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Evaluation of logistics factors on successful delivery of building construction projects in South East Nigeria

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Abstract

In most construction locations, many of the projects are facing logistic difficulties due to poor material coordination and inefficient planning. Therefore, this study developed a regression model to evaluate successful project delivery with respect to building construction logistics critical factors. The instruments for data collection and measurement were well-structured questionnaires on a Likert five-point scale, and also a semi-structured in-depth interview with personal observation to obtain responses from construction firms. The survey results were analyzed and interpreted with the use of SPSS software. It was found that the prediction of successful project delivery by the building construction logistic critical factors was not very reliable, with coefficients of determination and correlation of 36.4% and 60.3%, respectively. It was further revealed that only four out of seven critical logistic factor groups have a significant influence on achieving successful project delivery, while three critical logistic factors have no influence on project delivery.

Keywords: Building projects; Construction industry; Logistics factors; Regression model; Successful project delivery

1. Introduction

Despite the growth in the construction industry, the management of construction logistics at project sites has become increasingly complex with rising construction volume, which has made it relatively inefficient in developing nations even with technological advancement [1]. Construction logistics management can be defined as "the management of the flow of materials, tools, and equipment (any related object) from the point of discharge to the point of use or installation [2]. However, bringing together and coordinating the management of this important component between the project's principal parties would increase productivity substantially. At the construction site, this component must be properly managed to ensure a project's success [3]. Logistics in the construction industry plays an important role, which is part of the supply chain management that is used to supply construction sites with the correct materials in the right quantity, quality, and time [4]. Logistics management has been characterized as poor because of the many problems that arise during the project. For example, there can be many unnecessary production costs, a high waiting time for the materials, and accidentally damaged materials that are thrown away before they are even used. This clearly shows that poor logistics weakens the way a construction industry is perceived by others [5, 6].

In the construction industry, building construction logistics factors have become an issue of concern that needs to be focused on to ensure effective, successful, and timely execution of quality projects. According to [7], the construction industry was criticized for being uncoordinated, wasteful, and disruptive, i.e., ordering larger volumes of materials that are delivered long before they are needed. Construction logistics should be designed to deliver clients' needs as well as satisfy the performance requirements of the contractor in the most efficient way. The process should include characteristics like rationalized supply base, involvement of strategic suppliers at the design stage, communication,

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tracking facilities on site, and performance measurement. Cost in construction should be more transparent in what other industries do, for example, retail and manufacturing industries. Any non-value-added activity that does not benefit logistics in a project should be eliminated to minimize waste [8]. The shortcomings in the construction industry, with incremental investment and rising demand for infrastructure and building projects, make researchers continually challenged to tackle these issues experienced in the execution of construction projects. Some of the problems that are common in building construction logistic activities in south eastern Nigeria include poor roadways, long lead time, poor inventory management, limited public space, and paucity of material transportation. In addition to these factors, the availability of the right trucks and equipment that will adequately meet the delivery requirements of construction projects remains a glaring challenge. According to [9], potential problems in the construction industry lead to an increase in construction costs and a decrease in construction productivity. [10] stated that the transportation of materials is one of the most important activities within logistic operations. Previous studies, according to [11], opined that this can be achieved by having dedicated logistics coordination within the site organization and utilizing logistic-based site layout plans that specify unloading zones and storage places on site. Other studies highlighted the need for a well-designed material planning system and Just-In-Time approach to address the chaotic situation at construction sites [12,13]. According to [14,15], to ensure the efficiency of construction projects' on-site operations by managing logistics activities such as planning, storage, material tracking, waste management, and managing on-site processes related to physical flows. [16] stated that managing the site and physical material flow is essential to reducing unnecessary material movements, material-related accidents, and freeing up space on site. [5] discovered that dedicated material handlers can be utilized for on-site material handling. This helps the construction project to increase the control of material handling, but more importantly, it allows craftsmen to focus on their trades, thus increasing their value-adding time. [17] highlights that warehousing on- or off-site can alleviate material-related issues by increasing the overall material control on-site. In the long term, increased material control can lead to higher productivity and lower costs as materials are accounted for and present when needed [18].

