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Predicting Probable Cost Allocation for Building Elements in Nigeria

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Abstract
Practitioners are usually faced with the challenge of providing initial cost solution to the design process at the inception of design process when detail design is not ready. This paper explores the possibility of relating building cost to building function and establishing a cost allocation framework that could serve as guide to practitioners at the inception of the design process. Historical data from 15 educational building, 15 residential building, 15 factory building and 20 office building were obtained and a one-way analysis of variance (ANOVA) test showed that there is a significant relationship between building function and percentage of total cost allocated to each of Roof, Substructure works, Services and Finishes. Analyses further show that such relationship does not exist for blockwork. In the case of concrete work, and painting and decoration, no inference can be drawn. Based on these results a 99% confidence interval was set up for the significant elements for educational, residential, factory and office building using the t–distribution. The study is significant because the established confidence intervals represent the percentage of total cost that could be allocated to the elements/worksections. It should guide cost advisors in arriving at a preliminary cost plan for projects. The reliability of the cost framework could be improved by using a larger data size.

Keyword
Preliminary Estimate, Cost plan, Cost allocation, Building elements, Nigeria.

1. Introduction

Estimating the probable cost allocation to building elements/worksections is one of the challenges associated with preliminary cost estimating and cost planning at the inception of projects when scope definition is limited. This is particularly the case when the design team is required to design a proposed scheme to a target cost. In such situation, achieving a balanced cost framework is usually very difficult. It could be useful if there is a cost guide at the disposal of the design team. Such cost guide could serve as a starting point for the design process and cost planning.

With the knowledge of building function and the target total cost it may be possible to establish a cost allocation framework from mathematical modeling technique simulating a large number of possible solutions obtained from historical data. Such mathematical model based on the principle of Monte Carlo simulation has been applied to building services elements in previous studies. This paper explores, conceptually, the applicability of the principle to selected building elements/worksection.

The significance of the study is that it provides cost advisor and designers with a framework for arriving at a preliminary cost allocation plan to building elements for a given target total cost when detail design is not ready.

2. Theoretical Viewpoint

Early estimates are critical to the initial decision-making process for the construction of capital projects (Trost and Oberlender, 2003). Preliminary cost estimate of project are typically plagued by limited scope definition. In some cases the only information available is knowledge of building function and the target cost. In order to design a proposed scheme to the target cost the design team is faced with the challenge of having to establish an initial cost framework within which the elements/worksections could be designed.

It has been suggested that mathematical modeling technique simulating a large number of possible solutions could provide the best solution (Brown,1987). This according to Brown can be facilitated by the use of Monte Carlo simulation and could provide a useful design tool. Monte Carlo simulation is based upon simple and logically consistent assumption that it is valid to repeat a series of events a very large number of times to determine the frequency distribution as it is to attempt to derive the frequency distribution mathematically based upon a set of assumptions of variable values (Brown,1987).

From a study of historical cost data of completed projects, a frequency distribution of cost allocation for individual elements of buildings could be constructed. The result could yield a probable cost allocation to the elements. Brown used this approach to establish a probable cost allocation framework for building services element. The resulting cost allocation model allows an initial freedom in selecting a likely design cost framework. The cost allocation selection framework could assist designers at the preliminary estimating stage of project development. Brown found that there is a significant relationship between building function (designated by types) and the ratio of "cost of building services" to "total cost of the scheme". He presented a confidence interval estimate of the mean proportion (expressed as a percentage) for cost of building services to total cost of scheme for eight building types. Based on these, it is hypothesized in this paper that the method could be applied to other building elements. Although, there are many factors influencing cost of project such as location, type of project, contract duration, and contract size (Hegazy and Ayed, 1998) but this study is focused on the influence of building type/function. This is important in certain instances where building function is the only information available within which the designers would be required to provide initial cost solution. Therefore, being able to relate building cost to building function would be useful to the design team.

3. Methodology and Data Analysis

3.1 Data collection

In order to explore the possibility of establishing a predictor cost allocation framework for building projects, historical data in respect of completed building projects were obtained from construction industry practitioners in the Nigeria construction industry. They information was extracted from bill of quantities and final account statement and was recorded on data collection pro forma specially designed for the purpose. The information obtained includes the following: the type of project, the elemental and or work sectional cost breakdown for each project, and year of execution.

At the end of the data collection exercise information on sixty-five (65) completed building projects were obtained. They consists of 15 educational building, 15 Residential Building, 15 factory Building and 20 office Building.

3.2 Data analysis

It has been suggested that building types poses characteristics peculiar to their group. Prior to establishing the cost framework using the data collected, it is necessary to first establish that there is relationship between building form/types and proportion of 'cost of each element' to 'total cost of project'. In order perform this analyses certain inconsistencies in the data were addressed.

Firstly, an examination of the cost breakdown of the 65 completed project revealed that the cost breakdown for some of the projects are in worksection format while others are in elemental format and others are a combination of the two. This shows a lack of uniformity in billing format amongst practitioners. The first obstacle is to ensure uniformity across the 65 projects. To achieve this, the following elements and worksections were found to be common to all the projects and were therefore selected for the analysis: Substructure, concrete work, Blockwork, Roof, Fittings and Fixture, Finishing, and Painting and decorating.

