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Original Article

Key Determinants of Life Cycle Costing Adoption in Nairobi's Construction Industry

Thomas Berhe Tsegai[1], Mugwima Njuguna[2], Kennedy Aburili[3]

[1]*Department of Civil Engineering, PAUSTI, Juja, Kenya.*
[2]*Centre for Urban Studies (CUSt), JKUAT, Juja, Kenya.*
[3]*Department of Construction Management, JOUUST, Bondo, Kenya.*

[1]*Corresponding Author : thomasb.tsegai@gmail.com*

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Abstract *- Despite the availability of various Life Cycle Costing (LCC) methodologies, the widespread uptake of LCC remains limited. This study delves into the adoption of LCC practices within the Nairobi County construction industry, seeking to unravel the factors influencing its limited uptake despite the availability of diverse methods. The central predicament addressed revolves around the moderate levels of LCC adoption, a paradox considering its potential advantages. The primary objective is to dissect the influential factors affecting the Level of LCC Adoption (LoA) alongside secondary goals like exploring correlations between different factors, assessing the significance of User Experience (UX) and Fit for Purpose (FP), and validating the model's adequacy in explaining observed data patterns. Involving a sample of 185 respondents from Nairobi county's construction sector, the study employed descriptive statistics, correlation analyses, ANOVA, regression analysis, and Confirmatory Factor Analysis (CFA) to scrutinize collected data. Results revealed a moderate mean LoA (2.5149), with UX standing out significantly (mean = 5.2622), underlining its pivotal role. FP, Navigability (NA), Visibility (VI), and Institutional Context (IC) exhibited varied impacts on LoA. Regression analysis confirmed substantial positive relationships between UX, FP, and LoA, while CFA endorsed the model's robustness in explaining data patterns. These findings hold considerable implications for strategic decision-making and policy formulation within the construction domain, offering insights into factors driving LoA. Moreover, they lay the groundwork for further research avenues, particularly in unraveling the nuanced role of IC in steering LCC adoption rates.*

Keywords *- Life Cycle Costing, Construction industry, Adoption factors, User Experience, Institutional context.*

1. Introduction

The construction industry stands as a prominent influencer of the environment, economy, and societal development, albeit significantly contributing to greenhouse gas emissions and resource depletion. To mitigate these impacts, the industry has increasingly embraced sustainable construction methodologies, among which Life Cycle Costing (LCC) emerges as a promising approach [1].

LCC is a method of economic analysis that considers all costs related to constructing, operating, and maintaining a construction project over a defined period of time. The history of LCC began in the UK in the late 1950s [2]. It was developed as a tool to identify the total cost of ownership of construction assets[3]. Through the years, it has been recognized as an evaluative tool that encompasses direct and indirect costs throughout a construction project's lifespan, offering substantial promise for informed decision-making in sustainable construction practices[4]. Particularly within building design projects, LCC plays a pivotal role in identifying cost-effective design choices, including material selection, cost reduction strategies, and heightened environmental performance [5].

However, despite its multifaceted advantages, the adoption of LCC within building projects remains restricted. The design phase, a crucial stage for implementing LCC in construction, provides stakeholders with an opportunity to establish cost and performance objectives, fostering cost-effective design alternatives for the entire lifecycle of a building [3]. By evaluating various design possibilities, stakeholders can make informed decisions grounded in life cycle costs, energy efficiency, and environmental impact, aligning with the contemporary emphasis on sustainability in the construction industry [6].

Moreover, integrating LCC during the design phase can proactively mitigate the need for costly future upgrades and retrofits[7]. Early identification of potential issues through LCC analysis empowers stakeholders to opt for design choices that are less prone to necessitate modifications or retrofits, ensuring substantial cost savings and minimizing disruptions throughout the building's lifecycle[4]. While existing studies have outlined various factors influencing LCC adoption in the construction sector, these analyses often lack scrutiny specific to developing countries [3]. Nairobi, as a rapidly growing African city and the capital of Kenya, demands sustainable construction methods to support its burgeoning growth. Nevertheless, the research on the factors influencing LCC adoption in this context remains limited.

Hence, this study endeavors to examine the specific variables shaping LCC adoption within Nairobi County's construction sector. To establish these determinants, the paper delves into the multifaceted exploration of theoretical frameworks crucial to understanding the adoption of new technology. Grounded in the Technology Acceptance Model (TAM), the study unveils the significance of perceived value and usability in technology adoption, particularly in the context of LCC integration [8-11].

Further, the Diffusion of Innovation Theory illuminates critical factors shaping LCC adoption, including Relative Advantage, Compatibility, Complexity, Trialability, and Observability [12, 13]. Insights from different various studies underscore this theory's relevance in evaluating LCC adoption dynamics, emphasizing stakeholder engagement and organizational culture in technology assimilation [3, 14, 15].

Additionally, the Institutional Theory elucidates institutional isomorphism, legitimacy, and industry norms as pivotal factors influencing LCC integration[3, 4, 16, 17]. This collective theoretical framework provides a robust foundation for comprehending the determinants and complexities underpinning LCC adoption within Nairobi's construction industry, guiding the empirical investigation of this study.

