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Factors Influencing Adoption of Building Management System in Commercial Buildings in Lagos State, Nigeria

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Abstract

Against the backdrop of increasing technological innovation and rising demand for sustainability in the built environment, there is a clear need to explore the application of Building Management System BMS in the Nigerian real estate sector. Accordingly, this paper examined the concept of adopting Building Management System (BMS) in commercial buildings in Lagos State, Nigeria with a view to assessing performance on SDG 11 (Sustainable cities and communities) where issues around resilience in buildings is hosted. The study administered one hundred and eighteen questionnaires to facility managers of commercial buildings that have adopted BMS in five local government areas in Lagos State. The data were processed using the principal component (factor) analysis and regression correlation analysis tool. It was found that a range of social and cost factors influenced the adoption of BMS in the study area. Specifically, level of occupant comfort and ease of use of the system were the most significant factor while implementation cost and extent of energy savings also strongly influenced BMS adoption in the study area. The chapter offers suggestions on strategies to improve adoption of BMS and recommends awareness campaigns and the introduction of promotional incentives to the public on BMS.

Keywords: Adoption; Building management system; Factors; Sustainable development goals

1.0 Introduction

Nowadays the smart building concept has become quite fashionable among segments of the population, especially in terms of the long-term business opportunity that it represents (Simpeh & Smallwood, 2015). This growing embrace of 'building smartness' is a reaction to the negative environmental effects of the greenhouse emissions from conventional buildings that use high volumes of energy and, consequently, impede efforts to achieve the Sustainable Development Goal on resilient buildings (Awosode 2018; Ofori 2012). As a major component of smart cities, BMS has contributed immensely to achieving low energy consumption in buildings (Wigginton, 2002). According to literature, a number of factors have been identified to influence the adoption of BMS in the construction industry (Nguyen & Aiello, 2012).

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BMS is software/hardware that helps to control, monitor and manage the lighting, heating, ventilation, and air conditioning (HVAC), water supply, physical access and other related components of buildings (Shang, Ding, Marianantoni, Burke, & Zhang, 2014). Data can be gathered through these systems and used for evaluation, fault finding, bill and report generation and many other purposes related to building performance (Shang, *et al,* 2014). The component sub-systems of BMS also include utility and monitoring systems, fire and life safety systems, security and access control systems and the vertical transportation system, leading to significant energy savings, drastic reduction of CO_2 gas emission and improvement of appliance efficiency (Wambui, 2014).

Managers of commercial buildings are consistently faced with the challenge of competition and need to consistently upgrade their systems in order to meet customer expectations and taste while keeping an eye on profit (Janes & Wisnom, 2003). Having BMS in commercial buildings helps to cut costs in many ways (Trauthwein, 2012). However, owing to certain factors, not all commercial buildings have been able to adopt BMS in Lagos State, Nigeria's commercial hub (Cunningham, 2013). The choice of Lagos for this study is justified by the sheer number of technologically-driven businesses in the state (Awosode, 2018). The study identifies the various factors influencing the adoption of BMS in commercial buildings in five local government areas of the state. The aim is to examine the current performance of the system while seeking to improve it and promote its use to more people.

2.0 Literature Review

The Building Management System (BMS) is one of the recent technological innovations in the construction industry, and it appeals to users for different reasons (Faruque, 2019). According to Hankinson and Breytenbach (2012), acceptance of technological innovation in the construction industry may sometimes be constrained by issues such as conflicting building codes, fear of accepting new products by the professionals, lack of awareness, lack of experience of use, lack of local expertise, and level of availability of the innovation. According to Djokoto, Dadzie and Ohemeng-Ababio (2014), acceptance of innovation may be influenced by the belief system and culture in a society. As Du Plessis et al. (2002) found, the construction industry in developing countries such as Nigeria and South Africa may not place a high premium on technological innovation, hence the likely slow embrace of BMS.

Ben and Margaret (2014) examined the adoption of smart building devices in Nigeria and found that cultural and economic factors tend to influence their acceptance. According to the authors, automated doors in public buildings, use of closed-circuit television (CCTV) for security reasons and smart cards for accessing certain buildings were the most commonly adopted BMS features. However, the authors suggested that BMS will eventually be fully embraced in the country. At present, many professionals are not aware of BMS and most clients cannot afford the installation cost. As Dalibi, Feng, Shuangqin, Sadiq, Bello and Danja (2017) reported, green building technologies have not been embraced because of their high costs.

