International Journal of Integrated Engineering, Special Issue 2018: Civil & Environmental Engineering, Vol. 10 No. 2 (2018) p. 1-6

DOI: https://doi.org/10.30880/ijie.2018.10.02.001

Sustainable Procurement in Australia: Quantity Surveyors' Perception on Life Cycle Costing

Benson Teck-Heng Lim[1,*], Wanting Zhang[1], Bee Lan Oo[1]

[1]Faculty of Built Environment
UNSW Sydney, New South Wales 2052, Australia

Received 01 January 2018; accepted 15 April 2018, available online 07 May 2018

Abstract: Life cycle costing (LCC) has long been recognised as one of the essential techniques for sustainable development. Over the past decades, the use of LCC in the industry has been restricted and building stakeholders are blaming each other for its limited application. The research aims to investigate quantity surveyors' perception towards LCC implementation in Australia by specifically examining their general awareness and application of LCC; determining the key obstacles hindering LCC implementation; and identifying the key enablers for LCC implementation. An online survey of 24 quantity surveying professionals was undertaken. The overall results indicate that quantity surveying professionals do have basic knowledge of LCC and appreciate its benefits. However, the results suggest that clients and architects are the key culprits for hindering the implementation of LCC by placing greater emphasis on initial costs and design over strategic value of an asset. For wider application, it is suggested that government and professional bodies play a vital role to enforcing and promoting the future use of LCC. In conclusion, the research informs building stakeholders the key issues in LCC implementation and adds to the existing body of knowledge on LCC application for future research to be undertaken.

Keywords: Australia, life cycle costing, procurement, Quantity Surveyor

1. Introduction

The concept of 'Life Cycle Costing' (LCC) is no longer new in the construction industry and has indeed been commonly allude to in sustainable-related studies. According to the International Organization for Standardization standard (ISO 15686-5) [1], LCC involves economic assessment of all agreed projected significant and relevant cost flows over a period of analysis and is expressed in monetary value. Furthermore, the projected costs relate to those items to achieve defined levels of performance such as reliability, safety and availability. In brevity, LCC could be used for assessing the economic performance of a building throughout its life cycle, starting with its initial planning and design to construction, operation and maintenance, refurbishment and ending with its demolition stages [2]. Through the assessment process, project stakeholders would be informed of the financial and non-financial gains of those environmental and social sustainability initiatives and thereafter make procurement decisions (see [3]).

Despite the prevailing thrust for sustainable procurement, it is surprising that LCC implementation in construction is relatively slow. Over the past two decades, a considerable amount of research has documented the benefits, barriers and drivers for LCC implementation across different countries and stakeholders. For example, Sterner [4] surveyed Swedish clients, while Cliff and Bourke [5], Higham et al. [6] and Oduyemi et al. [7] surveyed the U.K. building stakeholders, on the use and awareness of LCC and its barriers. Further to the U.K., Swaffield and McDonald [8] and Chiurugwi et al. [9] surveyed quantity surveyors about their perceptions on the importance and use of life cycle costing within private finance initiative and general projects, respectively. More recently, Goh and Sun [10] undertook a literature survey on the development of LCC concept and approach, pointing to the increasing trend of publications focusing on the economic assessment of options for green buildings design and performance. Estevan and Schaefer [11] later showcased the development of LCC methodologies within the European framework of sustainable public procurement and public procurement of innovation, and highlighted the obstacles hindering effective LCC implementation and some workable solutions.

Hitherto, it appears, however, that little empirical research has been undertaken to examine the implementation of LCC in the Australian building industry. The most relevant study was from Highton [12] who provided future direction of and guidelines for LCC and building procurement. It is thus not known if Australian quantity surveyors were aware of LCC and did consider the economic benefit and viability of a proposed building at the feasibility and design stages of procurement. In addressing this gap, this research aimed to explore Australian quantity surveyors' perception

*Corresponding author: b.lim@unsw.edu.au

towards LCC implementation in the building industry by specifically (i) examining their general awareness and application of LCC; (ii) determining the key obstacles hindering LCC implementation; and (iii) identifying the key enablers for LCC implementation.