In summary, the construction industry, while pivotal for societal development, significantly impacts the environment and economy, necessitating the adoption of sustainable construction methodologies. LCC emerges as a promising approach, offering a comprehensive evaluation of costs throughout a construction project's lifespan. Despite its potential, LCC adoption within building projects remains limited, particularly in developing countries like Nairobi and Kenya.

Existing studies have outlined various factors influencing LCC adoption, but scrutiny specific to Nairobi's construction sector is lacking. Therefore, this study aims to fill this research gap by examining the variables shaping LCC adoption within Nairobi County's construction industry. Drawing upon theoretical frameworks such as the TAM, Diffusion of Innovation Theory, and Institutional Theory, the study seeks to provide a comprehensive understanding of the determinants and complexities underpinning LCC adoption. By offering guidance to policymakers and industry stakeholders, the findings of this study will not only enhance the sector's sustainability but also contribute to advancing comprehension of LCC adoption in construction, thereby paving the way for future research endeavors in this domain.

2. Methods

2.1. Research Design

The study employs a comprehensive cross-sectional survey design to investigate the determinants influencing the adoption of LCC within Nairobi County's construction sector. Guided by theoretical frameworks such as the TAM, Diffusion of Innovation Theory, and Institutional Theory, this research identifies determinants crucial to LCC adoption. Utilizing a multifaceted approach, the study conducts a rigorous multiple regression analysis to test hypotheses derived from these theories.

This statistical analysis aims to ascertain the significance of various determinants in influencing the adoption of LCC. Through this analytical process, the study endeavors to pinpoint the key determinants that play a substantial role in shaping the acceptance and integration of LCC practices within the construction industry of Nairobi County.

2.2. Research Setting

The study is set within Nairobi County, the capital of Kenya, encompassing an approximate land area of 696.1 square kilometers and serving as a hub for construction activities within the country. The county's construction sector significantly contributes to its economic growth, manifesting in a multitude of ongoing projects spanning residential, commercial, and infrastructure development. Nairobi County was chosen as the research area due to its anticipated higher adoption rate of LCC, attributed to its status as one of Kenya's most developed counties.

Additionally, the diverse array of construction projects within the county provides a rich landscape for studying LCC adoption in various settings. The accessibility and ease of data collection further facilitated the choice of Nairobi County as the research setting. Focusing primarily on the design phase, the study delved into building construction projects within Nairobi County, engaging multiple stakeholders such as architects, engineers, contractors, and clients through surveys to explore the factors influencing LCC adoption during this critical stage of construction projects.

2.3. Target Population and Sampling Design

The study engaged 338 professionals from Nairobi County's construction industry, drawn from various specialities such as architects, quantity surveyors, civil engineers, structural engineers, electrical engineers, and mechanical engineers. These professionals were selected through a purposive sampling approach, determined using the Krejcie and Morgan Sample Size Table, out of a total population of 2,776 individuals (as shown in Table 1).

Table 1. Sample size using Krejcie and Morgan sample size table

Professionals	Population Number	Sample Number	Pilot	Source
Architects	1184	144	17	BORAQS
Quantity Surveyors	771	94	11	BORAQS
Civil Engineers	213	26	3	Engineers Board of Kenya
Structural Engineers	99	12	1	Engineers Board of Kenya
Electrical Engineers	51	6	1	Engineers Board of Kenya
Mechanical Engineers	458	56	7	Engineers Board of Kenya
Total	2,776	338	40	

A pilot study involving 40 participants across these professional categories was conducted to refine research instruments and procedures before the main study. Data sources included the Board of Registration of Architects and Quantity Surveyors (BORAQS) and the Engineers Board of Kenya.

This comprehensive sampling strategy aimed to gather diverse perspectives on the factors influencing the adoption of LCC during the design phase of construction projects within Nairobi County.

2.4. Variables

The independent variables utilized to elucidate the level of LCC adoption (LoA) in construction projects stem from three key theoretical frameworks: the TAM, Diffusion of Innovation Theory, and Institutional Theory.

User Experience (UX) originates from the TAM and encapsulates users' perceptions and interactions with technology. It involves perceived usability and ease of use, signifying how users' experiences influence their satisfaction and acceptance of a system or technology.

Fit-for-Purpose (FP) aligns with the Diffusion of Innovation Theory, assessing an innovation's compatibility with existing systems and its advantages over alternatives. It evaluates how well an innovation meets specific user demands and context, impacting its adoption.

Navigability (NA), also linked to the Diffusion of Innovation Theory, focuses on the ease of understanding and trialing an innovation. It highlights trialability before full-scale adoption, shaping users' perceptions and decisions regarding the innovation's complexities.

Visibility (VI), grounded in the Institutional Theory, emphasizes communicating observable advantages derived from innovation adoption. It stresses showcasing tangible benefits and outcomes to stakeholders, influencing their decision-making processes.

Institutional Context (IC) arises from the institutional theory, which examines external structures shaping organizational behavior within the broader institutional environment. It explores how regulatory frameworks, cultural norms, and industry-specific practices influence the adoption of innovations like LCC within organizations.

