	3.50	0.969

Reasons for stopping use of LCC.

Table 11 shows that 'LCC not meeting organisation expectations in its ability to manage costs' was the chief reason indicated by the respondents as causing their organisation to stop the use of LCC (27.9%), followed by 'general lack of familiarity with LCC' (23.3%), and then 'market not requiring the use of LCC' (14%). The results show the reason organisations might be seeking ways to better manage project costs, where they lack of the necessary understanding of the LCC technique, a situation that could be linked to uncertainties in the stages of LCC. This results indicates those reasons were also the barriers to implement LCC in the project.

Table 11: Reasons for stopping use of LCC (n=59)

	Valid Percent	Cumulative Percent
General lack of motivation to use LCC	9.3	9.3
General lack of familiarity with LCC	23.3	32.6
Facing more pressing business problems	9.3	41.9
LCC did not get top management support	2.3	44.2
LCC did not meet organisation expectations in its ability to manage costs	27.9	72.1
Market did not require it	14.0	86.0
LCC required too much time	2.3	88.4
People in organisation unwilling to adapt to new costing procedure	7.0	95.3
Other	4.7	100.0
Total	100.0	

Correlation analysis on relationship between implementation of LCC in various project stages and impact on aspects of project performance

To determine the relationship between implementation of LCC at various project stages and aspects of project performance, a Spearman Rank Correlation analysis was performed. Investment planning, scheme/conceptual design, detail/final design. construction and commission, as well as operation and maintenance were the variables used to represent project stages while quality, cost and time were used as variable to measure performance. Time, cost, and quality are the common parameters used for measuring project performance (Ling, and Leong, 2002). Overall project performance on the other hand was indirectly measured and represented a proxy variable for the aggregation of time, cost, and quality. Proxy variables have been used in previous research (Baharum, 2011) where a particular variable cannot be directly measured. The Spearman Rank Correlation in Table 12 showed that significant statistical relationships existed between project stages and project performance. The highest correlation under the 'Investment Planning' is 'Quality' of project, which is 0.410, followed by 'Time' of the project, which is 0.351 and 'Cost' of the project, which is 0.269. The correlation between 'Investment Planning' and 'Quality' of project indicates that there is a moderate relationship between these variables. All variables show the p-value is less than the significance level of 0.05, which indicates that the correlation coefficient is significant.

Table 12: Spearman rank correlation analysis on relationship between implementation of LCC in various project stages and impact on aspects of project performance (n=59)

Project Stages	Quality Performance	Cost Performance	Time Performance	Overall Project Performance
Investment Planning	.410**	.269*	.351**	.406*
Scheme/ Conceptual Design	.373**	.302*	.253	.361**
Detail / Final Design	.341**	.248	.216	.302**
Construction & Commission	.215	.238	.130	.215
Operation & Maintenance	.318*	.173	.157	.247

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

For the 'Scheme Design' stage, the highest correlation recorded is with 'Quality' of project, which is 0.373. This is followed by 'Cost of the Project' with correlation of 0.302 and 'Time of the Project with correlation of 0.253. The p-value is less than the significance level of 0.05, which indicates that the correlation coefficient is significant except for 'Time of the Project' where the p-value is slightly higher than 0.05.

Under the 'Detail Design' stage, the highest correlation is with 'Quality' of project, which is 0.341. The p-value is less than the significance level of 0.05, which indicates that the correlation coefficient is significant. However, the correlation between this stage with 'Cost' of the project and 'Time' of the project, shows that the correlation coefficient is not significant because the p-value is greater than 0.05.

A slight change in correlation is identified for 'Construction and Commission' stage, whereby the result indicates that all variables have a very weak relationship. The p-value shows that all variables are not significant. The result on the last stage show that the highest correlation is with 'Quality' of project, which is 0.318 with p-value less than 0.05. This shows that this variable is significant.

On the other hand, result on the 'Overall Project Performance' shows that, 'Investment Planning', 'Scheme Design' and 'Detail Design' stage have a significant correlation coefficient with overall project performance with a p-value of less than 0.05. This indicates that the implementation of LCC during the pre-contract stage will significantly influence the overall project performance. It is also identified that the 'Quality' of project is the most important criteria that influences the implementation of LCC.