2. Literature review

LCC has long been recognized as one of the cornerstones for achieving sustainability and an important technique for evaluating the total cost of ownership of procured goods and services in construction [13]. Admittedly, undertaking LCC during the design phase would be most beneficial for clients as the possibilities of operation and maintenance cost reduction are large [4]. Many authors, however, pointed out that the practicality of LCC is often constrained by its oversimplification to a monetary perspective where the critical integration and optimization of the economic, social and environmental considerations to a building was largely ignored by stakeholders in construction (e.g. [4], [10]).

Arditi and Messiha's [14] early research on the life cycle costing in the U.S.A. municipal construction projects has shown that 40% of the municipalities use LCC analysis for over 20 years, and that 60% of the municipalities did not use LCC analysis due to the lack of formal guidelines and the difficulty of estimating future costs and incomes. In accepting this, Cole and Sterner's [15] critical review of LCC in practice has revealed the limited use of LCC was mainly attributed to a host of human and technical factors, which could be broadly classified into: (1) motivational hindrances; (2) contextual hindrances; (3) methodological problems and limitations; and (4) data problems and limitations. Around the same time, Sterner [4] surveyed U.K. clients on their awareness and application of LCC, and found that the use of LCC was limited mainly attributed to the lack of relevant data inputs and clients' inexperience of LCC calculation.

In Swaffield and McDonald's [8] survey of U.K. contractors' quantity surveyors, it is found that their respondents generally did consider life cycle costs when procuring new products or elements for private finance initiative (PFI) projects. However, during exceptionally busy times or when working within tight budgets, the quantity surveyors did not consider life cycle costs and generally, procurement decisions were made on the basis of lowest price. This however contradicts Chiurugwi et al.'s [9] overall finding that there was a limited understanding of LCC among U.K. quantity surveying consultants and that clients seem to be the main promoter of LCC use when it is used. The authors further point out that the limited use of LCC was mainly due to: (1) the quantity surveyors' lack of appreciation of LCC benefits; (2) their unawareness on LCC methodologies and calculation; and (3) the lack of procurement or contract award incentives. Similarly, Olubodun et al.'s [16] and Oduyemi et al.'s [7] analyses of the barriers to LCC application has shown that the lack of understanding of the LCC techniques, the absence of a standardized guideline, and the lack of reliable data input for life cycle cost estimates were the key factors limiting wider implementation of LCC in the U.K. construction industry.

More recently, D'Incognito et al.'s [17] analyses of the key actors and barriers of LCC application reveal that organizational culture was the most relevant barrier for LCC implementation, following by technical and financial barriers, and that clients and authorities were the key actors driving the adoption of LCC. These findings are further supported by Higham et al. [6], who found that U.K. clients was the main inhibitor of LCC implementation, followed by the lack of awareness among professional and the unreliability of data into long term use of buildings.

3. Research method

In this study, an online survey questionnaire was developed using the University of New South Wales survey platform. In the first section, respondents were required to provide their background information such as years of experience and the type of company. In the second section, they were asked to rate statements relating to: (1) their knowledge and application of LCC; (2) the perceptions of the barriers and enablers to the implementation of LCC in the industry, based on a seven-point Likert Scale, ranging from 1(Strongly disagree) to 7 (Strongly disagree) (see Table 1 for those statements). An odd-point Likert scale was used to provide a neutral point for respondents to select. Lastly, an open-ended question was included, requesting respondents to propose strategies to promote the use of LCC in the industry. The questionnaire was pretested, validated and amended before an industry-wide survey was undertaken.

