THE ACCEPTANCE AND USE OF LIFE CYCLE COSTING (LCC) AS DECISION SUPPORT TOOL FOR RENOVATION INVESTMENTS

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ABSTRACT

This paper seek to explain why LCC is used or not for renovation projects. The study is based on a theoretical explanation model called the Technology Acceptance Model (TAM). The model assumes that a number of factors determine whether and when individuals will use a particular technology. Two main components of the model are (1) Perceived usefulness, and (2) Perceived ease of use. The response rate was 32,3%. The results show that the climate in terms of the extent to which LCC is advocated and used by colleagues affects how the individual experience both usefulness and ease of use. Our study also demonstrates that the perceived usefulness, i.e. how well you feel that LCC can be used in your daily work, lays the foundation for if it is perceived as positive to use, and thus also a prerequisite for creating an intention to use and subsequently applying LCC in actual renovation projects. The study shows that the ease of use does not have the same effect.

Keywords: Life Cycle Costing, LCC, renovation, investments, construction client, Technology Acceptance Model, questionnaire survey

INTRODUCTION

Construction clients face several forces steering them towards a more sustainable built environment, including EU directives, national legislation, industrial standards, policies and other requirements (Ludvig et al., 2013). For these reasons many are adopting a more long-term sustainable life-cycle perspective, increasing interest in estimating long-term economic consequences of investment decisions, for example by using tools such as Life Cycle Costing (LCC).

This increased interest in LCC among practitioners and researchers can be related to the single monetary unit of LCC as a possible means to translate environmental complexities into a more familiar unit of measure for a broader audience (Gluch and Baumann, 2004, Gluch et al., 2013). Interest in LCC can also be related to the ever-expanding quest of finding more sustainable alternatives to

meet the significant increasing need to renovate an aging building stock (cf. Olubodun et al., 2010, Filipsson et al., 2013, Korpi and Ala-Risku, 2008, Ludvig et al., 2010). These trends have led to a revival of LCC and a large increase in publications on the topic over the decade (Goh and Sun, 2015). However, a majority of research on LCC concerns tool modeling and development and surprisingly few studies pay interest into how practitioners perceive the usefulness of the tools developed. Thus, it seems the actual use of tools is taken for granted due to the actual development of models and tools.

The aim of the present paper is therefore to increase understanding of why decision makers' use LCC in construction client companies/organizations for decisions involving sustainability and energy efficiency issues. This paper is based on a questionnaire. In the questionnaire scale items measuring central concepts of the technology acceptance model (TAM) model was used. This paper highlights what explains the extent to which LCC is used. Such knowledge can be used in order to create conditions for an extended use.

THE TECHNOLOGY ACCEPTANCE MODEL (TAM)

The Technology Acceptance Model (TAM) (Davis, 1989) has previously been used to explain the acceptance and use of various types of technical systems and applications. The model is an adaption of the theory of reasoned action (TRA) proposed by Ajzen and Fishbein (1980), which seek to explain and predict behaviors of people in specific situations. The model has been widely tested and used in various types of contexts, such as office tools, software tools and business application tools, and for various types of technological systems and applications, such as electronic mail, world wide web, voice mail, and production control tools (see review in Legris et al., 2003).

TAM suggests that when users are presented with for them a new technology and/or application, a number of factors influence their decision about whether they will use it. The model assumes that a number of factors determine whether and when individuals will use a particular application. Two main components of the model are (1) Perceived usefulness - to what extent the use of a given system is perceived to improve how work is performed, and (2) Perceived ease of use - to what extent the use of a given system is perceived as easy and effort free to use. The extent to which these two factors are perceived in turn depends on external impact variables concerning the extent to which there are requirements or preferences that the new application will be used and the extent to which colleagues and others in the industry use the technology/application. Perceived usefulness and perceived ease of use are factors which in turn is assumed to influence the attitude towards usage. However, just an attitude is not sufficient to predict behavior (Ajzen and Fishbein, 1980), i.e. use, it also requires an intention to use the specific technology. The degree of positive attitude towards using the technology is assumed to influence the extent to which an intention is created. In a final step this assumed intention affects the degree of actual use of a technology.

METHOD

To obtain as broad a representation of LCC use and experience as possible, a questionnaire was sent to individuals working in 99 different Swedish companies/organisations that own and/or manage properties on a long-term basis (state, municipal, and private). The individuals were chosen based on their likely involvement in decisions about building renovation and thus assumed to be in position to influence their company's long-term environmental and economic sustainability. These were specialized energy strategists, CEOs, division managers, property/facility managers, technical development managers, construction project managers, or sustainability and environmental managers, depending on their organizational structure. Data was collected in September-November 2013. The questionnaire and two reminders were sent by e-mail using the SurveyMonkey™ online software. Responses were obtained from 70 respondents of a sample of 217 individuals, for a 32,3% response rate.

In order to test the TAM model the questionnaire was designed so that indicators of the TAM factors were included. Then index variables (mean values of these indicators) were created. To test to what extent the TAM model can predict the use of LCC, a number of regression analyzes of survey data was conducted. The analysis was conducted in SPSS software for statistical analysis.