According to Wambui (2014), writing within the context of Kenya, BMS allows for energy efficiency, convenience, ease, security and safety achieved by automation of building components. Moreover, it allows for easy tracking and managing of building operations to maximise energy efficiency which offers cost benefits, and helps to promote resilience in buildings. The study identified three main factors with the most influence on the adoption of BMS in the study area, viz: comfort and ease of use of the system, level of awareness, and client's taste. Korani, Ghaderzadeh and Korani (2015) showed that in Iran BMS adoption was influenced by level of awareness and availability alongside cultural and economic issues.

3.0 Methodology

The study utilised primary and secondary data. The primary data were sourced through a survey of facility managers of commercial buildings adopting BMS in five local government areas of Lagos State, namely: Ikeja, Surulere, Eti-Osa, Lagos Island, and Ibeju-Lekki. A total of 169 commercial buildings were identified from the available maps and data retrieved from the Lagos State Ministry of Works. The study assessed 118 commercial buildings out of the sample frame, that is, 70% of the population. A questionnaire was designed to assess the impact of the factors influencing the adoption of BMS in the study area, using a five-point Likert scale showing the level of significance of the twenty (20) factors that were identified. The data were analysed using principal component (factor) analysis and regression correlation analysis.

4.0 Findings

Table 1 presents the result of the test of sample adequacy for factor analysis. The Kaiser-Meyer-Olkin (KMO) value of 0.801 obtained indicates that the sample is adequate. The result of Bartlett's Test of Sphericity (χ^2 = 690.808, P = 0.000) revealed that the correlation matrix of the 20 factors is not an identity matrix. This further showed that the off-diagonal values are not zeros but ones.

Table 1: KMO and Bartlett's test of sample adequacy for the analysis of factors influencing adoption of BMS in commercial buildings

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.810**
Bartlett's Test of Sphericity		690.808
		190
		0.000

The communalities of the factors influencing the adoption of BMS facilities in commercial buildings were established for the purpose of determining the extent to which the underlying factors account for the variance of the 20 factors. The result in Table 2 shows that all the variables had communalities greater than 0.4, thus implying that the variables actually measured the underlying factors.

Table 2: Communalities of factors influencing adoption of BMS in commercial buildings

Factor	Initial	Extraction
Savings on maintenance costs	1.000	0.716
Energy efficiency	1.000	0.624
Technical compatibility of BAS and user needs	1.000	0.774
Comfort and ease of using the system	1.000	0.628
Changes in customer tastes, preferences and style	1.000	0.681
Global competition	1.000	0.543
Efficiency of building services equipment	1.000	0.617
Enhanced comfort for occupants	1.000	0.792
Friendly responsiveness of BMS on the environme	1.000	0.512
Provides safety and security	1.000	0.480
Low level of awareness	1.000	0.662
Lack of demand by building users/owners	1.000	0.688
High implementation cost	1.000	0.563
Availability of local expertise	1.000	0.618
Management strategies	1.000	0.650
Type of building	1.000	0.735
Age of organisation	1.000	0.713
Location of organisation	1.000	0.595
Number of floors	1.000	0.606
Employee expectation	1.000	0.730

Extraction Method: Principal Component Analysis

The principal components analysis is presented in Table 3. The components have Eigenvalues that were not less than one and rotation sums of square loadings that ranged between 1.686 and 2.740. These suggest that six components could be extracted to represent the underlying factors. The dominant one accounted for 31.701% of the observed variance with the Eigen value of 6.340. The second component accounted for 8.536% of the observed variance, with an Eigenvalue of 1.707. The third component accounted for 7.131% of the variance of the data set, with an Eigen value of 1.426. The fourth component accounted for 6.256% of the variance and had an Eigen value of 1.251. The fifth component accounted for 5.896% of the observed variance, with an Eigen value of 1.79, while the last component accounted for 5.117% of the variance of the data set, with an Eigen value of 1.023. The scree plot in Figure 1 shows inflections that rationalise retention of the six components.