Table 1: List of statements

Item code	Description
Knowledge; Authors: modified from [8]	
K1	I have a good understanding of LCC and its benefits
K2	I received adequate information and training about LCC from my tertiary education
K3	I am fully aware of the different mechanisms available to estimate LCCs at the early stage
K4	My company has provided me with training about LCC
Application; Authors: modified from [6] & [8]	
A1	My company promotes the importance of using LCC when procuring works and services
A2	I consider things other than just the initial cost when analyzing and preparing tenders for projects
A3	When procuring for a new sub-contractor for works and services, I strive minimizing initial expenditure to increase possible return on investment for clients
A4	I only undertake LCC analysis upon the request of my clients and/ or design consultants
A5	When undertaking LCC analysis, I adhere to the ISO15686-5:2008 guidelines
A6	When tendering for new projects, I always think that by conducting a LCC analysis it will help saving money for our clients or increasing the possibility of wining the project
A7	When undertaking LCC, I work with an integrated design team to obtaining a more reliable outcome

A8	I use LCC techniques to develop the best value for money product and service options
Barriers; Authors: modified from [6], [7] & [9]	
B1	Tight budget
B2	Insufficient time to carry out LCC during the early design and procurement stage
B3	Lack of sufficient and reliable information at the early design stage to perform a proper LCC analysis
B4	Lack of support and commitment from architects
B5	Lack of knowledge of architects on LCC
B6	Lack of government initiatives to help improving the adoption of LCC
B7	Lack of training on the standardized LCC approaches and guidelines
B8	Clients are unwilling to pay money and spend time on LCC exercises
B9	Client do not request for LCC
B10	Lack of knowledge of clients on LCC
B11	Client place greater emphasis on saving capital investment than maintenance cost saving
B12	LCC efficient alternatives are not always the most environmentally and socially sustainable ones (i.e. lack of appropriate cost-effective alternatives)
Enablers; Authors: modified from [6], [9] & [17]	
E1	Introduction of an integrated design team at the early design stage for undertaking LCC
E2	Incorporation of LCC exercises as one of the elements in green certification
E3	Clear guidance should be provided on how and when to conduct LCC exercises
E4	LCC should be made mandatory for sustainable public procurement policies
E5	LCC should be regulated as part of the quantity surveying scope
E6	Client should provide the necessary information, budgets and expertise to perform LCC analysis

For the survey, members of the Royal Institute of Chartered Surveyors in Australia were invited to participate. To further improve the response rate, email invitations with the survey link were also sent to the human resource managers of large size consulting and construction firms for distribution of the survey link to their fellow quantity surveying colleagues. After three weeks, a total of 35 responses was collected but only 24 were completed and valid. Of the 24 respondents, 22 were consultant quantity surveyors and two were contractor quantity surveyors. Most of the respondents (66.7%) had more than five years of experience in the industry.

For data analysis, the relative prevalence indexing (RPI) method was adopted to facilitate the relative comparisons of items relating to the application and barriers hindering LCC implementation. The RPI method was preferred over the arithmetic average method because the former can derive relative indices within the range of 0-1 for each item and therefore enable researchers to undertake relative comparisons of items. This is an outcome that could be not achieved by directly comparing the arithmetic average of each items considering that items could have different maximum mean values (see [18]). Equation 1 below shows the formula for calculating the Relative Prevalence Index (RPI) of each item.

$$RPI = \frac{\sum_{i=1}^{n}\left(i\ x\ frequency_i\right)}{Total\ number\ of\ samples\ x\ \max imum\ rating} \quad (1)$$

where: i and n represent a respondent's choice along the lowest (1) and the highest (7) points in the 7-point Likert scale, respectively. "Frequency" is the number of respondents who provided the respective ratings; and the "maximum rating" is the highest point that could be given by the respondents, i.e. 7. In this study, a higher RPI indicates that an item is more prevalent than other items with relatively lower RPIs.

