ECONOMETRIC ENTROPY- NEURAL NETWORK-BASED MODEL FOR PROJECT COST ADJUDICATION SYSTEM IN RESIDENTIAL BUILDING PROJECT PROCUREMENT

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Abstract

The main aim of this research work is to develop a Neural network –Econometric –Entropy-Based Project Adjudication Model for Residential Building Project Procurement. An econometric model which incorporates exigency escalator and inflation buffer was generated in this study, this is accompanied with risk entropy matrix that could aid determination of the extent of risk implication on the project elements at tendering and construction stages of building projects. The model incorporates residential building elemental dichotomies within the context of early and late constructible elements with speculated prediction period, taken into consideration the present value of cost. This attributes would enable a builder or contactor load cost implication of an unseen circumstance even on occasion of deferred cost reimbursement.

Keywords: Neural network, Econometric, Model, Escalator, Risk, Dichotomy, Adjudication, Entropy.

1.1 Introduction

On a typical construction project, monitoring the projects' progress cannot be overemphasized improper monitoring of project cost could lead to project abandonment. A number of uncompleted and abandoned projects however are attributable to overall bad projects management of which poor forecasting approach is a factor. Poor cost forecasting approach will lead to underestimation and inadequate fund which often culminates in project abandonment. Project abandonment because of cost overrun arising from poor cost forecasting approach, is an interesting phenomenon locally as well as globally.

The awareness of this phenomenon has resulted in various stakeholders in built environment being aware of the importance of accurate project cost right from conceptual stage of building project to the entire life cycle of the project work. The awareness of working with accurate cost has thus created a trend among various clients including private, corporate, as well as public clients (government), that prudency in resources allocation is a great necessity for successful execution of project works (Mosaku and Kuroshi 2008; Hegazy et al, 1993, Murtaza and Fisher, 1994; Moselhi et al, 1994; Jain et al, 2002; Williams, 1994). On a typical construction project monitoring the project progress cannot be overemphasized. Irrespective of the procurement route deployed, scheduling resources for effective execution of the items contained in the project need to be taken into consideration during the pretender process. Therefore it is insufficient for builder to take into consideration the tender or bid figure but as well the system of fund release for the project when it commences.

There are different procurement systems that could be deployed in project execution, it includes: traditional approach which allows for client determination of issue and policy direction; direct labor, labor-only contracts among others. Considering any procurement type, work done need to be valued before payment certification could be handed to the builder in charge of the projects. Ideally, stage payments are not often made before the completion of work stage, rather, it takes weeks to months before work could be valued and payment recommend by the quantity surveyor, meanwhile, during the delay, builders fund is tied into the project and results in additional cost for the builder and negative project cash flow (Christodolou 2008). However, builders and contractors had developed different methods of buffering negative impacts of delayed payment on project cost such as project elements' cost harmotization, cost smoothing, un-balanced and balanced bidding system, among others. However the activeness of project elements cost often progress at a rate that the funding from client would not be able to match leaving the builder to progress with the project at the expense of his profit. It is on this account that this work present neural network-econometric entropy-based project bid adjudication system in residential building project procurement. The model will enable upward loading of elemental cost to buffer the negative effect of delayed payment on project using expert system-entropy-based technique.

1.2 Concept of Project Cost Adjudication (Unbalanced-Bidding)

Since the beginning of the century, paradigm has shifted as a matter of necessity in the direction of using classical approach to curtail the negative effect of payment delay on project,one of such approaches is bid-unbalancing method. Bid unbalancing according to Cattel, Bowen and Kaka (2007) and Christodolou (2008) can be described as the process by which intelligent approach is used in evenly distribution of overral project actual cost and profits among project activities without jeopardizing the total bid price for the work.

1.3 Schools of Thought in Project Bid-Balancing

There are different schools of thought in the study of unbalanced-bidding, Stark (1972); Cattel, Bowen and Kaka (2008) described available schools of thought as Back-end loading, Front-end loading and Individual rate loading systems.

1.3.1 Front-End Loading Approach

Front-end loading school of thought believes in marking-up of items scheduled to come up early at beginning of the project as high as possible in order to provide avenue for builders to generate as much profit as could help in further project financing. The method is described by the following mathematical model. $\text{pvj} = \sum_{n=0}^{N} \left(\frac{1}{1-r}\right)^{n} \lfloor \lambda_{nj} Q_j (P_j - C_j) \rfloor]$(Cattel et al., 2008).