DISCUSSION

The findings show that more than half (67%) of the surveyed respondents were ready to invest in future costs and about 37% were currently implementing LCC or a similar costing principle with similar characteristics. This finding is in contrast with Olubodun et al. (2010), where a higher use LCC application was reported in the UK. However, the finding by Higham, et al. (2015) found that majority of surveyed construction professionals in the UK rarely implemented LCC across a variety of construction projects. They further clarified that the major hindrance for LCC implementation was the need of clients for budgeting on short-term and not the long-term horizons. Other factors included were lack of awareness of the tool by practitioners and clients, unreliability of data into the long term and the overriding need for commercially driven projects to achieve maximum return on investment. This is supported by Saridaki and Haugbølle (2019) who found difficulties in accessing reliable data due to unavailable tools for implementing LCC. These factors are in line with this study where the main reasons organisations discontinued to use LCC are due to inability of LCC to meet expectations of organisation in its ability to manage costs (28%), general lack of familiarity with LCC (23%) and the market not requiring the use LCC (14%).

This study also found that the most important stage to incorporate and implement LCC is on the 'investment and planning' stage in a project life cycle. In addition, the respondents' feedbacks show that the client expectations for projects will increase due to better project performance, which in turn improve the understanding of total cost of an asset. This is supported by Shade (2007) and Alex (2013) who identified that LCC should be implemented at early stage of project life cycle for a balance decision in quality and cost effectiveness of buildings.

On the benefits of LCC to client, influencing future costs in the design stage, greater emphasis on achieving a better 'value for money' in projects and improving awareness of total cost of projects were the three major benefits identified in this study. These findings are largely in agreement with earlier findings from Alex (2003), Al-Hajj and Aouad (1999), and Schade (2007). Lack of procurement and contract award incentives to use LCC, lack of a standard method of LCC, clients' unwillingness to pay for LCC, difficulty in obtaining appropriate relevant and reliable information of data, and separation of capital/acquisition and running costs of most projects were the five main barriers to implementing LCC identified by this study. These findings largely support the findings of Olubodun et al. (2010) and Higham et al. (2015). The separation of capital/acquisition and running costs of projects particularly in public projects, for instance, is considered to be at odds with the LCC framework (Cole and Sterner, 2000). The correlation analysis demonstrated that, implementation of LCC has statistically significant relationship with aspects of project performance. Implementation of LCC during 'investment planning', 'scheme/concept design', 'detail/final design', 'construction and commission', and 'operation and maintenance' was found to be positively correlated with 'quality performance', while implementing LCC during 'investment planning', 'scheme/concept design', 'detail/final design', 'construction and commission', and 'operation and maintenance' were found to show a significant relationship with 'overall project performance'. According to Alex (2013), LCC improves forecasting because it allows more accurate forecasting of future expenditure to be applied to long-term costing assessment.

CONCLUSIONS

This study has identified that clients are willing to implement LCC in the construction industry and over a third are currently implementing LCC or a similar costing principle. As expressed by the respondents, there is a general willingness to make use LCC but for several issues associated with the implementation of the LCC technique. The study also demonstrated that some of the clients who had implemented LCC in the past discontinued its use for reasons such as LCC not meeting the organisation's expectations in the life cycle costing technique's ability to manage costs, general lack of familiarity with LCC and lack of demand. Besides, this study shows the importance of LCC in a project. It highlights the client expectations for projects will increase due to better project performance when the project implement LCC at the early stage of project life cycle, improving understanding of the total cost of an asset, a tool for the financial assessment of alternative options instilling greater confidence in decision-making in a project. Three main barriers were identified with lack of procurement and contract award incentives to use life cycle costing, lack of standard LCC method and clients' unwillingness to pay for LCC. Where implemented appropriately, the study suggests that benefits such as achieving better 'value for money' and improving awareness on total costs of projects can be realised. Also, as demonstrated by the correlation test, implementation of LCC in various project stages could give impacts on the quality performance and overall project performance. Therefore, efforts need to be made to create more awareness on LCC implementation as well as developing a standardised LCC implementation methodology for the construction industry.

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