These variables, stemming from the amalgamation of the TAM, Diffusion of Innovation Theory, and Institutional Theory, collectively form a comprehensive framework to understand the determinants of LCC adoption within construction projects.

2.5. Data Collection Instrument

The data sources and measurements utilized in this study to assess the adoption of LCC within construction projects in Nairobi County encompass a combination of primary and secondary sources. Primary data collection involves structured surveys distributed among various professionals in the construction industry, including architects, quantity surveyors, civil engineers, structural engineers, electrical engineers, and mechanical engineers. These surveys are designed to gather insights into the factors influencing the adoption of LCC during the design phase of construction projects. The questionnaire items are crafted based on established theories such as the TAM, Diffusion of Innovation Theory, and Institutional Theory to explore variables like UX, Fit-for-Purpose, NA, VI, and Institutional Context.

Additionally, secondary data sources are employed to supplement the primary data collected. These secondary sources include relevant literature, scholarly articles, reports, and documented industry practices pertaining to LCC adoption in construction projects. These sources provide a broader contextual understanding, historical perspectives, and industry trends related to LCC adoption, thus supporting the analysis and interpretation of the primary data.

The measurement instruments for primary data collection involve structured questionnaires with Likert scale items, open-ended questions, and categorical responses. Likert scale items are used to quantitatively gauge respondents' perceptions, attitudes, and experiences related to the identified variables influencing LCC adoption.

Open-ended questions allow participants to provide qualitative insights, elaborations, and specific examples regarding their experiences with LCC adoption in construction projects. Moreover, categorical responses aid in gathering demographic information about participants, such as their professional roles, years of experience, and affiliations within the construction industry.

The combination of primary survey data and supplementary secondary sources provides a comprehensive and multifaceted approach to understanding the determinants of LCC adoption within the construction industry of Nairobi County. The structured measurement instruments ensure that both quantitative and qualitative data are captured, enabling a thorough analysis of the factors influencing the adoption of LCC in construction projects.

2.6. Analysis Methods

The study employed an array of statistical methodologies to comprehensively investigate the determinants influencing the adoption of LCC in Nairobi County's construction industry. Initially, descriptive statistics were leveraged to encapsulate the data's characteristics, employing measures like mean, median, standard deviation, and frequency distributions to grasp central tendencies and variability across professional categories.

Subsequently, inferential statistics, particularly multiple regression analysis, were engaged to discern relationships between the theoretically derived independent variables - UX, Fit-for-Purpose, NA, VI, and Institutional Context and the level of LCC adoption. This allowed for the identification of significant determinants while accounting for potential confounders and controlling variables, providing a nuanced understanding of the intricate relationships between these factors.

In tandem with inferential statistics, hypothesis testing was performed to gauge the strength and direction of associations between the aforementioned independent variables and the dependent variable (LoA). Formulating hypotheses based on established theoretical frameworks (such as the TAM, Diffusion of Innovation Theory, and Institutional Theory) allowed for the methodical testing and validation of relationships, contributing to a robust analysis of the factors influencing LCC adoption within the construction industry of Nairobi County. Additionally, the study incorporated an evaluation of validity and reliability using statistical assessments to ensure the accuracy and consistency of the data. Rigorous checks for internal consistency, measurement validity, and reliability of survey instruments were conducted to fortify the study's findings, enhancing the credibility and trustworthiness of the conclusions drawn from the statistical analyses. This systematic approach buttressed the study's overall framework, enabling a comprehensive and methodologically sound exploration of the multifaceted determinants shaping LCC adoption.

In conclusion, the amalgamation of descriptive statistics, inferential techniques like regression analysis and hypothesis testing, and validity assessments constituted a methodologically rigorous foundation for examining the complexities of LCC adoption in Nairobi County's construction sector. The systematic deployment of these statistical methods not only facilitated the analysis of collected data but also illuminated crucial insights into the influential factors driving the adoption of sustainable practices within the construction industry, thus offering valuable guidance for stakeholders and decision-makers in fostering the integration of LCC methodologies.

3. Results and Discussion

3.1. Participants

185 participants completed the questionnaires, representing a 55% return rate out of the total 338 questionnaires distributed. The study's participant analysis reveals a diverse demographic distribution among the 185 individuals surveyed within Nairobi County's construction industry.

As shown in Figure 1, the age profile indicates a predominant representation of youthful respondents, with 48.1% falling within the 25-34 age group, followed by 23.2% in the 18-24 category.