1.3.2 Back-End Loading Approach

Back-end loading system involves marking up of prices of project items that is billed to be executed later on the project (Cattel et al., 2008). It was described as method over overcompensating a project builder or contractor for inflationary increases consequent upon inflationary buffer already built into the project cost package as contained in the projects' terms of agreement. This is illustrated by: $\text{pvj} = \sum_{n=0}^{N} \left(\frac{1}{1-r}\right)^{n} \lfloor \lambda_{nj} Q_j (P_j - C_j) \rfloor]$(Cattel et al., 2008)

1.3.3 Individual Rate Loading Approach

This school of thoughts supports the practice of margin high, the project components that has tendency to increase later as the project progresses while marking low the components that could be executed early on the project. This is described by the model below:

$\text{pvj} = \sum_{n=0}^{N} \left(\frac{1}{1-r}\right)^{n} \lfloor \lambda_{nj} Q_j (P_j - C_j) \rfloor]$(Cattel et al., 2008)

Legend:Pv—present value; j ---item number; N– duration of project; n --- number of months; rj – monthly discount rate; Qj – Bill of quantity of an item; Pj – bill price per unit of item j, Cj – unit price per unit of item.

1.4 Leveraging Influence of Elemental Cost on Project Cost Entropy

Entropy in the real sense of it is a measurable concept; this is regarded as a function of inverse of probability of variable in consideration. This is linked to influence of cost centers on final cumulative as-built cost of a project. Quantitative analysis of cost influence on total as-built cost of selected residential accommodation was carried out and presented in Table 1.1 with a view to determining entropy state of the project cost centers.

In this section, influence of cost center on project cost was quantified, this was carried out through quantitative analysis of cost component of sampled projects bill of quantities of some selected residential building projects, that were used in model development. The elemental cost component was used for this purpose and is presented in the Table 1.1. Influence of the elements' cost on total project cost was factored on rating scale one (1) to ten (10) using percentage cost composition as base reference point. Cost of substructure for 4-Bedroom Duplex, 2/3 -Bedroom bungalow, Frame and walls were rated high on scale 10^{+} high relative to base cost, for all building types. Finishing is ranked high on scale 10^{+} 4-Bedroom Duplex, 1-Bedroom apartment, 3/4 –Bedroom on 3 Floors-24 Units and 2/3-Bedroom Bungalow, this indicates that the influence of this is high on the project final cost. The implication of this is that a great deal of resource is at stake on this particular element, careful management of this cost center can determine to a very large extent the overall success of the project work. Value added Tax, Contingencies, Preliminaries, Soil drainage; Fittings were rated low on scale 4 down to 1.

However, this does not mean they are the least in term of importance, they as well has contributory effect on the total project cost. Ideally, one would have been tempted to select those cost centers with high rating and high risk index as the core parameters and prorate the remaining elements; danger in this option lies in imbalance cost composition that could arise as the consequence. Therefore in bid adjudication cost of elemental components with high influence factor should be considered first and ensure adequacy since they attracts higher risk. Contingency can be built around them to cushion effect of eventuality.

1.5 Entropy Level and Risk Threshold Perspective on Project Cost

In every econometric model risk impact measurement is a great necessity that should be addressed. A planner should consider both financial assignment that will minimize project risk and maximize cost and activity also financial assignment that will maximize profit and prevent project disarray. Therefore at tender stage, elemental components with high risk factor should be considered first since they attract higher risk. Analysis of risk distribution on three different types of projects is presented in Table 1.2.

1.6 Methodology

Random sampling was used in project sampling for the purpose of analysis. Analysis was carried out on thirty-six residential building projects in the following order; 2/3 –Bedroom unit (12 samples), 4-Bedroom Duplex (12 samples) and 2&3-Bedroom bungalow (12 samples). Content analysis technique was used to extract component cost and validate inter-cost center relationship. Also the following were carried out: factoring of cost center influence on total project cost, determination of monetary-entropy, risk impact matrix formulation based on entropy level, project monetary dynamics, comparative analysis of different bid-loading system also synthesization of neural network-econometric parameters-based tender adjudication system using back-end loading as base reference was achieved using the selected projects. Suitability position of the developed neural network-econometric model was validated relative to front-end loading and individual rate loading with the aid of Monte-carlo comparison technique, contingency coefficient and Kendal Tau values were used as comparison model Also, probability technique was used to generate entropy state of the project element using probability method.

