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A PROBABILISTIC ESTIMATE OF INCREASE IN CONSTRUCTION COST

*T.H.O Salami and T.O. Alao
*Department of Quantity Surveying Kwara State Polytechnic, Ilorin
Department of Building Technology Kwara State Polytechnic, Ilorin

Abstract

This paper examined the trends in housing construction cost between the year 2000-2005 for Ilorin environs. The method used an all inclusive elements in the computation of rates to obtain unit rates for a diversed range of bill items. The distribution of increase in construction cost for a particular year related to a base year was treated as a continuous randomized probability distribution for which density functions were obtained. This method enables the testing of the validity of the computed Central Bank of Nigeria (CBN) inflation indices over the same period 2000-2005 for a wide range of rate items. The study showed that construction cost remains on the increase. Also, the paper has shown that the inflation index published by the Central Bank of Nigeria's real sector statistics popularly used for updating construction cost estimates is not appropriate. It is suggested that construction cost indices would be most appropriate for updating construction cost estimates, for cost planning and for budgeting purposes. The construction cost indices for the same period 2000-2005 is also computed. It was obtained from the computed relative frequency distribution of all possible increases in cost for a particular year related to a base year.

Keywords

Probabilistic estimate, construction cost, inflation index, cost indices

1. Introduction

Construction Industry is an important sub sector of the national economy and as such any change in the economy affects the industry. Government's measures to control the economy will affect the industry either directly by the control of the output through reduction in public expenditure or indirectly by restriction on borrowing to finance projects. For example a measure to control the economy could result in the volume of work available thereby resulting in massive job cut in the industry. Also, a reduction in the

consumption of Building materials will affect the business of manufacturers and distributors of these construction materials. A decision to increase wage also has an attendant effect on increase in construction cost indirectly from manufacturing and directly on the production of the finished product.

In the past two decades, housing construction cost has shown a continuous upward trend in Nigeria such that almost all projects were completed at sums higher than their initial contract sum (Nwuba, 2004). Determination of construction cost trend over the period 1986–2000 and 1989-1999 was carried out previously by Nwuba (2004) and Oladele (2000) respectively using the total cost for a 4–bedroom bungalow for empirical demonstration. In these studies, the total costs (materials and labour) were computed. Similarly, a computation of the cost per m^2 for a small residential building was carried out between 1992-2001 by Nuhu, (2001) to reveal the increase in construction cost for the period. In the study, the increase in construction cost was compared with increase in the money market (exchange rate). In all the above studies, construction costs have showed an upward trend. These increase in cost however, were computed based on the information from the published Central Bank of Nigeria inflation index for the same period. The resulting estimates of increases in cost in these studies were presented as percentage increases of the total cost of the project. This method however, does not give an account of trends in increases in cost of individual elements and/or work category. This method could therefore not identify solutions in the form of alternative methods or material substitution.

This paper however, tries to examine the trends in housing construction cost with a view to identifying the pattern of these increases in cost for all individual elements of work and/ or work categories.

2.1 The Concept of Cost Indices

Cost information is essentially historical in nature, being collected over a period of years. These indices change with the passage of time. For this reason, a construction cost index, to be of any use must be brought up to date and possibly projected into the future. Bathurst and Butter (1980) has presented the following methods of producing index numbers, which measure price changes from one period to another.

i) **The Price Relative Index**
This measures the price of a component in one year related to the price of a similar component in another year and related as:

$$\frac{P_1}{P_0} \times 100 \qquad (1)$$

where P_1 = price in the given year and P_0 = price in the base year.

A simple index of this type is not suitable for measuring the cost of building/civil engineering works whose elements is made up of materials, labour, plants/equipments. The computation of the increases in cost carried out in this study was based on the modification of the Price Relative Index formula to take into account materials, labour, and plants/equipments

ii) Weighted Average of Price Relative Index

This is expressed as:

$$\frac{\sum \frac{P_1}{P_0} \times 100 \times \omega}{\sum \omega} \qquad (2)$$

where P_1 = current year price, ω = weighting and P_2 – base year price.

In this case, different weights are given to the price of each component. It measures price movements, which makes its application limited to building/civil construction costs where it is necessary to measure both prices and quantities.

iii) The Laspeyre Price Index

This method relates the current price to price and output at base year. It is expressed as:

$$\frac{\sum P_1 q_0}{\sum P_0 q_0} \times 100 \qquad (3)$$

where P_1 = current year price, q_0 = base year quantity and P_0 = base year price

iii) The Paasche Price Index

This method relates the current price and quantity to the cost of current quantity at base year price and is expressed as:

$$\frac{\sum P_1 q_1}{\sum P_0 q_1} \times 100 \tag{4}$$

where P_1 = current year price, q_1 = current year quantity and P_0 = base year price

A more consecutive estimate is the geometric average of the last two indices (Bathurst and Butter,1980).