Secondly, the projects were completed at different time period. To ensure a homogeneous cost comparison and have a common basis required for statistical analysis the effects of inflation need to be neutralized. Based on this, the costs of each element/worksection for each project were converted into ratio of total cost of the project (expressed as a percentage). The expression is of the form:

$$\%\text{ cost ratio of element/worksection} = \frac{\text{Cost of Element/ worksection}}{\text{Total cost of project}} \times 100$$

For the first stage of the analysis, fifteen projects each were selected for each of Educational, Residential, Factory and Office buildings. This implies that 5 projects belonging to office building group were not used. The first stage of the analysis is to examine whether there is relationship between cost allocated to each of the elements/worksections and building function/type. That is:

$$\%\text{ Cost ratio of element/worksection} = f\,(building\ Type)$$

The One-way analysis of variance (ANOVA) method was employed for the analysis. The following hypotheses were tested for each of the elements/worksection.

The null hypothesis,

H_o: The data comes from a single population, i.e. there is no difference in the mean of the percentage cost ratio examined between different building types.

The alternative hypothesis,

H_1: The data comes from different populations, i.e. that the mean of the percentage cost ratio examined varies from one building type to another.

The F statistics obtained for each of the building elements/worksections and the decision made based on the critical values of F at both 99% and 95% levels of significance are presented in Table 1.

4. Results

The results reveal the following:

a) in the case of substructure , roof , services , and finishing , the null hypothesis is rejected and the alternative hypothesis accepted, and it implies that there is a significant relationship between building function/type and the proportion of total cost allocated to these elements.
b) For blockwork, the null hypothesis is accepted and it implies that the cost allocation to this element is independent of building type/function.
c) For concrete work and, painting and decorating no inference can be drawn because the value of Statistic is less than 1.

Table 1 Summary of result of Analysis of Variance (ANOVA) Test

Element/Worksection	Confidence Level	Calculated Fvalue	Critical Fvalue	Action
Substructure	99%	18.44	4.17	Reject Ho
Concretework	95%	0.54	2.78	No inference
Blockwork	95%	2.13	2.78	Accept Ho
Roof	99%	10.56	4.17	Reject Ho
Services	99%	5.5	4.17	Reject Ho
Finishes	95%	3.88	2.78	Reject Ho
Painting and Decorating	95%	0.8	2.78	No inference

4.1 Establishing confidence intervals for significant elements/worksections

The result of the first stage of the data analysis show that the percentage of total cost allocated to substructure, roof, services and finishes are significantly related to the building function. Based on this, a 99%confidence interval was set up for these elements using the t-distribution. To achieve this, the mean percentage cost ratio allocated for the elements were estimated. In this case 15 factory projects, 15 residential projects, 15 educational projects and 20 office projects were used. The t-distribution estimates the interval limits for the mean obtained for each sample. In estimating the population mean, a probable error of 1% was assumed which suggests that 99% confidence is exercised in accepting the sampling distribution as the true representation of the population.
The deviation cost range is given by:

$$X \pm \frac{t\sigma}{\sqrt{n}}$$

Where X = population mean
σ = standard deviation
n = sample size/ number of cases
t = area under the normal curve to the right hand critical values with n-1 degrees of freedom and $\frac{Q}{2}$, where Q is the confidence level.

The deviation cost range estimated for each of the elements/ work section across the 4 building types are presented in Table 2.

Table 2 99% confidence intervals for the Mean Values of 'cost of elements/worksection' to 'cost building'

Building type		Substructure	Roof	Services	Finishes
Education Building	Mean	8.76	16.78	9.47	16.88
	Confidence interval for pop. Mean(%)	3.94≤mean≤13.58	11.62≤mean≤21.94	5.15≤mean≤13.79	12.83≤mean≤20.93
Factory Building	Mean	27.68	14.4	9.29	10.25
	Confidence interval for pop. Mean(%)	16.78≤mean≤38..58	9.57≤mean≤19.26	0.19≤mean≤18.39	4.52≤mean≤15.98
Office Building	Mean	11.06	6.01	23.5	11.65
	Confidence interval for pop. Mean(%)	7.42≤mean≤14.7	2.59≤mean≤9.43	15.79≤mean≤31.21	7.67≤mean≤15.63
Residential Building	Mean	12.2	7.37	17.57	17.26
	Confidence interval for pop. Mean(%)	7.81≤mean≤16.59	1.69≤mean≤13.05	11.23≤mean≤23.91	9.71≤mean≤24.8

5. Conclusion

This study shows that there is relationship between percentage of total cost allocated to substructure, roof, services, and finishing. The confidence interval established for these elements for the selected building types serve as guide to cost advisors at the inception of project when no information about the scope of work is available save the building function and the target total cost. The reliability of the cost framework developed could be improved by using a larger sample size for the selected project types.

6. References

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