1.7 Risk-Entropy Level Determinations in Selected Project

In determining price movement pattern(entropy state) in a project collection, the tri-partite variables must be considered keenly. A Tri-partite variable refers to money, risk, and time. This constitutes some of the variables whose entropy state can be quantified. Risk entropy therefore should be quantified so as to know the risk activeness of the project cost centers. Cost centers of selected building projects were analyzed for risk implication. Risk is categorized into low medium and high scale as contained in Table 1.2. The risk component is presented on scale 0-20. Risk range 9-20 is regarded as Extreme, 3-5 as Medium, 6-8 as high. The centers that belong to the extreme class include: 4-Bedroom Duplex, 2&3-Bedroom Bungalow, 1-Bedroom Apartment, 3 /4-Bedroom, 24 Units on 4 Floors. The risk breakdown of cost center with Extreme risk range include: 14 (1.4Substructure), 15 (1.5 Finishing), 19 (1.9Frame), 7 (0.7Services), 9 (0.9Upper Floor), 7 (0.7 Roof), 20 (2.0) Finishing) and 20^{+} (2.0) Frame. Also, low risk component on scale 0-2 is presented in Table 1.2, this includes 2(0.2 Stair) 2 (0.2 Soil-drain), 2 (0.2 Fittings), 2 (0.2Soil -drain) and 2(0.2 Contingency).

Having identified the range of risks, the next step is to quantify the probability of the risk occurrence and the likely effect or consequence on the project and the amount at stake. Risk impact quantification in cost prediction as presented in Table 1.2 is primarily concerned with determining what areas of risk warrant response and where resources are limited, a risk priority will identify the areas of risk that should be addressed first. The risk matrix developed for each project types with degree of risk liability of cost centers is presented in Table 1.2.

1.8 Risk Entropy Level Determinations in Selected Project

Considering the influence factors of cost component on final cost of building works and attendant risk implication on project as discussed earlier, the cumulative effect of this is exerting pressure on projects monetary distribution. In recent times this phenomenon is encapsulated in concept of monetary entropy. Monetary entropy has been defined as a function of financial assignments often derived from multiple inverse of variables probability (Cristodolou 2008). Pattern of monetary entropy distribution on twenty (20) residential projects is presented in Tables 1.3 to 1.7. Sample projects includes: 2-Bedroom bungalow, 2/3-Bedroom bungalow and 4-Bedroom Duplex. The highest percentage variation between as-built cost and Tender Cost from table occurred on project 11th with 154% increase, with lowest percentage being 35%. This occurrence leaves the cost variation in the threshold of N3,861,000 down to N1,111,397 in upper and lower boundary respectively. This therefore makes it imperative to determine the level of the cost activeness to be able to appreciate the extent of the variation. Therefore dynamic nature of the elements' cost needs to be ascertained.

Monetary entropy dynamic is a function of cost variation. Entropy change for the selected projects is based on cost variation in the project distribution; this is an index of attrition level in project cost distribution. It is believed that the higher the cost variation that occurred the higher is the tendency to obtain certain level of entropy disparity. In the selected twenty projects relative entropy level 0.011 was obtained with cost variation of N3,115,000 arising from N3,510,000 tender sum to N6,265,000 completion cost (As-built cost). Also, relative entropy of 0.016 was also obtained from project with initial tender sum of N2,145,000 leaving variation margin in the range of N2,180,000. The implication of this is that the entropy level when considered on scale 1 to 10 is relatively low, thus there should be more reflection on this disparity, caution need to be taking to guide against overgeneralization of outcome. In order to avoid this, critical determination of level of entropy on the component elements need to be carried out to determine actual contribution of each elemental component to the entropy value derived. Cost disparity among the project and the entropy level follows law of inverse proportion, considering the cost distribution pattern obtained in Tables 1.13-1.15. The higher the cost variation the higher the variation probability and consequently the lower the state of entropy generated. The entropy in this parlance refers to the nature of price movement within the hierarchy of cost pockets among the projects. The price movement however could be attributed to the incessant price movement occasioned by fluctuating economic situation at the time of project execution. The projects were executed during the economic meltdown period; this is adjudged as one of the factors that could lead to the price movement and disparity in cost-entropy obtained. The dynamic nature of price movement in a project being executed often dictates the pace of entropy magnitude. It is believed the greater the price movement and the higher the entropy that will be generated. Twenty projects were selected for illustration the cost movement pattern as discussed; Tables 1.14 to 1.18 illustrates the cost distribution with corresponding monetary entropy schedule and their implications on projects.