In many construction projects, the construction companies do not pay the appropriate attention to logistics [6], and that lack of attention creates many problems and conflicts between the different parties during the project's timeline. According to [19], logistics is part of the supply chain to increase productivity and avoid decreasing profits. It has been observed that workers on the chain and the construction companies should effectively manage the various parts. They have to pay more attention to logistics management in construction projects; they experience more stress and have less confidence on-site if the logistics are poor. This happens when the workplace is limited due to the way that the materials are stored, causing space inconsistencies on-site [20]. Other techniques in other countries found that construction consolidation centers can reduce 50% of vehicle movements and 35% of material waste. Systematic application of supply chain management techniques will address the most critical logistics issues and thereby reduce construction costs and improve industry performance [21, 20] . Logistics experts tried and tested ways of achieving these benefits through integrated project teams, supply chains and the increased adoption of information technology.

In view of the complex nature of construction logistics factors in building construction projects, the previous studies had given little attention to establishing a relationship between successful project delivery and construction logistics factors. Therefore, this study focused on developing a regression model for evaluating successful delivery of building projects in relation to critical logistics factors (CLF) such as regulatory compliance and sustainability, execution efficiency, technology integration, site management, resource management, as well as strategic management and coordination.

2. Methodology

The study adopted a field survey and multiple case study approaches applied to building projects in South Eastern Nigeria. Data was collected through semi-structured questionnaires and interviews with organizational representatives at the construction site. The respondents that were used in the study were one hundred and eight (108), which included project managers, project coordinators, site managers, civil engineers, building technicians and academicians.

2.1. Questionnaire structure

The questionnaire structure of this survey was divided into two parts. The first section aims to collect background information or the profile analysis of the respondents, e.g., their educational qualifications, building categories, extent of involvement in building construction logistics factors, and professional background. The second section seeks to identify and evaluate the critical logistics factor groups of building construction logistics that influence project success.

2.1.1. Questionnaire design

The survey questionnaire was designed and formulated by looking through the relevant literature in the area of building construction logistics, and then a pilot survey or study was conducted with fifty (50) respondents and analyzed using reliability coefficient of Cronbach's alpha. The pilot survey responses formed the basis for modifying the questionnaire for the subsequent full-scale survey, and therefore, new inputs raised by the respondents were incorporated into the final full-scale survey questionnaire. The questionnaire is based on a Likert five-point ordinal scale (ranging from "strongly agree to strongly disagree" and it was administered to architects, project managers, and Civil Engineers. Logistic officers, planners, etc.

3. Results and Discussion

We analyzed the survey results using the Statistical Package of Social Studies (SPSS) software 25.0. This software is one of the management tools that helps in analyzing data and then comes out with more credible and meaningful results and interpretations.

3.1. Respondent discipline

Figure 1 described the distribution of respondents based on their area of specialization, profession, or position and a total of one hundred and eight (108) respondents were involved in this study. In terms of the respondents discipline, 24 (22.2%) are project managers, 40 (37.04. %) are civil engineers, 15 (13.8%) are architects, 6 (5.6%) are quantity surveyors, 20 (18.5%) are builders and 3 (2.78%) are academicians. It can therefore be deduced that the majority of the respondents that took part in the research survey are in the portfolio as civil engineers, representing 37.04% of the total respondents. Based on these findings, it can be inferred that the majority of the respondents who took part in the survey therefore have ample knowledge in the field of building construction logistics management in the construction industry, which makes the respondents reliable and credible sources of information that are required to satisfy the research goal.