RESULTS

Use of LCC in renovation projects

With its 40 year-old history it can be discussed whether LCC should be seen as a new tool for the industry or not. However, although LCC has been around for many years the increased emphasis on sustainability has led to a revival of the tool in a new context and 72% of our respondents indicate that LCC has been used or discussed within the organization only within the past 5 years.

Table 1. Estimated share of renovation projects were LCC has been used to support decisions

Percentage of projects	Answer %
0	5
1-25	38
26-50	24
51-75	17
76-99	12
100	4

When it comes to the number of renovation projects where LCC calculations were used as part of the decision-making basis, respondents answered across the entire scale (Table 1). 38% answered that LCC calculations are done in less than 25% of the projects. Twenty-four percent report more than 25% but less than 50%. 33% indicate that in more than 50% of projects, they have used LCC. To this

question, 5 % of respondents' state they do not calculate LCC in any construction project at all.

Environmental influences - external impact variables

Individuals use different types of tools often due to an external demand. The extent of requirements or preferences for using LCC and the extent to which colleagues and others in the industry uses the LCC was investigated. As Table 2 shows, there is no external impact variable that stands out as extraordinary in terms of driving the use of LCC in a renovation context. The results however indicate that it is partly driven by external requirements and that the organization and/or management advocate the use of LCC. There also seems to be a driving effect that other colleagues and others in the industry use LCC. There are individual variations within the results but in terms of mean value the influence from external impact variables are moderate.

Table 2 . External impact variables that influence why LCC is used or not. The scale runs from 1 (strongly disagree) to 6 (strongly agree).

Statements	Mean
The organization advocates the use of LCC	3,9
My colleagues believe that LCC is a good tool	3,8
Many within the industry use LCC	3,6
It is a requirement to use LCC	3,5
My managers think I should use LCC	3,4
Many others within the company use LCC	3,0
People that use LCC have higher status	2,1

Perceived usefulness

The respondents were asked to indicate how they feel about different statements related to the usefulness of conducting an LCC in their daily work. From the results presented in Table 3 we can see that it is perceived to be quite good conditions for the use of LCC. Lack of resources in terms of finance, time and knowledge, often highlighted as obstacles for a wider use of technology, seem not be perceived as a major problem. The actual terminology and apparatus of LCC is at least partly considered as consistent and familiar for many of the respondents. The respondents also indicate that the idea of LCC lies at least partly in line with how they normally work. LCC is also considered to be sufficiently flexible and adaptable. In addition, LCC is also perceived to make it easier to identify key information needed when making decisions on renovation of buildings and properties. The one thing that seems to be problematic in relation to LCC's usefulness is lack of clear guidelines and expertise to consult on LCC.

Table 3. Perceived usefulness of LCC. (The scale ranges from 1 (strongly disagree) to 6 (strongly agree)).

Statements	Mean
Lack of cooperation between involved parties makes LCC difficult	2,6
It is too expensive to do an LCC	2,1
It takes too much time to do an LCC	2,3
I make mistakes doing an LCC	2,2
Conducting an LCC creates frustration	2,0
Use of LCC counteract with how I normally work	2,1
I have got profound guidance on how to do an LCC	3,1
There are guidelines available on how to do an LCC	2,7
We have an LCC expert I can get advice from	2,6
In respect of resources, knowledge and possibilities it is easy for me to do an LCC	3,6
I have enough knowledge to do an LCC	3,5
I have necessary resources to do an LCC calculation	3,5
I can adjust LCC so it serves the purpose I am interested in	3,4
There are several different ways to conduct an LCC (flexibility)	4,2
LCC makes it easier to identify key information	3,8
I do not have to adjust my way of working to do an LCC	3,6
The terminology in LCC is consistent	3,9
The terminology in LCC is familiar to me	4,1

Ease of use

How easy it is perceived to use a certain type of tool often influences whether it is used or not. Table 4 indicates that LCC seems to be neither difficult nor easy to use. The responses align fairly well with the responses stated regarding the conditions users have to use LCC in their daily work, i.e. perceived usefulness.

Table 4. How easy it is to use LCC. (The scale ranges from 1 (strongly disagree) to 6 (strongly agree)).

Statements	Mean
LCC differs from other investment calculus tools I have used	2,8
LCC does not look like other tools I have worked with	2,6
Using LCC is a new experience for me	2,8
It is easy to use LCC in a way I need it for	3,7
To become a skilled LCC user is easy	3,1
To learn how to use LCC is easy	3,5

Attitudes towards LCC

The results show that there seems to be a generally positive attitude about LCC (Table 5). The respondents especially agree regarding the statement that they like the actual idea of LCC and that LCC is representing something good.

Table 5. Attitudes regarding LCC and results of LCC calculations. (The scale ranges from 1 (strongly disagree) to 6 (strongly agree)).