2.2 Formula for Adjusting Increase in Construction Costs

One of the methods of computing cost indices on monthly basis is that published by Her Majesty's Stationary Office (HMSO) under the National Economic Development Office (NEDO). In this method, labour indices are prepared by the Department of the Environment (DOE) while the material indices are prepared by the Industries and these are computed and published by HMSO. To simplify the application of adjustments to prices, all construction contracts are divided into work categories e.g, excavation, concrete, reinforcements etc. and the indices listed against them. This adjustment is computed as:

$$C = \frac{V(I_i - I_0)}{I_0} \tag{5}$$

where C = amount of price of adjustment, I_i = the index for the work category, V = value of work done and I_c = index for the base month

3. Basis of Construction Cost Increase

3.1 The Construction Company Cost System

The estimate of construction cost usually consists of the cost of materials, labour and plants/equipments. The cost system usually reflects the total business of the firm as evident in the rates charged on items in the Bill of Quantities. These rates could integrate the methods, construction planning and scheduling, equipments and managerial needs etc. Cost systems also differs even where similar works are to be carried out for building construction works, earthworks or highway construction works etc. The cost

in itself is also probabilistic over the construction period which could span for more than one or more years. Usually the estimate or the budget is compared with actual cost during the construction period to highlight problem areas to be addressed in future estimates. It could therefore be said that a cost system is essentially historic in nature and is a function of estimating procedure used. It is important that every historic data should contain a breakdown of labour, materials and equipments utilized. It should also contain work conditions, methodology and major problems encountered in order to make it reliable.

3.2 Increase in Cost During Construction Period

For most contracts, there usually occur increases in cost incurred by the contracting firm during the period of construction and these are usually reimbursed. Provisions are usually made for example, under the Joint Contract Tribunal contract conditions for reimbursements due to changes in cost of labour, material and statutory costs. However, all labour and materials subject to fluctuations are listed including their current basic prices as at the time of tenders. Within the contract period, construction cost can differ, this is as a result of the probabilistic nature of construction cost.

3.3 Cost Control During Construction Period

While fluctuations generally adjusts estimates due to price increase or decrease during construction, cost control is aimed at reducing the effect of uncertainties as they have influence on the overall construction costs. Frequently, time constraints could require the use of faster methods in which the precision of estimate is sacrificed for speed which would ultimately have overall effect on cost. Cost control aims at reducing such effects. These cost control techniques could be exercised in construction methodology, equipment selection/utilization, optimizing construction plans etc. The effect of delays and labour productivity are better handled under cost control.

3. Methodology

The data used here were obtained from the estimation of percentage increases in cost of an item for a current year related to a base year. The rates used included the cost of material, labour, and plant/ equipment. All items were priced at all-in rates. The distribution of the increase is treated as every possible price increase in the sample space for a current year related to a base year. Although the method is most common in manufacturing, it is well applicable to physical situations such as every possible height above 1.5m in a class.

Usually in an experiment involving a continuous random variable, the density function $f(x)$ is unknown and the form is also unknown. Statistical data generated are therefore presented in the form of a relative frequency distribution (Walpole and Myers, 1980). Such an arrangement is obtained by grouping the data into classes and determining the proportion of measurements in each of the classes. The estimated probability that the increase in construction cost lies between a range when selected from the sample space can be obtained from probability curves estimated for each of the years 2001-2005. The validity of the Central Bank of Nigeria inflation indices over the period was tested based on this method. The essence of the test is that, even where there occurs no increase in cost for a particular item, yet the CBN index has generalized that there is an increase in cost. However, the distribution pattern of these increases in cost is skewed about the mean for the range of years considered in this study.

The curve of any density function is constructed so that the area under a curve bounded by two ordinates $x = x_1$ and $x = x_2$ equals the probability that the random variable x assumes a value between $x = x_1$ and $x = x_2$. This can be written as:

$$P_r(x_1 < X < x_2) = \frac{1}{\sqrt{2\pi\sigma}} \int_{x_1}^{x_2} e^{-\frac{1}{2}\left[\frac{x-u}{\sigma}\right]^2} dx \qquad (6)$$

Transformation of all observations of any random variable X to a new set of observation of a normal variable Z with mean $u=0$ and variance $\sigma^2 = 1$ converts it to standard normal distribution i.e.

$$\Pr(x_1 < X < x_2) = \frac{1}{\sqrt{2\pi}} \int_{z_1}^{z_2} e^{\left[\frac{-z^2}{2}\right]} dz = \Pr(z_1 < Z < z_2) \qquad (7)$$

where $z = \left(\frac{x-u}{\sigma}\right)$, u = mean, x = ordinate (x_1, x_2) and σ = variance

This transformation reduces the required number of tables of normal curve areas to one, namely that of the standard normal distribution (Walpole and

Myers, 1980). In using this method, firstly the percentage increase in cost was calculated. Every succeeding year uses the preceding year as a base year. Secondly, the mean increase in cost was estimated and subsequently the standard deviation was calculated. Thirdly, suitable interval for obtaining relative frequency distribution was selected. Fourthly, equation *vii* and the table of probability distributions was used to estimate the probability of occurrence of any cost increases

4. Results and Discussion

The computed rates for all the work items considered has shown an inproportionate increase in cost in the interval of years 2000-2005 considered. A comparison of the rising cost trend when compared with the published inflation index by the Central Bank of Nigeria's real sector statistics (usually published every three years) is shown in Table 1.