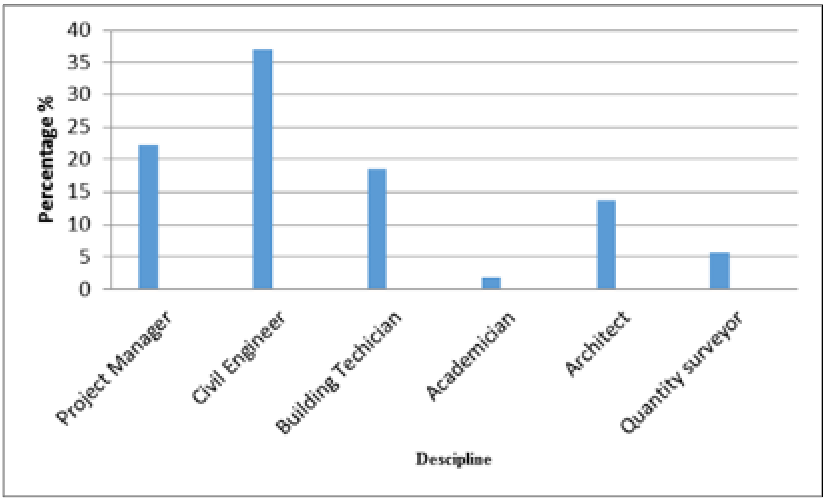

Figure 1 Respondents discipline

Figure 2, depicts the amount of respondents that had the knowledge of building construction logistics factors, 95 (87.1%) answered Yes about the concept, while 13 (12.9%) answered No.

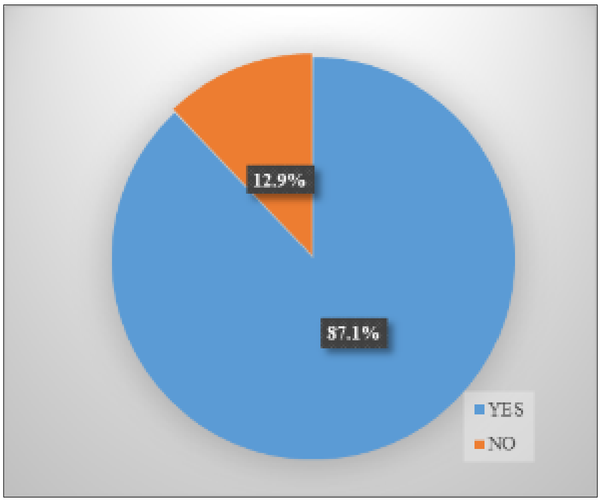

Figure 2 Concept of building construction logistics factors

It can therefore be deduced that the majority of the respondents are aware of the concept of building construction logistics factors in the construction industry.

Figure 3, shows the extent of involvement of the respondents in building construction logistic factors related activity. 35(32.4%) were only involved in it twice for building construction logistic factor activity, 58 (53.7%) were involved in it only four times, and 15 (13.9%) got involved eight times.

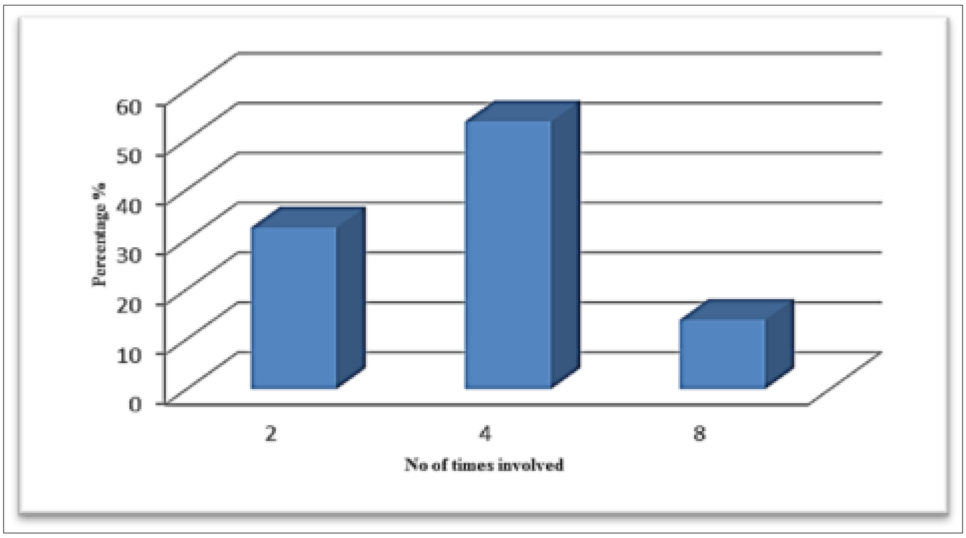

Figure 3 Extent of involvement Building construction logistic factors activity

This implies that the majority of the respondents are ignorant of the concept of building construction logistics factor in South East Nigeria. Most of the respondents are not aware that they are deploying some of the critical logistics factor groups of building construction logistics for successful project delivery identified in the literature. Hence, there is a need to adequately educate the respondents on these key features.