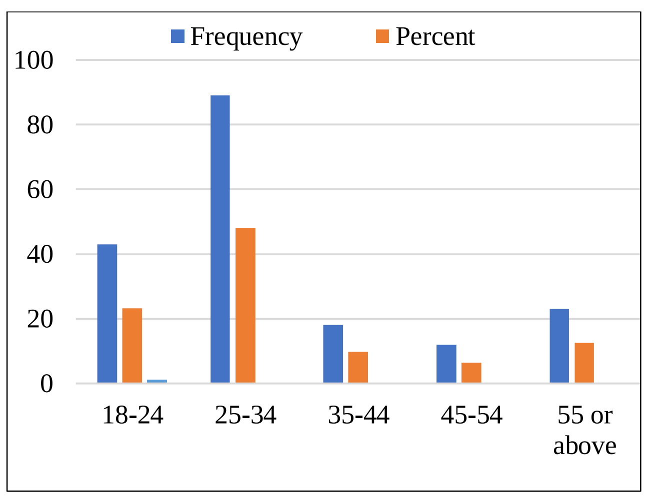

Fig. 1 Age profile

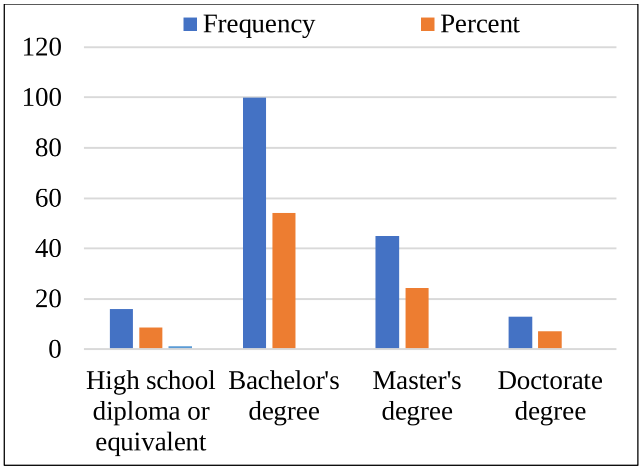

Fig. 1 Education profile

In terms of education, as Figure 2 indicates, the majority (54.1%) possess Bachelor's degrees, while 24.3% hold Master's degrees. The occupation profile showcases Architects as the highest number of respondents at 45.4%, followed by Quantity Surveyors (16.8%) and Engineers (14.6%) (see Figure 3).

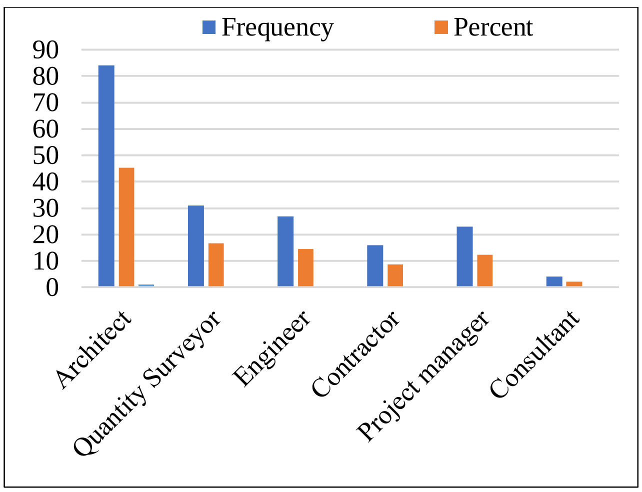

Fig. 2 Occupation profile

Regarding experience in the industry, as shown in Figure 4, the largest group (33.5%) holds 6-10 years of experience, followed closely by those with 1-5 years (32.4%), indicating a mix of professionals with varied experience levels.

Additionally, the organizational size profile demonstrates that 58.0% are associated with small-sized organizations (1-50 employees), while medium-sized (51-250 employees) and large-sized organizations (251 or more employees) represent 29.3% and 12.7%, respectively, as shown in Figure 5. Finally, as illustrated in Figure 6, the analysis of previous knowledge of LCC reveals a balanced distribution, with 50.8% having prior education or training in LCC, while 49.2% do not possess such knowledge within the construction sector.