Table 1. Comparison of CBN inflation index with measured construction rate increases.

(a)	(b)	(c)	(d)	(e)
Year	CBN Inflation index	$\Pr(0 < x < b)$	Mean increase in cost (%)	Percentage of rate items subject to increase in cost.
2000	6.9	-	-	-
2001	18.9	1	12.07	12
2002	12.9	0.1684	8.02	50
2003	11.5*	0.1218	18.60	87
2004	16.0*	0.1050	35.55	54
2005	14.2*	0.4087	17.59	61

** assumed based on the projected 10% inflation growth*

Column 'a' shows the respective year. 'b' records the CBN inflation index for the year. 'c' computes the probability of occurrence. 'd' computes the mean percentage increase in cost and 'e' computes the percentage of rate items subjected to increase in cost

NOTE: The Central Bank Inflation index is published every three years

This table has shown that the inflation index do not adequately describe the inflationary trend in the construction industry. This computed inflation index is a performance index on the general economy.

Column 'a' shows the respective year. Column 'b' records the CBN inflation index for the year. Column 'c' computes the probability of occurrence of increase in rate items for the CBN computed inflation index. Column 'd' computes the mean percentage increase in cost for the year and Column 'e' computes the percentage of rate items subjected to increase in cost within the sample space considered. The inflation index computed by the CBN and shown in column 'b' enables a cost planning of new developments and updating costs to be reasonably made. However, it is not appropriate for the Construction Industry. For instance, there may be zero increase, marginal increase or even a substantial increase in cost as evident in Table 2 but the CBN index has generalized an increase in cost which is inappropriate. Cost indices appropriate for the Construction Industry which would reflect increase in different work items is desired. It is for the following reasons.

i) to assist designers in materials specifications in order to produce economic designs.
ii) to allow policy formulations on alternative materials and possible import substitution.
iii) to challenge the construction professionals and professional institutions to provide updated data effecting trends in construction costs with a view to addressing them accordingly.
iv) to match the quality and productivity with the increase in construction costs within the industry.

The reliability of cost indices however relies largely on the choice of class interval. Usually, the larger the number of data, the larger the number of class interval thus the higher the reliability. Table 2 presents the grouping of work items and entering the corresponding cost indices. However, in attempting this grouping, subdivisions of work items are not carried out. The year 2000 is used as the base year and each preceding year represents the base year for the succeeding year.

Table 2: Construction cost indices for year 2000-2005

WORK CATEGORY		2000	2001	2002	2003	2004	2005
1.0	Excavation	100	100	125	100	120	100
2.0	Concrete works	100	111	104	135	152	122
3.0	Reinforcements	100	100	104	100	200	124
4.0	Alumn doors & windows	100	100	104	107	100	108
5.0	Wooden doors						
	Flush doors	100	100	104	100	129	140
	Hardwood doors						
	Mansonia	100	100	100	155	100	140
	Mahogany	100	100	100	140	100	180
	Iroko	100	100	100	193	100	200
6.0	Finishes						
	Paints (Gloss & Emulsion)	100	100	100	104	109	112
	Texcotes	100	100	100	104	106	115
	Screeding/Rendering	100	100	111	123	130	102
	Terrazzo/Granolithic	100	100	110	122	132	122
7.0	Blockworks						
	Clay bricks	100	104	100	102	103	103
	Sandcrete block	100	115	104	107	137	115
8.0	Roofing						
	Asbestos	100	100	104	112	190	100
	Gal. Iron	100	100	106	107	150	100
	Aluminium long span	100	100	101	111	116	100
9.0	Steelworks	100	100	101	140	133	118

note (1) base year is march 2000.
(2)each preceeding year is a base year to the succeding year.

Using concrete works for example with a base year 2000, there is 11% increase in cost of concrete works in year 2001. Similarly, using year 2001 as a base year, there is 4% increase in the cost of concrete works in the year 2002 etc. These percentage increases were obtained from the relative frequency class interval chosen.

5. Conclusion

The analysis has shown that construction cost is on the increase and that the increase in rates is in-proportionate for all items of work. For this reason, the development of construction cost indices is desired for the construction industry to reflect cost patterns of individual work items. This would obviously enable cost planning and other controls at monitoring increase in construction cost to the made.

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