3.2. Reliability analysis

The most common reliability coefficient is Cronbach's alpha, which estimates internal consistency by determining how all variables (factors) in a test relate to all other items and the total test-internal coherence of the data. The Cronbach alpha value is widely used to verify the reliability of the variables. The internal consistencies of contributing factors in building construction logistics for successful project delivery were determined using Cronbach's alpha coefficient. Therefore, Cronbach's alpha was used to test the reliability of the proposed study results. The Cronbach's alpha value for contributing factors of building construction logistic for successful delivery of building projects in Nigeria is 0.931.

This is an indication that the instrument is perfect in terms of reliability and, as such, possesses adequate proof of internal consistency. However, a reliability value of less than 0.6 is usually adjudged poor, 0.6–0.7 is acceptable, and over 0.8 is adjudged to be good [22, 23].The findings further state that higher Cronbach's alpha coefficient values indicate that the data generated are reliable as they possess a relatively high internal consistency and can be generalized to reflect the opinions of all the respondents in the target or study area. This is shown in Table 1.

Table 1 Cronbach's Alpha Coefficient

Cronbach's Alpha	**Cronbach's Alpha based on standardize items**		**No. of items**
0.931	0.934		50
Item statistics	Mean	Standard deviation	N
VAR00001	3,3000	1.17429	20
VAR00002	3.8000	1.10501	20
VAR00003	3.9000	1.29371	20
VAR00004	4.3000	.97872	20
VAR00005	4.2000	.69585	20
VAR00006	4.3000	.65695	20
VAR00007	4.3000	.80131	20
VAR00008	4.3500	.81273	20

3.3. Inferential analysis

The use of multiple regression and factor analysis, i.e., contributing factors, will be clustered into component groups. The factors will be ranked, and the factor with the highest value is the most significant. The multiple regression measures the relationship existing between three or more variables. It also helps to examine the nature of the relationship between a given dependent variable and two or more independent variables in a regression function. Tables 2 and 3 show the factor analysis of the component group and its multiple regression coefficient. Also Equation 1 presented the multiple regression equation.

$$B = -305R + 0.622C + 0.233E - 081T + 0.053S + 0.005M - 184P + 2.718 \qquad \text{........(1)}$$

Table 2 Component Matrix

Contributing Factors	**Component**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Transit time	0.782											
Respondent	0.672											
Trucking companies	0.655											
Plan for traffic flow	0.642											
Just in time	0.641											
Efficient tracking of companies	0.622											
Procurement management	0.570											
Extra space for the compound	0.552											
Municipal policy priorities	0.542											
Capacity to know physical environment		0.662										

Documentation		0.632										
Communication network configuration		0.652										
Good access for equipment delivery		0.622										
Accurate inter team competition		0.612										
Training		0.602										
Knowledge and skill management		0.532										
Development of standard procedure		0.530										
Information and communication technology			0.736									
Communication and network configuration			0.672									
Client understanding of logistics services			0.662									
Cost transparency			0.652									
Schedule effectiveness												
Cooperation among suppliers			0.536									
Qualitative capacity of suppliers				0.609								
Innovation in cost saving				0.608								
Logistics capacities				0.603								
Public- private partnership				0.508								
Trust				0.507								
Rationale supply base				0.503								
Supplier transportation influence on project delivery				0.501								
Time influence on supplier transportation					0.679							
Quality influence on supplier transportation					0.667							
Cost influence on supplier transportation					0.647							
Inventory and procurement management					0.517							
Time on inventory and procurement management						0.701						
Quality on inventory and procurement management						0.680						
Cost on inventory and procurement management						0.651						
Logistics planning on project delivery						0.640						
Time on logistics planning							0.709					