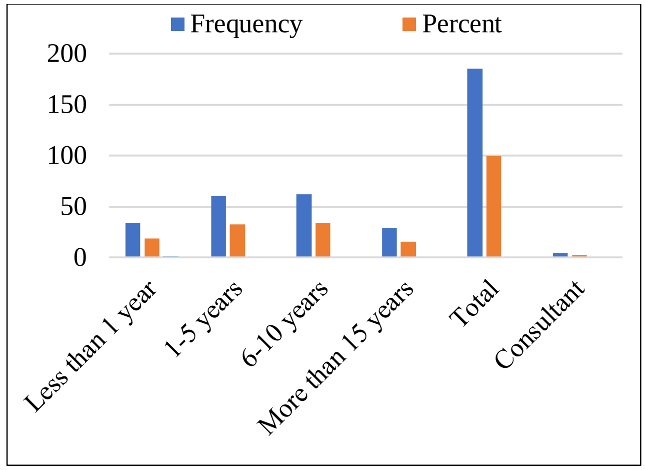

Fig. 3 Experience profile

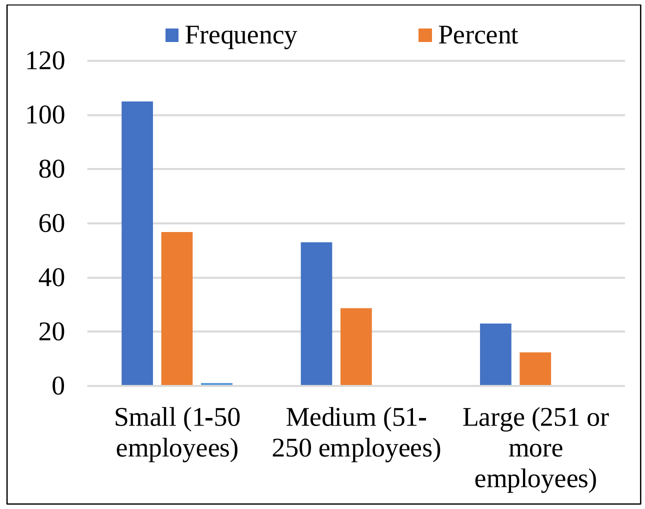

Fig. 4 Organizational size profile

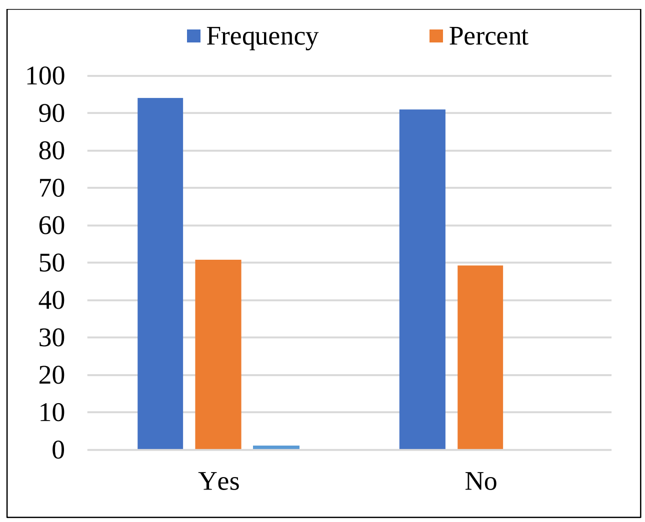

Fig. 5 Previous knowledge on LCC profile

These comprehensive profiles highlight the diversity and varied backgrounds of the participants involved in the study.

3.2. Descriptive Data

Based on the provided statistics for the LoA and various influencing factors, the analysis was conducted on a sample of 185 respondents with no missing data.

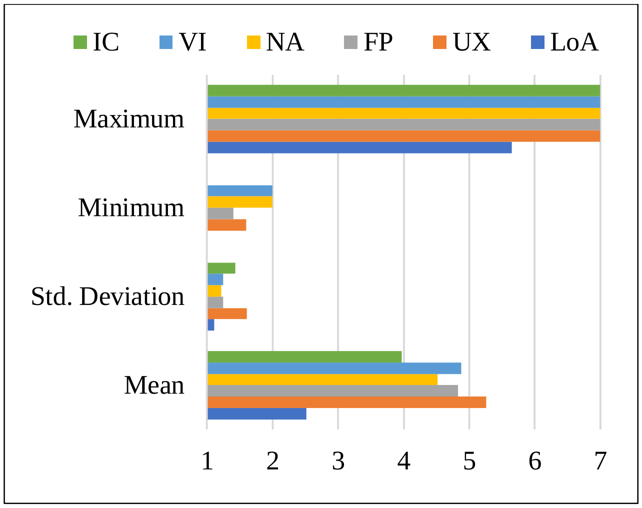

Fig. 6 Descriptive data

The analysis in Figure 7 reveals key insights into the factors influencing the adoption of LCC. The mean LoA among respondents was 2.5149, reflecting a moderate adoption rate. Variables affecting LCC adoption were detailed: UX displayed a high influence (mean = 5.2622), FP showed considerable impact (mean = 4.8292), NA indicated moderate influence (mean = 4.5135), VI demonstrated substantial impact (mean = 4.8746), and IC exhibited a moderate effect (mean = 3.9708) due to external influences.

Median values are closely aligned with means, indicating balanced data distribution. Moderate standard deviations (ranging from 1.11257 to 1.60742) signified moderate dispersion around means. The diverse range across variables, reflected in minimum and maximum values, showcased varied participant responses. Collectively, these statistics highlight varying degrees of influence among factors on LCC adoption within this sample, emphasizing the multifaceted nature of LCC adoption determinants.

3.3. Correlations

The correlation matrix shown in Table 2 examines the relationships between variables. In this study, the Pearson correlation coefficients were calculated to determine the associations between the LoA and the predictor variables: UX, FP, NA, VI, and Institutional Context. The analysis revealed several noteworthy findings:

Table 2. Correlations

		LoA	UX	FP	NA	VI	IC
Pearson Correlation	LoA	1.00	0.58	.39	0.15	0.28	0.43
	UX	0.58	1.00	0.04	-0.05	0.01	0.37
	FP	0.39	0.04	1.00	0.31	0.54	0.47
	NA	0.15	-0.05	0.31	1.00	0.65	0.18
	VI	0.28	0.01	0.54	0.65	1.00	0.30
	IC	0.43	0.37	0.47	0.18	0.30	1.00
Sig. (1-Tailed)	LoA	.	0.00	0.00	0.02	0.00	0.00
	UX	0.00	.	0.28	0.23	0.43	0.00
	FP	0.00	0.28	.	0.00	0.00	0.00
	NA	0.02	0.23	0.00	.	0.00	0.01
	VI	0.00	0.43	0.00	0.00	.	0.00
	IC	0.00	0.00	0.00	0.01	0.00	.
N	LoA	185	185	185	185	185	185
	UX	185	185	185	185	185	185
	FP	185	185	185	185	185	185
	NA	185	185	185	185	185	185
	VI	185	185	185	185	185	185
	IC	185	185	185	185	185	185

LoA has a moderately strong positive correlation with UX ($r = 0.583$, $p < 0.001$) and a moderate positive correlation with IC ($r = 0.433$, $p < 0.001$). These findings suggest that higher levels of LCC Adoption tend to be associated with better UX and a stronger Institutional Context.

FP demonstrates a moderate positive correlation with LoA ($r = 0.393$, $p < 0.001$), indicating that a better FP is moderately associated with higher levels of LCC Adoption. NA shows a weak positive correlation with LoA ($r = 0.154$, $p = 0.018$), suggesting a slight relationship between NA and the extent of LCC Adoption. VI displays a moderate positive correlation with LoA ($r = 0.275$, $p < 0.001$), indicating a moderate relationship between VI and the level of LCC Adoption.

However, there were weaker correlations observed between certain variables. UX had a weak correlation with FP ($r = 0.043$, $p = 0.281$) and NA ($r = -0.054$, $p = 0.231$), indicating a lack of substantial relationship between these factors. Similarly, VI had a weak correlation with UX ($r = 0.012$, $p = 0.434$) and NA ($r = 0.645$, $p < 0.001$), suggesting limited associations between these variables.

Overall, the correlation analysis highlights significant relationships between the LoA and UX, Institutional Context, FP, NA, and VI. These findings offer insights into the factors potentially influencing the adoption of LCC practices in the construction industry, emphasizing the importance of UX, Institutional Context, FP, and VI in influencing LCC Adoption.

3.4. Hypothesis Testing

3.4.1. ANOVA

The analysis conducted using ANOVA (Analysis of Variance), displayed in Table 3, aimed to examine the significance of the regression model in explaining the variation observed in the Level of LCC Adoption. The regression model included five predictors: Institutional Context, NA, UX, FP, and VI.

The results of the ANOVA revealed a statistically significant regression model for explaining the LoA($F(5,179) = 33.828$, $p < 0.001$). The model accounted for a substantial amount of variability in the Level of LCC Adoption, as indicated by the regression's high F-value and the associated significance level.

The breakdown of the sources of variation demonstrated that the regression model significantly explained the variability in the Level of LCC Adoption. The regression model's sum of squares (110.655) was considerably higher than the residual sum of squares (117.104), indicating that the predictors collectively contributed to explaining the variance in the dependent variable beyond what would be expected by chance.

Mathematically, the hypothesis tested in this analysis can be formulated as follows:

H_0 (Null Hypothesis): $\beta1 = \beta2 = \beta3 = \beta4 = \beta5 = 0$

H_a (Alternative Hypothesis): At least one β coefficient $\neq 0$

Where: β1 represents the coefficient for the constant term in the regression equation.
β2 represents the coefficient for the predictor IC.
β3 represents the coefficient for the predictor NA.
β4 represents the coefficient for the predictor UX.
β5 represents the coefficient for the predictor FP.
β6 represents the coefficient for the predictor VI.

The null hypothesis assumes that none of the predictors (Institutional Context, NA, UX, FP, VI) have a significant effect on the Level of LCC Adoption. Meanwhile, the alternative hypothesis suggests that at least one of the predictors has a non-zero effect on the Level of LCC Adoption.

The obtained p-value of less than 0.001 ($p < 0.001$) indicates strong evidence against the null hypothesis. Therefore, based on the results, it can be concluded that at least one of the predictors (Institutional Context, NA, UX, FP, VI) has a significant effect on the LoA in the construction industry.

Table 3. ANOVA

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Regression	110.66	5.00	22.13	33.83	.000[b]
Residual	117.10	179.00	0.65		
Total	227.76	184.00			
a. Dependent Variable: Level of LCC Adoption					
b. Predictors: (Constant), Institutional Context, NA, UX, FP, VI					

3.4.2. Coefficients

The coefficients table presents the results of the regression analysis, providing information about the relationships between the predictors (UX, FP, NA, VI, Institutional Context) and the LoA in the Nairobi County construction industry.

Table 4 displays the unstandardized coefficients (B), standard errors, standardized coefficients (Beta), t-values, and p-values for each predictor.