Table 3: Total variance explained of factors influencing use of BMS in commercial buildings

Total Variance Explained									
Comp	**Initial Eigen value**			**Extraction sum of square loadings**			**Rotation sums of squared loadings**		
SN	**Total**	**% of variance**	**Cumul. (%)**	**Total**	**% of variance**	**Cumul. (%)**	**Total**	**% of variance**	**Cumul. (%)**
1	6.340	31.701	31.701	6.340	31.701	31.701	2.740	13.698	13.698
2	1.707	8.536	40.237	1.707	8.536	40.237	2.636	13.182	26.880
3	1.426	7.131	47.367	1.426	7.131	47.367	2.305	11.524	38.404
4	1.251	6.256	53.624	1.251	6.256	53.624	1.855	9.277	47.681
5	1.179	5.896	59.520	1.179	5.896	59.520	1.705	8.524	56.204
6	1.023	5.117	64.637	1.023	5.117	64.637	1.686	8.432	64.637
7	0.960	4.799	69.436						
8	0.785	3.924	73.360						
9	0.716	3.581	76.941						
10	0.651	3.256	80.197						
11	0.599	2.995	83.192						
12	0.562	2.809	86.001						
13	0.502	2.509	88.510						
14	0.485	2.423	90.933						
15	0.426	2.131	93.064						
16	0.382	1.908	94.972						
17	0.322	1.610	96.582						
18	0.255	1.277	97.860						
19	0.233	1.167	99.027						
20	0.195	0.973	100.000						

Extraction Method: Principal Component Analysis

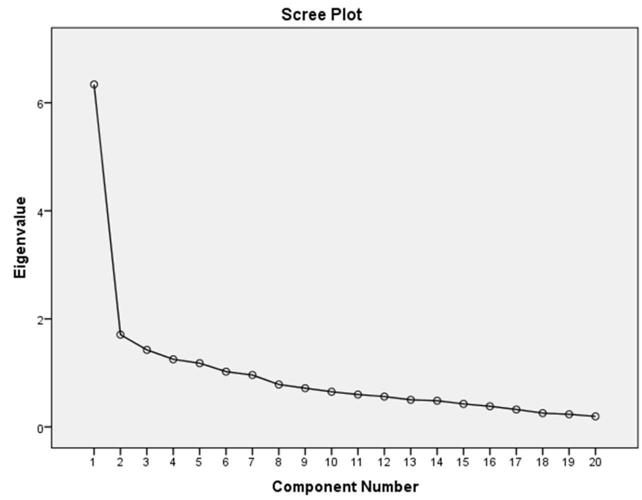

Figure 1: Scree plot of factors influencing use of BMS in commercial buildings

The component matrix of Table 3 presents the results of the Pearson's correlation analysis between the components and factors influencing adoption of BMS facilities in commercial buildings. All the factors considered were loaded into six components. Some of the variables were observed to measure more than one underlying factor, giving rise to cross loadings. An example of these variables is 'lack of demand by building users or owners.' In tackling this challenge, rotation of the component matrix using Varimax with Kaiser Normalisation method was performed.

Table 4: Component matrix of correlations between components and factors influencing adoption of BMS in commercial buildings

Factors	Components					
	1	2	3	4	5	6
Savings on maintenance costs	0.691	0.437				
Energy efficiency	0.592	0.338	-0.348			
Efficiency of building services equipment	0.427	0.414		-0.395		0.396
Comfort and ease of using the system	0.635	0.376				
Changes in customer tastes, preferences and style	0.595		-0.353	0.362		
Global competition	0.565					
Employee Expectation	0.550		-0.402			
Enhanced comfort for occupants	0.305	0.402		0.635		-0.347
Friendly responsiveness of BMS on the environment	0.366				0.455	
Provides safety and security	0.609		0.310			
Low level of awareness	0.355		0.366	0.468		0.425
Lack of demand by building users/owners	0.550		0.476			
Technical compatibility of BAS and user needs	0.679					
Availability of local expertise	0.683		0.301			
Type of building	0.699				-0.365	
Management strategies	0.545		0.342		0.482	
Age of organisation	0.471	-0.498			-0.452	
Location of organisation	0.598	-0.481				
Number of floors	0.485		0.321			-0.389
High implementation cost	0.630	-0.464				

Table 5 shows the results of the rotation performed using Varimax with the Kaiser normalisation method. (Data in bold indicate the dominant factor loadings.) Overall, seventeen (17) factors were extracted from the principal components. These factors were extracted and adopted for further analysis, since they have factor loadings that were not less than 0.5 after rotation of the component matrix was performed. Therefore, type of building (0.679), age of organisation (0.759), location of organisation (0.559) and number of floors (0.538) were factors that loaded into the first component. Loaded into the second component were savings on maintenance costs