Quality on logistics planning							0.708					
Cost on logistics planning							0.697					
Information and control management							0.668					
Time on information and control management							0.659					
Quality on information and control management							0.648					
Cost on information and control management							0.639					
Supply chain management influence on project delivery								0.709				
Time on supply chain management								0.708				
Quality on supply chain management									0.689			
Cost on supply chain management											0.608	
Cost influence on supplier transportation												0.648

The method used to carry out this extraction is principal component analysis, and twelve components were extracted. The findings from the results shown above indicate that fifty (50) contributing factors can be grouped into twelve (12) decision matrices (components) for success factors in construction logistics. However, twelve principal components were later extracted for effectiveness. In the first component, nine (9) factors in that order load positively maximally; eight (8) factors load positively maximally in the second component; and five (5) factors load positively maximally in the third component. In the fourth component, seven (7) factors load positively and maximally. While in the (5) fifth, (6) sixth, (7)seventh and (12) twelve components, four (4), four (4), seven (7), and one (1) factor, respectively, load positively maximally. From this result, the components that emerged could be the dominant underlining success factors for construction logistics.

Table 3, with a p-value of 0.006, implying that the coefficient is significant at the 0.05 threshold of significance. This demonstrates that regulatory compliance has a considerable positive influence on contributing factors in construction logistics. Continuous improvement and adaptability were 0.092, which was greater than zero. This coefficient has a p-value of 0.000, which is less than 0.050. This means that the coefficient is significant. Continuous improvement and adaptability have a significant effect on the contributing factors of construction logistics. Execution efficiency has a coefficient of 0.091, which is more than zero, according to the coefficient table. The p-value is 0.012, which is less than 0.05, implying that the coefficient is significant at the 0.05 level of significance. This demonstrates that the contributing factors of construction logistics are significantly influenced by execution efficiency. Table 3 further reveals that technology integration had a coefficient of 0.086 and a p-value of 0.346 (greater than 0.05). This means that the coefficient is not significant at the 0.05 threshold of significance. This demonstrates that technology integration has a considerable negative influence on the contributing factors of construction logistics. Site management had a coefficient of 0.096 and a p-value of 0.580 (greater than 0.05). This means that the coefficient is not significant at the 0.05 threshold of significance. This demonstrates that site management has a considerable negative influence on the contributing factors of construction logistics. Resources management had a coefficient of 0.093 with a p-value of 0.959 (greater than 0.05). This means that the coefficient is not significant at the 0.05 threshold of significance. This demonstrates that resource management has a considerable negative influence on the contributing factors of construction logistics. Strategic planning and coordination had a coefficient of 0.091 and a p-value of 0.05 (equal to 0.05). This means that the coefficient is significant at the 0.05 threshold of significance. This demonstrates that strategic planning and coordination have a considerable positive influence on the contributing factors of construction logistics.

Table 3 Coefficients of Multiple Regression

Coefficients											
Model(CLFs)		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
	(Constant)	2.718	.747		3.638	.000					
1	Regulatory Compliance	-0.305	0.109	-0.247	2.803	0.006	-0.039	-0.270	-0.224	0.822	1.217
2	Continuous Improvement and Adaptability	0.622	0.092	0.575	6.796	0.000	0.513	0.562	0.542	0.889	1.124
3	Execution Efficiency	0.233	0.091	0.212	2.574	0.012	0.210	0.249	0.205	0.937	1.067
4	Technology Integration	-0.081	0.086	-0.080	0.948	0.346	-0.089	-0.094	-0.076	0.894	1.119
5	Site Management	0.053	0.096	0.045	0.555	0.580	-0.004	0.055	0.044	0.950	1.053
6	Resource Management	0.005	0.093	0.004	0.052	0.959	-0.015	0.005	0.004	0.879	1.137
7	Strategic Planning and Coordination	-0.184	0.091	-0.172	2.031	0.045	-0.046	-0.199	-0.162	0.883	1.132