4. Results and discussion

4.1 General knowledge and application of LCC

Table 2 shows the general knowledge and application of LCC of the respondents. The results reveal that most respondents did have an adequate level of understanding about LCC (K1) and were fully aware of possible building maintenance requirements and those mechanisms available to estimate LCCs at the early stage (K3), with the corresponding RPI of 0.76 and 0.74. These findings somehow disagree with those of Chiurugwi et al.'s [9] and D'Incognito et al. [17] that quantity surveyors were the inhibitor of LCC implementation and they lacked a good understanding of LCC principles and general building maintenance requirements. Despite their strong consensus for K1 and K3, the results show that about half of the respondents did not feel that their company had provided them with adequate training to undertake LCC analysis (K4; RPI = 0.49). Added to this pessimistic, the results show that only a handful of respondents (i.e., 8) have received sufficient information and training from their tertiary education (K2). A picture that emerges from here is that having a good understanding and ability to undertake LCC analysis could be a hidden prerequisite skillset for quantity surveying professionals in Australia, and that employers would assume quantity surveyors to have fundamental knowledge of LCC and undertake relevant analyses whenever required.

Turning to the application of LCC, the results show that most respondents had undertaken LCC analysis only upon the request of their clients (A4; RPI = 0.75). This indeed adds weight to the assertion that understanding and undertaking LCC could be a hidden job requirement for quantity surveyors. Furthermore, it is found that when procuring for new subcontractors for works and services, the key focus of most respondents was to minimize initial expenditure for higher return on investment for their clients (A3; RPI = 0.71). This further points to the short term and cost driven mindset of both quantity surveyors and clients, neglecting the importance of optimizing a building's performance throughout its entire life cycle. This supports the conclusions of Chiurugwi et al. [9] and

Olubodun et al. [16] that the use of LCC in the U.K. construction industry was largely dependent on clients' demand. As explained by D'Incognito et al. [17], clients are usually less concerned about the operation and maintenance cost of buildings because they are not involved in managing the buildings after completion. Another possible explanation why clients placed higher emphasis on initial costs over operation and maintenance costs could be attributed to the tax depreciation system in Australia.

Table 2: General knowledge and application of LCC

Item	Percentage of respondents*							RPI
	1	2	3	4	5	6	7	
K1	4.2	4.2	0	25.0	12.5	25.0	29.2	0.76
K2	8.3	12.5	4.2	37.5	4.2	20.8	12.5	0.61
K3	4.2	4.2	0	25.0	16.7	25.0	25.0	0.74
K4	29.2	12.5	8.3	16.7	16.7	4.2	12.5	0.49
A1	16.7	8.3	16.7	20.8	20.8	8.3	8.3	0.54
A2	8.3	0	20.8	16.7	25.0	16.7	12.5	0.64
A3	12.5	33.3	16.7	16.7	20.8	12.5	33.3	0.71
A4	4.2	4.2	4.2	20.8	16.7	16.7	33.3	0.75
A5	4.2	16.7	4.2	37.5	20.8	12.5	4.2	0.58
A6	12.5	12.5	12.5	29.2	12.5	16.7	4.2	0.55
A7	8.3	12.5	4.2	41.7	20.8	8.3	4.2	0.57
A8	0	20.8	4.2	29.2	37.5	4.2	4.2	0.59

*1 = strongly disagree; 2 = Disagree; 3 = Relatively disagree; 4 = Neither agree nor disagree; 5 = Relatively agree; 6 = Agree; 7 = Strongly Agree

However, it is notable that most respondents did consider things other than just the initial cost when analyzing and preparing tenders for projects (A2; RPI = 0.64), and use LCC techniques to developing the best value for money product and service options (A8, RPI= 0.59). Also, when undertaking LCC analysis, some respondents had referred to the ISO15686-5:2008 guidelines (A5; RPI = 0.58), and worked with an integrated design team to obtain a more reliable outcome (A7; RPI = 0.57). Furthermore, some respondents had shown signs of positivity, endorsing that, by undertaking a LCC analysis, it will help saving money for their clients in a long run while at the same time, increasing their chance of winning new projects (A6; RPI = 0.55). However, the limited use of LCC could be partially related to the 'loose' attitude of companies on LCC, seeing that about 40% of the respondents disagree, to a varying degree, that their companies promote the importance of using LCC when procuring new works and services (A1; RPI = 0.54). These collectively suggest that procurement in construction is still largely cost driven and that Australian quantity surveyors do aware of LCC and its importance and benefits. However, the needs of conducting LCC analysis is subject to clients' situational demand.