(0.717), energy efficiency (0.698), efficiency of building services equipment (0.842) and high implementation cost. For the third component, friendly responsiveness to BMS on the environment (0.659), availability of local expertise (0.571) and management strategies (0.779) were loaded. Further, change in customer tastes, preferences and style (0.730) and employee expectation (0.695) loaded into the fourth component. Low level of awareness (0.752) and lack of demand by building users or owners (0.678) loaded into the fifth component, while comfort and ease of using the system (0.558) and enhanced comfort for occupants (0.839) loaded into the sixth component. This result suggests that the variables in components 1-6 were adequately correlated with the underlying factors represented by each component.

Table 5: Rotated component matrix of correlations between components and factors influencing adoption of BMS in commercial buildings

Factors	**Components**					
	1	**2**	**3**	**4**	**5**	**6**
Savings on maintenance costs		**0.717**				
Energy efficiency		**0.698**				
Efficiency of building services equipment		**0.842**				
Comfort and ease of using the system		0.413	0.332			**0.558**
Changes in customer tastes, preferences and style				**0.730**		
Global competition	0.325	0.490				0.429
Employee expectation				**0.695**		
Enhanced comfort for occupants						**0.839**
Friendly responsiveness of BMS on the environment			**0.659**			
Provides safety and security	0.395		0.333		0.339	
Low level of aware ness					**0.752**	
Lack of demand by building users/owners	0.341				**0.678**	
Technical compatibility of BAS and user needs		0.359	0.475	0.348		
Availability of local expertise			**0.571**		0.398	
Type of building	**0.679**	0.303				
Management strategies			**0.779**		0.322	
Age of organi sation	**0.759**					
Location of organisation	**0.559**		0.398	0.341		
Number of floors	**0.538**		0.335	-0.332		
High implementation cost		**0.687**		0.437		

Factors that loaded highly into components 1-6 were assigned unique names as shown in Table 6. Factors that loaded into components 1-3 were named organisational, cost and efficiency, and environmental factors respectively. Factors that loaded into the fourth, fifth and sixth components were customer expectation, awareness, and social factors respectively. These factors undergirded the variables in each of the six components. Figure 2 shows the various factors that were loaded into the six components.

The underlying factors were further subjected to descriptive statistical analysis. The results of the mean item scores for these factors are presented in Table 6. The social factor (MIS = 3.65, SD = 0.992) ranked highest among the factors influencing adoption of BMS facilities in commercial buildings in the study area. The awareness factor (MIS = 3.55, SD = 0.884) ranked next, while customer expectation (MIS = 3.51, SD = 0.927) ranked third. The organisational factor (MIS = 3.32, SD = 0.861) ranked lowest. As the results show, the social, awareness and customer expectation factors were significant in influencing the adoption of BMS facilities in commercial buildings in the study area. This finding is similar to Wambui (2014), in the Kenyan context. About 88.3% of the respondents ranked comfort and ease of the system (social factor) as the highest. Regarding the overall opinion of the professionals, 91.7% suggested the need for more awareness as well as public enlightenment and advertisement on the benefits of BMS. Kim et al. (2007) found that social factors and customer habits have a positive impact on the adoption of smart devices.

Clearly, therefore, a major reason for BMS adoption is the comfort it provides; most technological innovations in buildings are meant to offer a more comfortable environment for occupants as a way to enhance productivity and promote a sustainable environment (Awosode, 2018). Thus, BMS is embraced by professionals in the built environment because it offers comfort, sustainability and energy efficiency.

The level of awareness of building owners on the benefits of BMS was also a factor influencing its adoption. Awosode (2018) identified level of awareness of green building technological devices as one of the significant factors that enhance their adoption. Customer taste and expectations are also leading factors influencing BMS adoption, since commercial buildings are competitive and their owners are profit-oriented.