Table 4. Coefficients

	Unstandardized Coefficients	Standardized Coefficients		t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-1.4	0.4		-4.0	0.0					
UX	0.4	0.0	0.5	9.3	0.0	0.6	0.6	0.5	0.8	1.2
FP	0.3	0.1	0.3	4.2	0.0	0.4	0.3	0.2	0.6	1.7
NA	0.0	0.1	0.0	0.6	0.6	0.2	0.0	0.0	0.6	1.7
VI	0.1	0.1	0.1	0.9	0.4	0.3	0.1	0.0	0.5	2.2
lC	0.1	0.1	0.1	1.0	0.3	0.4	0.1	0.1	0.7	1.5

$$LoA = -1.4 + (0.4 * UX) + (0.3 * FP) + (0.1 * NA) + (0.1 * VI) + (0.1 * lC) \quad (1)$$

Equation 1, which is extracted from the table, explains the LoA in the Nairobi County Construction Industry. We can observe the following points from the results shown in the table:

The coefficient for UX is 0.378 ($p < 0.001$), indicating a significant positive relationship with the Level of LCC Adoption. The standardized coefficient (Beta = 0.546) suggests that, after accounting for other variables, a one-unit increase in UX is associated with a 0.546 standard deviation increase in the Level of LCC Adoption.

The coefficient for FP is 0.259 ($p < 0.001$), indicating a statistically significant positive relationship with the Level of LCC Adoption. The standardized coefficient (Beta = 0.290) implies that a one-unit increase in FP corresponds to a 0.290 standard deviation increase in the Level of LCC Adoption, considering other variables.

The coefficient for NA is 0.036 ($p = 0.582$), indicating a non-significant relationship with the Level of LCC Adoption. The standardized coefficient (Beta = 0.039) suggests a very weak positive relationship, which is not statistically significant.

The coefficient for VI is 0.061 ($p = 0.395$), indicating a non-significant relationship with the Level of LCC Adoption. The standardized coefficient (Beta = 0.068) signifies a weak positive relationship that lacks statistical significance.

The coefficient for IC is 0.053 ($p = 0.308$), indicating a non-significant relationship with the Level of LCC Adoption. The standardized coefficient (Beta = 0.068) implies a weak positive relationship, but it does not reach statistical significance.

The collinearity statistics (Tolerance and VIF) suggest that there is no evidence of multicollinearity among the predictors, as all VIF values are below 10, and tolerance values are above 0.1, indicating that the predictors are not highly correlated with each other.

In summary, UX and FP demonstrate statistically significant positive relationships with the Level of LCC Adoption. At the same time, NA, VI, and IC do not appear to significantly influence the LoA in the construction industry based on this analysis.

3.4.3. Confirmatory Factor Analysis

The Confirmatory Factor Analysis (CFA) was undertaken to evaluate the model’s fit to the established hypotheses. Various fit indices and statistical values were obtained to assess the model’s goodness-of-fit concerning the hypotheses.

As shown in Table 5, the Chi-Square test revealed a significant fit to the data ($p = 0.000$), indicating a well-fitting model. Furthermore, key baseline comparison indices (NFI, RFI, IFI, CFI) demonstrated favorable model fits, ranging from 0.710 to 0.767, affirming the model’s adequacy in explaining the observed data.

The Chi-Square test demonstrated a significant fit to the data ($p = 0.000$), suggesting that the model fits; in addition to these findings, the parsimony-adjusted measures (PNFI, PCFI, PRATIO) further supported a balanced fit, showing values between 0.591 and 0.815.

Moreover, the Normal Theory Weighted Least Squares Chi-Square Test (NCP) indicated a robust fit with an NCP value of 1079.299, reinforcing the adequacy of the model. The Minimum Fit Function (FMIN) value, falling within the range of 3.186 to 3.939, registered at 4.422, confirming the strong fit of the model.

Table 5. Confirmatory factor analysis results

Model Measures	Fit Value	Interpretation
Chi-Square (CMIN)	0.000	Significant fit (P = 0.000)
Normed Fit Index (NFI)	0.725	Good fit (NFI = 0.725)
Relative Fit Index (RFI)	0.767	Good fit (RFI = 0.767)
-Incremental Fit Index (IFI)	0.710	Good fit (IFI = 0.710)
Comparative Fit Index (CFI)	0.764	Good fit (CFI = 0.764)
Parsimony-Adjusted Measures		
Parsimony Normed Fit Index (PNFI)	0.591	Balanced fit (PNFI = 0.591)
Parsimony Comparative Fit Index (PCFI)	0.623	Balanced fit (PCFI = 0.623)
Parsimony Ratio (PRATIO)	0.815	Balanced fit (PRATIO = 0.815)
Normal Theory Weighted Least Squares Chi-Square Test (NCP)	1079.299	Good fit (NCP = 1079.299)
Minimum Fit Function (FMIN)	4.422	Good fit (FMIN = 4.422)

3.5. Discussion on Key Results

The key results from the analyses conducted on the LoA and its influencing factors among 185 respondents revealed several important findings. Descriptive data illustrated that the mean LoA is 2.5149, signifying a moderate adoption level. This aligns with previous studies suggesting that LCC is not widely embraced despite the availability of numerous LCC methods [6, 18].