The regression model summary on contributing factors in construction logistics is presented in Table 4. The table displays the values of the coefficients of determination and correlation which are R squared and R respectively, which are 0.36 and 0.60, respectively. The R-squared value denotes that 36.4% of the variance in the contributing factors of construction logistics can be accounted for by the fluctuations in the contributing factors of construction logistics. The coefficient of determination (R squared) indicates a suboptimal fit of the model. The coefficient of determination, adjusted for the number of predictors in the model, is 0.319, indicating a higher value than the unadjusted R square. This suggests that there may be further potential for enhancing the model's adequacy by incorporating an additional factor that affects the outcome variable. The inclusion of an extra independent variable would result in an increase in the R square value to that of the adjusted R square. The coefficient of correlation of 60.3% also implies that the goodness of fit of the prediction of the building project delivery by the logistic factors had a moderate accuracy. This level of accuracy of prediction might not be dependable because of the level of the complexities and uncertainties involved in logistics factors.

Table 4 Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.603[a]	0.364	0.319	1.06051

The analysis of variance (ANOVA) outcomes pertaining to the regression coefficients reveal that the F value is 0.00, indicating statistical significance at a level below 0.05. This suggests that the predictor coefficient is not equivalent to zero, at minimum. This also suggests that the model is well-suited for the task. It has a P-value 0.00 indicating all the factors of construction logistics put together will contribute to successful project delivery. Table .5 below presents the outcomes of an Analysis of Variance (ANOVA) conducted on the contributing factors of construction logistics.

Table 5 Summary of ANOVA

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	64.300	7	9.186	8.167	.000[b]
	Residual	112.468	100	1.125		
	Total	176.769	107			