4.2 Perceived barriers to LCC implementation

Table 3 summarizes the perceived barriers to LCC implementation. The respondents perceived that having tight budget (B1) is the greatest barrier to implementing LCC, with a RPI of 0.85. This agrees with the findings of previous studies (e.g. [8] & [9]) that limited budgets were the key hindrance against the effective application of LCC in the U.K. construction industry. This indeed could help shedding light on the afore-mentioned finding as to why the respondents had placed greater emphasis towards minimizing initial expenditure for higher return on investment for their clients whenever procuring for new works and services. Adding to this, it is found that the lack of support and commitment of architects (B4; RPI = 0.83) and clients' emphasis of initial capital investment over maintenance cost saving (B11; RPI = 0.83) were the two key hindrances for implementing LCC. This finding supports Rahman et al.'s [19] assertion that architects were not cost-oriented and often being perceived as the culprit of placing high emphasis on architectural and design features at the expense of the construction and long-term operation costs. Furthermore, as suggested by Bordass [20], clients were more likely to place greater emphasis on initial cost than the total ownership costs as they could obtain a better return on investment for selling or refurnishing their buildings within 25 years or less. The author further pointed out that clients' emphasis on initial capital cost saving over whole life cycle costs could mainly be due to the unproven and unreliable performance of building equipment and systems during the initial building operation stage, and the lack of appropriate and cost effective green technologies and systems in the market. Interestingly, these phenomena could also help explaining why 'clients are unwilling to pay money and spend time on LCC exercises' (B8; RPI= 0.79) and 'client do not request for LCC' (B9; RPI= 0.79) were perceived as the 3rd key barriers by the respondents, who also subsequently ranked the lack of sufficient information at the early design stage for LCC analyses (B3; RPI= 0.78) as the 4th barrier. This further supports Gluch and Baumann's [21] conclusions that the complexity and uncertainties of a building's life cycle, adding to the already complicated building design and procurement processes, have prevented informed decision-making on the justification of undertaking LCC exercises. In the view of this, it is not surprising that most respondents perceived the lack of knowledge of clients on LCC (B10; RPI= 0.74) and the lack of sufficient time to carry out LCC during the early design and procurement stage (B2; RPI = 0.74) had further hindered the wider implementation of LCC in the Australian building industry. According to Gluch and Baumann [21], the lack of understanding on existing buildings and construction methods is likely to affect clients' decision on whether to adopt LCC. Adding to this, it is also found that architects' unawareness on LCC (B5; RPI= 0.72) and the lack of training on standardized LCC approaches and guidelines (B7; RPI= 0.72) were part of the problems limiting the use of LCC in the industry. When comparing the average RPIs of client- (i.e. B8 to B11) and architect- related items (i.e. B4 and B5), it is notable that both clients and

architects shared the similar adverse role of limiting the current use of LCC in the industry (with both having an average RPI = 0.79). A picture that emerges from the comparative analyses of relevant items is that the root cause of limited use of LCC is mainly attributed to the short-sightedness of clients and architects on initial costs over strategic value, rather than their limited understanding on LCC. Lastly, most respondents also perceived that the limited use was brought about by the lack in government incentive (B6; RPI= 0.68) and appropriate cost-effective alternatives (B12; RPI= 0.66).

4.3 Enablers for LCC implementation

In complementing those barriers identified above, Table 4 shows the perceived enablers for LCC implementation. In
terms of enablers, most respondents perceived that by having clearer guidelines on the use of LCC (E3; RPI= 0.81) could help promoting the use of LCC. This is followed by having an integrated design team at the early stage (E1; RPI= 0.77) and specifying LCC as a mandate in the sustainable public procurement policies (E4; RPI= 0.77). These findings support the Chiurugwi et al.'s [9] and Goh and Sun's [10] conclusions that the incorporation and close administration of standardized methodologies is a key enabler for effective implementation of LCC.