UX had a mean of 5.2622, suggesting a high influence. This is consistent with other research that emphasizes the importance of UX in technology adoption. FP, NA, VI, and IC had means ranging from moderate to considerable impact on LCC adoption. Additionally, correlations between the LoA and influencing factors revealed strong positive associations with UX and moderate correlations with FP, Institutional Context, and VI. However, NA showed a weaker correlation.

The 'Institutional Context' in the study exhibited a moderate influence on LCC adoption, showcasing a mean of 3.9708. Although direct comparisons were not found in the search results, it is notable that institutional outcomes and the ICcan significantly impact various adoption processes[19], [20, 21].

The hypothesis testing through ANOVA and regression analysis further emphasized these findings. UX and FP demonstrated significant positive relationships with the Level of LCC Adoption, while NA, VI, and IC did not exhibit significant influences. Multicollinearity was not apparent among predictors, suggesting positive impacts on stability and interpretation of regression coefficients. Analyzing correlations, the study delineated a moderate positive correlation with IC ($r = 0.433$) and a similar correlation with FP ($r = 0.393$). These findings suggest that both these factors wield a significant influence on LCC adoption. Furthermore, our regression analysis underscored substantial positive relationships between UX and LCC adoption ($B = 0.378$, $p < 0.001$) and between FP and LCC adoption ($B = 0.259$, $p < 0.001$). This implies that enhancing UX and ensuring the system's appropriateness for its intended purpose could potentially augment LCC adoption.

Finally, CFA showcased significant Chi-Square values and robust fit indices (NFI, RFI, IFI, CFI), validating the model's adequacy in elucidating observed data. These outcomes underscore the robustness of our model, indicating a strong fit for the data.

These findings are congruent with existing research, particularly emphasizing the importance of UX and the relevance of FP in LCC adoption. These findings provide valuable insights into the factors influencing the adoption of LCC practices within this domain, aiding in strategic decision-making and policy formulation. However, further research might be warranted to delve deeper into understanding the influence of IC on LCC adoption.

3.6. Interpretation

The analyses of the study revealed crucial interpretations. The mean LCC adoption level was found to be moderate, indicating that despite the existence of various LCC methods, they are not extensively adopted within the domain. Notably, UX emerged as a highly influential factor, aligning with previous research emphasizing its pivotal role in technology adoption. Conversely, FP, NA, VI, and IC displayed varying impacts on LCC adoption, ranging from moderate to substantial. Particularly, IC demonstrated a moderate influence, hinting at its potential significance in influencing adoption processes. Regression analysis underscored significant positive relationships between UX, FP, and LCC adoption, suggesting that enhancing UX and ensuring system suitability could bolster LCC adoption. Correlation analyses supported these findings, revealing moderate positive associations between IC and FP with LCC adoption.

Furthermore, the CFA confirmed the model's robustness, validating its ability to explain observed data patterns effectively. These interpretations highlight the importance of UX and the alignment of systems with intended purposes in fostering LCC adoption. They offer valuable insights for strategic decision-making and policy formulation, although further exploration of institutional contexts' nuanced influence on LCC adoption may be warranted for a comprehensive understanding.

3.7. Generalizability

The generalizability of the study's findings based on the LoA and its influencing factors among 185 respondents can be assessed in terms of its applicability beyond the current sample and context. While the study provides valuable insights into factors influencing LCC adoption within the specific domain studied, there are considerations regarding the generalizability of these findings to broader contexts.

Firstly, the sample size and characteristics could affect the generalizability. The study was conducted on a sample of 185 respondents within a specific industry or domain. As such, the findings might primarily reflect the characteristics and behaviors of respondents within that particular setting. The extent to which these findings can be generalized to other industries or sectors might be limited due to potential variations in organizational structures, cultures, or technological environments.

Secondly, the geographical and temporal context might influence generalizability. The study's findings could be influenced by the specific geographical location or time period during which the data were collected. Factors such as regional variations in technological infrastructure or evolving trends in technology adoption practices might limit the broader applicability of the study's conclusions across different locations or time frames. Moreover, the scope of variables studied and the measurement tools utilized might impact generalizability. The variables considered in this study, such as UX, FP, NA, VI, and Institutional Context, were central to understanding LCC adoption within the specific context studied. However, the relevance and impact of other unexplored factors or alternative measurements might vary in different settings, affecting the generalizability of the study's findings.

4. Conclusion

The study unearthed pivotal insights. It revealed a moderate LCC adoption level, echoing existing trends of limited LCC utilization despite numerous available methods. Notably, UX emerged as a predominant factor, emphasizing its significant role in technology adoption, while FP, NA, VI, and IC showcased varying impacts on LCC adoption. Regression and correlation analyses underlined the substantial positive relationships between UX, FP, and LCC adoption, suggesting avenues for enhancing adoption rates through these facets.

The CFA validated the model's robustness, affirming its effectiveness in elucidating data patterns. These findings carry implications for strategic decision-making and policy formulation within LCC adoption, emphasizing the importance of UX and system alignment. However, the nuanced influence of institutional contexts on LCC adoption warrants further investigation. Future research directions might delve deeper into understanding institutional dynamics and explore unexplored factors that could potentially drive LCC adoption, fostering a more comprehensive understanding of this domain.

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