Statements	Mean
LCC is good in some projects but not the ones I work with	2,3
Input data for LCC calculations are unreliable	2,9
Input data for LCC calculations are missing	2,8
LCC is unusable	1,6
I like the idea of LCC	4,5
LCC is good	4,6
Calculating LCC gives me increased control	4,2
LCC is a suitable tool for doing my job	4,2
LCC contributes with relevant information	4,2
LCC provides information when I need it	4,0
LCC gives thorough information	4,0
LCC gives accurate information	3,9

Intentions to use LCC

The results indicate that there seem to be fairly good conditions for a more widely spread use of LCC in renovation projects, both regarding the users qualifications and the LCC tool in itself. However, according to theory it is not enough with positive attitudes towards a tool there must also be clear intentions to use the tool as well. Table 6 presents results on the intention to use LCC in actual renovation projects. Here we can see a rather varying view. Twenty-seven percent of the respondents fully or highly agree regarding the claim that they will use LCC regularly in their work. Twenty-three percent state that they will not at all or scarcely use LCC in their daily work.

Table 6. Respondents' intention to use LCC in their daily work.

I intend to use LCC in renovation projects	Answer %
Agree completely	11
Agree to an high extent	16
Agree to some extent	24
Disagree to some extent	25
Disagree to an high extent	19
Disagree completely	5

ANALYSIS

Regression analysis was used to investigate the relationship between external impact variables, usefulness, ease of use, attitudes towards LCC and the intention to use LCC. In Figure 2 the results from the regression analysis are presented. External impact variables are found to explain 27 % of the variation in perceived usefulness and 12 % of the variation in perceived ease of use. Looking at mean values, external impact variables in general are moderately influential regarding whether LCC is used or not (Figure 1), but in terms of the relationship between external impact variables

and perceived usefulness and ease of use the analysis indicates that a higher degree of external impact the more useful and user-friendly is LCC considered to be. It can therefore be concluded that external influences have effect.

It has already been noted that there is a generally positive attitude to the use of LCC in the renovation of properties and buildings (see Table 5). In accordance with the TAM model, the relation between usability, ease of use and attitude to LCC was examined. Here it can be concluded that only perceived usefulness explains any variation in attitude towards LCC use. Thus, it seems that perceived ease of use does not affect the attitude towards usage of LCC. Attitudes towards LCC were found to explain 29% of the variation in the intention to use LCC, which in turn explain 35 % of the variation in the use of the LCC. The results thus confirm the model's assumption that the higher intentions of use, the higher the degree of use.

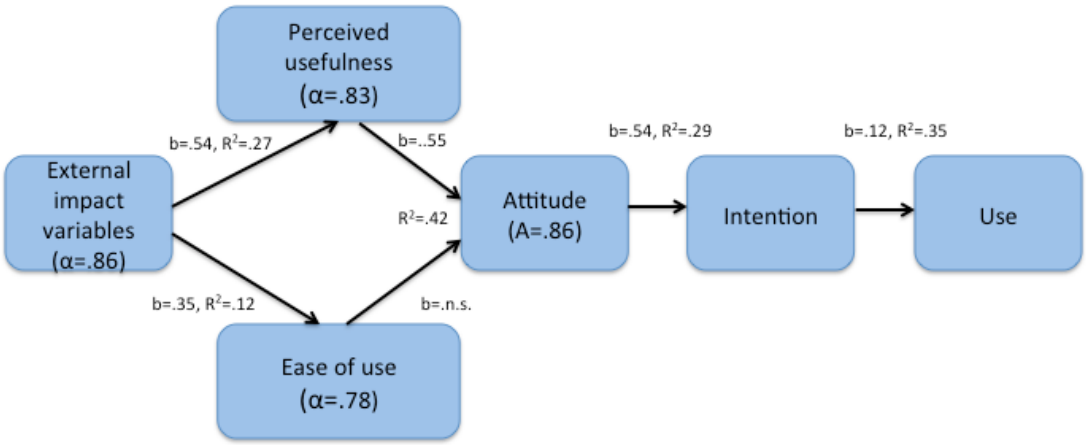

Figure 2. TAM to predict the use of LCC.[1]

CONCLUSIONS

The results show that TAM can be used to describe and understand factors that influence the use of LCC in renovation of buildings. From this study the following conclusions are drawn:

- Increased external impact have an effect on perceived usefulness and ease of use
- If LCC should be used for renovation of buildings it is important that the perceived usefulness of LCC is high
- The corporate climate in terms of the extent to which LCC is advocated and used by others affects how individuals experience both usefulness and ease of use.
- Perceived usefulness is a prerequisite for creating an intention to use LCC and subsequently applying LCC in the renovation of buildings.

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[1] α (Cronbach's alpha) is a measure of internal consistency among items compromising a factor. Values over .78 are considered acceptable.
R^2 (regression coefficient) is a measure of how much the variation an independent variable explains in a dependent variable.
b (beta coefficient) indicates whether an variable has a positive or negative effect on the dependent variable and the extent of this impact.

- An experience of good conditions for conducting an LCC in form of others using LCC and available resources in terms of time, money and contribute to a positive attitude towards LCC
- Ease of use has less effect on the attitude towards the LCC and play little importance in whether LCC is used or not
- To increase the use of LCC in the renovation of buildings companies should create a culture that advocates the use of LCC - both within the organization but also through joint industry initiatives.

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