3.4. Building construction logistics factors and its effect on project delivery.

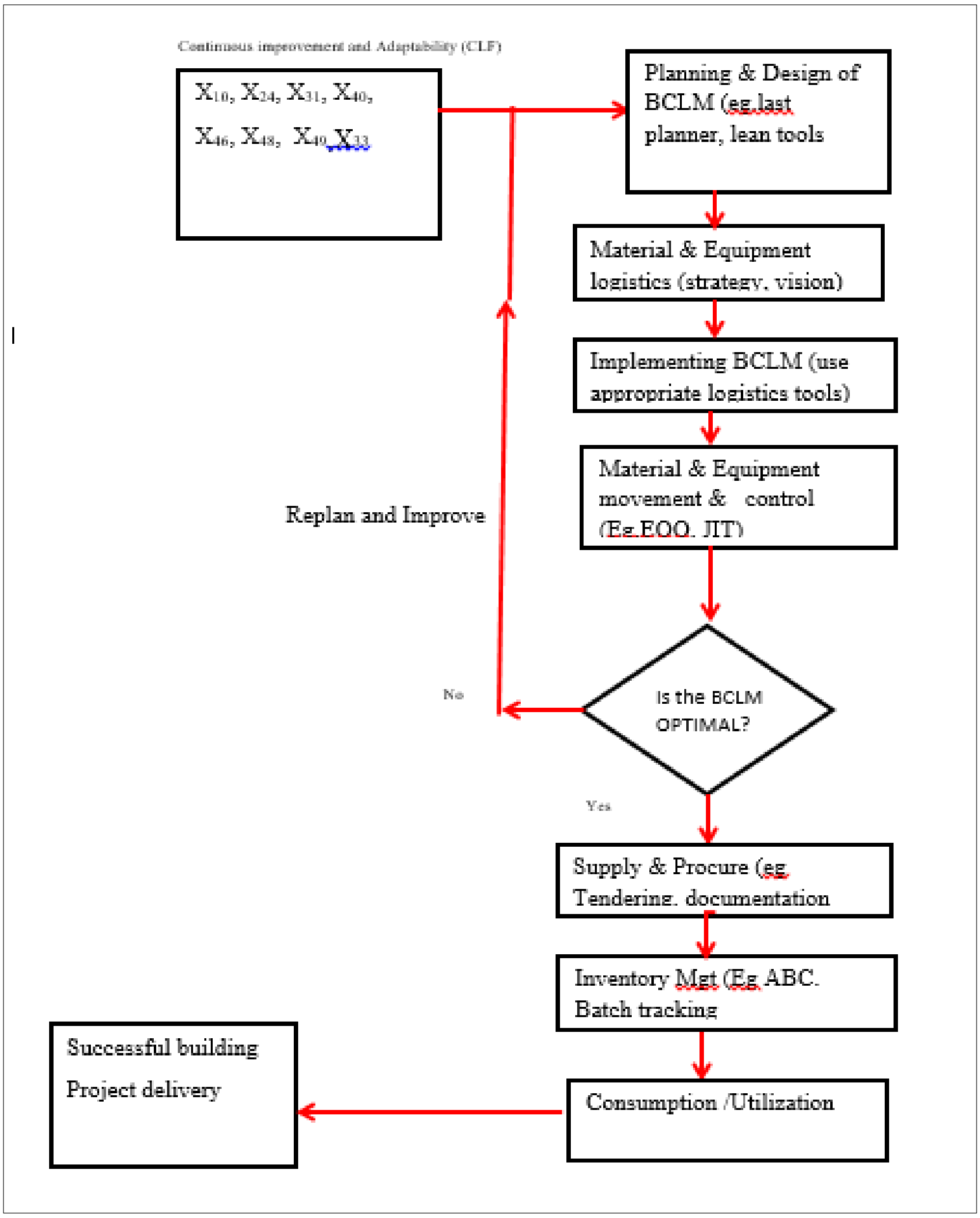

Figure 4 Proposed flow model for successful project delivery of building construction logistics

The findings from the study show the extent of the respondents' involvement in building construction logistics mechanism-related activity. 35 (32.4%) were involved in twice-building construction logistics factors activity; 58 (53.7%) were involved four (4) times; and 15 (13.9%) were involved eight times. This implies that the majority of the respondents are ignorant of the concept of building construction logistics factors. Most of the respondents are not aware that they are deploying some of the critical logistics factors as depicted in the seven (7) features of building construction logistics for successful project delivery identified in the analysis. The findings further indicate that the application of the following critical logistic factors (CLF): regulatory compliance and sustainability, continuous improvement and adaptability, execution efficiency, and strategic planning and coordination would lead to successful project delivery, while others contribute negatively. The study concludes that in deploying the critical logistic factor groups in successful project delivery of building projects, the ranking of the T-value of the critical logistic factors should be followed in order of significant influence and priority, starting from continuous improvement and adaptability (6.796), regulatory compliance and sustainability (2.80), execution efficiency (2.57), and strategic planning and coordination (2.031). The most critical logistics factor was used to formulate the proposed building construction logistic flow system model (BCLM) as shown in figure 4.

4. Conclusion

After the study of the relationship between building construction logistic factors and successful project delivery, the conclusions drawn were that there is general acceptance of the use of building construction logistic factors in achieving successful project delivery in South East Nigeria. 87.1% opined yes to the use of building construction logistic factors, while 12.9% affirmed that they have not used it. Although the prediction of successful project delivery by the building construction logistic factors was not very reliable, with coefficients of correlation and determination of 60.3% and 36.4%, respectively. The basic reason for the deployment of these critical success factor groups lies in the organization's capacity and scope of work involved. Construction firms executing small projects are yet to show a keen interest in the application of critical logistic factor groups in achieving successful project delivery. There is a need for professionals within the construction industry to deepen their knowledge about the adoption of the building construction logistics factors, which will be used across the length and breadth of any construction firm regardless of the size, capacity, and scope of the project. It should be embraced as a key tool in the execution of building projects in Nigeria. There should be greater emphasis on subcontractors/supervisors to incorporate the building construction logistics factors, no matter the volume of work given to them. Adoption of comprehensive logistics strategies that encompass supply chain management, inventory, and transportation are essential features that help to define construction processes, methods and sequences for material utilization. The use of the standard procedure in the formulation of detailed material planning is key in the actualization of building projects. In large projects, the contractor must ensure that they engage subcontractors who are willing to optimize their service delivery. This will go a long way to improving the project performance, value for money, and effectiveness for the client and stakeholders.

Compliance with ethical standards

Acknowledgments

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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