Table 3 Barriers to LCC implementation

Item	Percentage of respondents*							RPI
	1	2	3	4	5	6	7	
B1	0	0	0	12.5	16.7	33.3	37.5	0.85
B2	4.2	0	0	29.2	12.5	41.7	12.5	0.74
B3	0	0	4.2	16.7	29.2	29.2	20.8	0.78
B4	0	0	4.2	16.7	12.5	25.0	41.7	0.83
B5	0	4.2	12.5	25.0	12.5	25.0	20.8	0.72
B6	4.2	4.2	8.3	33.3	20.8	4.2	25.0	0.68
B7	0	0	8.3	37.5	12.5	25.0	16.7	0.72
B8	0	4.2	0	16.7	20.8	37.5	20.8	0.79
B9	0	4.2	0	25.0	8.3	37.5	25.0	0.79
B10	0	0	4.2	33.3	16.7	33.3	12.5	0.74
B11	0	0	0	25.0	8.3	25.0	41.7	0.83
B12	4.2	4.2	4.2	50	42.0	16.7	16.7	0.66

*1 = strongly disagree; 2 = Disagree; 3 = Relatively disagree; 4 = Neither agree nor disagree; 5 = Relatively agree; 6 = Agree; 7 = Strongly Agree

Furthermore, as suggested by Perera et al. [22], by including LCC as a key requirement for public procurement, it will help government to obtain long term financial savings and showcase their leadership and commitment, and more importantly, help educating and encouraging building stakeholders to adopt LCC in their projects. Furthermore, Sterner's [4] research has shown that an integrated design team would increase the cooperation between stakeholders towards sharing information for better LCC analysis at the early stage. Interestingly, the positive sign of increasing adoption of design and construct procurement and relational contracting could help reducing the previously mentioned issue of insufficient data for LCC analysis during the early design stage.

Table 4 Enablers for LCC implementation

Item	Percentage of respondents*							RPI
	1	2	3	4	5	6	7	
E1	0	4.2	0	25.0	20.8	20.8	29.2	0.77
E2	8.3	0	8.3	25.0	25.0	20.8	12.5	0.67
E3	0	0	0	16.7	29.2	25.0	29.2	0.81
E4	4.2	0	4.2	16.7	16.7	33.3	25.0	0.77
E5	4.2	0	8.3	25.0	20.8	25.0	16.7	0.71
E6	0	0	0	29.2	33.3	25.0	12.5	0.74

*1 = strongly disagree; 2 = Disagree; 3 = Relatively disagree; 4 = Neither agree nor disagree; 5 = Relatively agree; 6 = Agree; 7 = Strongly Agree

5. Conclusions

This exploratory research aimed to examine the implementation of LCC from the Australian quantity surveyors by undertaking an online questionnaire of 24 respondents. The overall findings show that quantity surveyors do have basic knowledge of LCC, and will only undertake LCC analyses upon the request of clients and should it be part of their contractual obligation. However, the application of LCC is hampered by clients' traditional mindset of initial costs over strategic value, and architects' overemphasis of architectural and design features at the expenses of their practicability and the whole life cycle costing of buildings. As such, construction companies are reluctant to promote the application of LCC when analysing and tendering for new projects. For wider application of LCC, it seems that government and professional bodies play a pivotal role towards changing and regulating the behaviours of project stakeholders.

Lastly, it is acknowledged that there are limitations in this study and the findings are indicative and not conclusive. First, the sample size of 24 is very small and not representative. However, the findings could further add to the existing knowledge of LCC implementation for future studies, whereby a larger sample size should be collected for generalization purpose. Further analyses (such as predictive modelling) should be conducted to examine the effect of different stakeholders and/ or different role projects on the effective implementation of LCC. A cross-culture investigation of LCC application should also be considered in future studies towards identifying exemplar of LCC practices.

References

[1] International Organization for Standardization standard (ISO 15686-5) *Buildings and Constructed Assets, Service-life planning Part 5: Life-cycle Costing (ISO 15686-5)* ISO.

[2] Volkov, A., Vitaliy, C. and Dmitriy, K. Life cycle of a building. *Advanced Materials Research,* Volume 1065-1069, (2014), pp.2577-2280.