Table 6: Interpretation of component factors influencing adoption of BMS in commercial buildings workers

Component Factors		**Factors (Interpretation)**	**MIS**	**SD**	**Rank**
1	Management strategies	Organisational	3.32	0.861	6th
	Age of organisation				
	Location of organisation				
	Number of floors Type of building				
2	Savings on maintenance costs	Cost and efficiency	3.38	0.909	5th
	Energy efficiency				
	Efficiency of building services equipment				
3	Friendly responsiveness of BMS on the environment	Environmental	3.40	0.883	4th
	Availability of local expertise				
4	Changes in customer taste, preferences and styles	Habit	3.51	0.927	3rd
	Employee expectation				
5	Low level of awareness	Awareness	3.55	0.884	2nd
	Lack of demand by users or owners				
6	Comfort and ease of using the system	Social	3.65	0.922	1st
	Enhanced comfort for occupants				

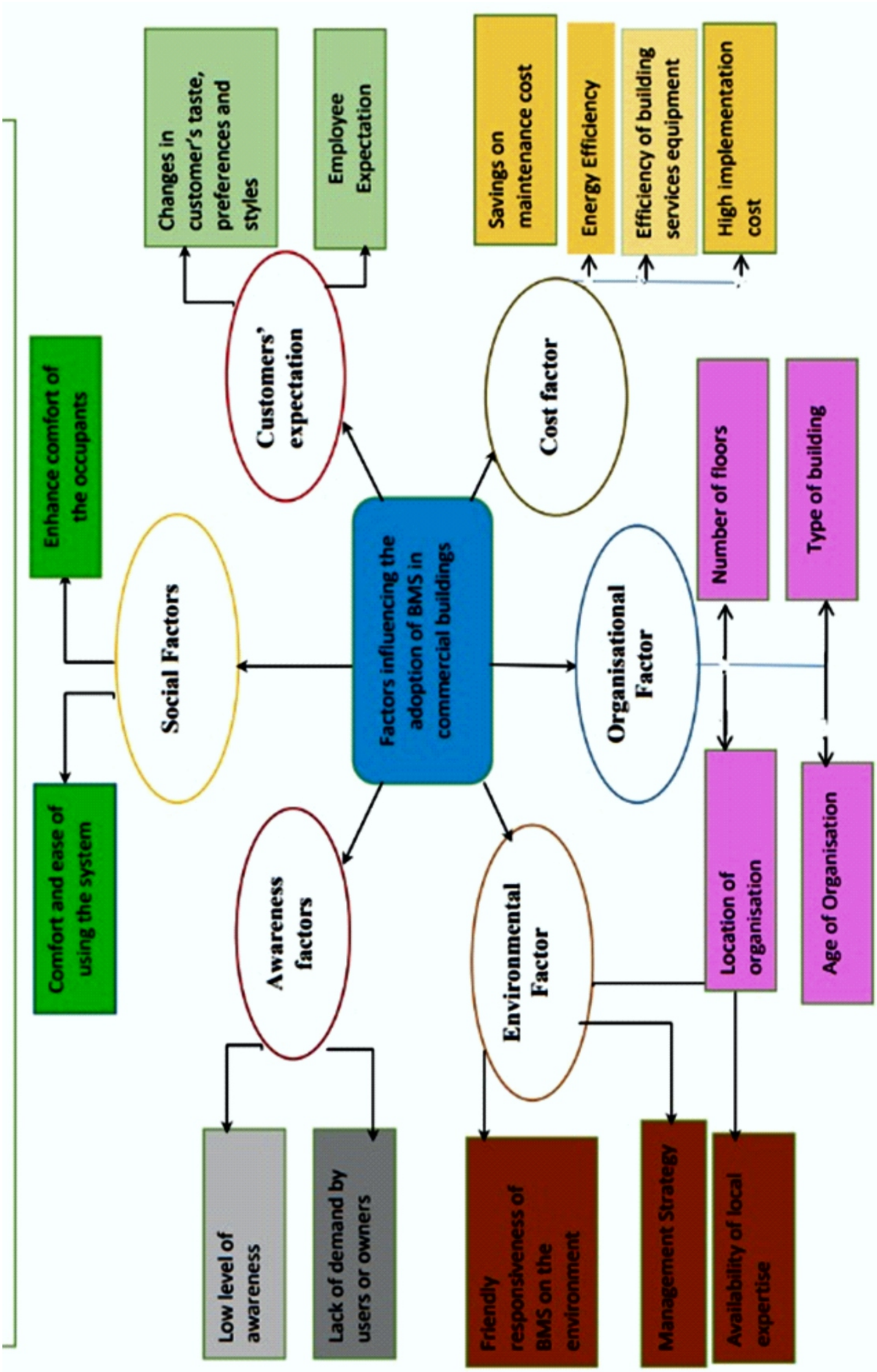

Figure 2. Model for Factors Influencing the Adoption of BMS in Commercial Buildings

Influence of Factors Motivating Adoption of BMS Facilities in Commercial Building Types on its Level of Adoption in the Study Area

Using multiple regression analysis, the researchers also examined the extent to which the factors motivating adoption of BMS facilities in commercial buildings influences their level of adoption in the study area. Factors influencing BMS adoption and the level of adoption constituted the independent and dependent variables respectively. At a 0.05 level of significance, we tested the null hypothesis:

> *Factors influencing the adoption of BMS facilities in commercial buildings will not have a significant influence on their level of adoption.*

With the multiple correlation coefficient (R) of 0.409 as indicated in Table 8, a good level of prediction of the level of adoption of BMS facilities and its influencing factors is suggested. A coefficient of multiple determinants (R^2) of 0.167 shows that 16.7% of variance in workplace violence can be explained by the influencing factors. This suggests that 16.7% of cases of BMS adoption in commercial buildings is attributed to the factors influencing its adoption.

$F(6, 54) = 1.810$ and $p = 0.114$ shows that the multiple correlation coefficient (R) is not statistically significantly different from zero. To determine the extent to which the factors influencing adoption of BMS facilities in commercial buildings influenced their level of adoption, their regression coefficients were further considered.

Regression coefficients 0.308, 0.176, 0.142, 0.036, -0.001 and -0.020 for cost and efficiency, as well as environmental, social, organisational, customer expectation and awareness factors respectively, as presented in Table 7, shows how the magnitude of effect of one factor varies from another. The cost and efficiency factor shows more influence on the level of adoption of BMS in commercial buildings in the study area than the other factors. Similarly, the environmental factor shows a stronger influence on the level of adoption of BMS in commercial buildings, in comparison to other factors. Therefore, given the regression coefficient of cost and efficiency factor, for instance, a unit change in cost and efficiency of a BMS facility, while keeping other factors constant, will yield a 0.308 change in its level of adoption. The result also shows that the cost and efficiency factor is the only factor with a regression coefficient (B) that is statistically significantly different from zero (p value = 0.018). Therefore, the null hypothesis is rejected for the factor, while the null hypothesis is accepted for the social, organisational, awareness, environmental and customer expectation factors (p values were < 0.05). The cost and efficiency factor showed a good level of significance across building types, since it is one of the major reasons why managers accept or decline adoption of BMS. There is either a setback on the implementation cost, as found by Johan and Rasmus (2012) on a hospital complex in Stockholm, or there is motivation to adopt the system because of future cost benefits and energy savings, as concluded by Kamali et al. (2014) on an office building in San Francisco, USA. The cost factor was also discovered by Awosode (2018) to have a strong influence on the adoption of automation in the facility management of high-rise buildings.

Table 7: Regression model for factors influencing adoption of BMS in commercial buildings

	Model	S.E	B	Sig.	Df	R	R^2	F	P
								ANOVA	
	(Constant)	0.079		0.000	6	0.409	0.167	1.810	0.114
	Organisational	0.072	0.036	0.780	54				
	Cost and efficiency	0.069	0.308	0.018					
	Environmental	0.082	0.176	0.179					
	Customer expectation	0.075	-0.001	0.993					
	Awareness	0.069	-0.020	0.874					
	Social	0.078	0.142	0.262					

5.0 Conclusion

This study identified and examined the potential factors influencing adoption of BMS in Lagos State commercial buildings. It was found that facility managers attested to the high significant level of social factors (e.g., level of comfort derived and ease of use of the system) as well as awareness and customer expectation factors. The cost factor was found to show the strongest influence on the adoption of the system in the study area. Those who adopted BMS did so based on considerations such as savings on cost, profit maximisation, efficiency of building services appliances and savings on energy costs. Managers of facilities that are yet to adopt the system cite its high implementation cost. Against this backdrop, the study recommends creating motivating schemes to encourage adoption of BMS for government and business facilities. It is also suggested that there should be public enlightenment on BMS contributions to achieving resilience through energy efficiency in the built environment.

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