[3] Sherif, Y.S. and Kolarik, W.J. Life cycle costing: concept and practice. *Omega,* Volume 9(3), (1981), pp. 287-96.
[4] Sterner, E. Life-cycle costing and its use in the Swedish building sector. *Building Research & Information*, Volume 28(5-6), (2000), pp. 387-393.
[5] Clift, M. and Bourke, K. *Study on Whole Life Costing Report*, (1999), UK: DETR.
[6] Higham, A., Fortune, C. and James, H. Life cycle costing: evaluating its use in UK practice. *Structural Survey.* Volume 33(1), (2015, pp. 73-87.
[7] Oduyemi, O., Okoroh, M. and Dean, A. Barriers to life cycle costing usage. Ed Raiden, A.B. and Aboagye-Nimo *30th Annual ARCOM Conference Proceedings.* (2014) Portsmouth UK.
[8] Swaffield, L.M. and McDonald, A.M. The contractor's use of life cycle costing on PFI projects. *Engineering, Construction and Architectural Management*. Volume 15(2), (2008), pp. 132-148.
[9] Chiurugwi, T., Udeaja, C., Hogg, K. and Nel, W. 2010 Exploration of drivers and barriers to life cycle costing (LCC) in construction projects: professional quantity surveyors' assessment. Ed Tizani, W. *Proceedings of the International Conference*, (2010) Nottingham UK, pp.1-9.
[10] Goh, B.H. and Sun, Y. The development of life-cycle costing for buildings. *Building Research & Information*, Volume 44(3), (2016), pp. 319-344.
[11] Estevan, H. and Schaefer, B. Life Cycle Costing: State of the art report, (2017), available at: http://www.sppregions.eu/fileadmin/user_upload/Life_Cycle_Costing_SoA_Report.pdf
[12] Highton, J. Life-cycle costing and the procurement of new buildings: The future direction of the construction industry. *Public Infrastructure Bulletin,* Volume 1(8), (2012), pp. 1-6
[13] Gundes, S. The Use of Life Cycle Techniques in the Assessment of Sustainability. *Procedia – Social and Behavioural Science*, Volume 216, (2016), pp. 916-922.
[14] Arditi, D.A. and Messiha, H.M. Life cycle costing in municipal construction projects. *Journal of Infrastructure System*. Volume 2(1), (1996), pp. 5-16.
[15] Cole, R.J. and Sterner, E. Reconciling theory and practice of life cycle costing. *Building Research and Information,* Volume 28(5/6), (2000), pp. 368-375.
[16] Olubodun, F., Kangwa, J. Oladapo, A. and Thompson, J. An appraisal of the level of application of life cycle costing within the construction industry in the UK. *Structural Survey,* Volume 28(4), (2010), pp. 254-265.
[17] D'Incognito, M., Costantino, N. and Migliaccio, G. C. Actors and barriers to the adoption of LCC and LCA techniques in the built environment. *Built Environment Project and Asset Management,* Volume 5(2), (2015), pp. 202-216.
[18] Loosemore, M. and Lim, B.T.H. Inter-organizational unfairness in the construction industry. *Construction Management and Economics*, Volume 33(4), (2015), pp. 310-326.
[19] Rahman, S., Perera, S., Odeyinka, H. and Bi, Y. A conceptual knowledge-based cost model for optimizing the selection of materials and technology for building design. *Proceedings of the 24th Annual ARCOM Conference*. (2008), pp. 217-226.
[20] Bordass, B. Cost and value: fact and fiction *Building Research & Information*. Volume 28(5-6), (2000), pp. 338-352.
[21] Gluch, P. and Baumann, H. The life cycle costing (LCC) approach: a conceptual discussion of its usefulness for environmental decision-making. *Building and Environment,* Volume 39(5), (2004), pp. 571-580.
[22] Perera, O., Morton, B. and Perfrement, T. Life Cycle Costing in Sustainable Public Procurement: A Question of Value, (IISD), (2009) Canada: I. I. f. S. D.