1.9 Monetary Entropy

Monetary distribution on project is presented in Table 1.6, the variation depend largely on the cost variation for the twenty selected projects. Lowest monetary entropy with -5.120 is obtained on a project with cost variation of N4,289,916 and tender sum of N16,360,084 with As-built cost background of N20,650,000, highest monetary entropy is obtained on project cost variation of N6,632,131 with relative entropy -2.272. Careful observation revealed disparity between the tender cost and As-built cost. Most of the sampled projects were completed at a cost higher than tender cost. Implication of the derived entropy lies in its usefulness in cost adjudication at tender and bidding stage of project work.

1.10 Elemental Monetary Entropy

Elements tender costs were adjusted with econometric parameters (inflation, price location index, exigency factor) and were loaded onto a back-elimination neural network system with Levenberg Marqua, set at 1000 epoch and delta rule. The resultant cost generated is presented in Table 1.8. Neural network is an expert system that masters trends in the array of data and used the trend to generalize an order of sequence for subsequent group of data. The network configuration will learn the network first before adapting to the sequence. The outcome of network iteration is presented in Table 1.8. However, average sum of the neural network generated output was factored differentially into the elemental components of each project category and used as sample for the econometric based model. The loading result of the elements cost loaded onto the three types of bid-balancing loading system revealed that the econometric-modified system yield the best output in term sequential difference. There tends to be a close margin between the Econometric-Neural-based generated model cost output and tender sum used for the award of the projects. The implication of this discovery is that the model presents the Net Present Value (NPV) of the elements in an upward manner (futuristic) in terms of period 'n' in consideration. The model is used in achieving this feat. Therefore in determining the worth of an element at a period 'n', the project could be factored using desired econometric parameters as demonstrated in this study.

1.11 Econometric Factor Adjusted Bid-Balancing Model Using Back-end Loading Technique

The modified version of the existing bid-balancing model is presented in this section. Three techniques were used to determine cost benchmark for each of the component of project elements. The Front-end loading, Back-end Loading and Individual- rate loading.

1.12 Structural Component of Neural Network Econometric Modified Back-End Loading Approach

The current Back-end loading by Cattel et al., (2008) $pvj = \sum_{n=0}^{N} \left(\frac{1}{1-r}\right)^{n} [\lambda njQj(Pj - Cj)]]$ (Cattel et al., 2008)is modified with incorporation of exigency escalator and inflation buffer, the neural network econometric modified back-end loading approach is presented thus: $Pvj = [\Sigma (1/1-r)^n]([C_{nj}[Q_j + Q_i][\gamma_{nj} fP_j - C^1)] + _{nj}[Q_j + Q_i][\gamma_{nj} fP_j - C^1)])$ where rj --- monthly discount rate ; n --- month number; C^1--actual increase in cost of items; nj --- proportion of elements; Q_j; Q_i ---- bill cost of iitem i, j; γ_{nj} --- adjustment for escalation; fP_j----Haylet Factor(0.85) and C^1 ---- unit cost of item j. The modified model was applied on 2&3-bedroom projects, the output of the model compared alongside with other front-end and individual rate loading. It was discovered that the values of the modified -econometric model is consistent in structure, the detail is presented in Table 1.9, from the table, the modified models' output is closed to the bill of quantity sums, the model has incorporated escalator buffer and inflation factor which makes the assigned cost to the elements on the bill to be valid for six(6) months, for instance, the cost of substructure on the bill of quantities is ₦2,669,340 while after loaded with escalator buffer and inflation factor, ₦ 2939503.9. Once there is no incidence of inflation, contractor or builder will tend to save cost from onset while no effect of inflation will be felt on occasion of inflation during the course of the work execution. The econometric model output can then be used as tender sum for the elements at tender stage, since effect of project variants has been taken into consideration.

1.13 Validating Neural-network Econometric Entropy-based Model Using Comparative Analysis of the Econometric Loading Attributes

Strong positive relationship exist between cost limit of 1-bedroom duplex and 2/3-bedroom bungalow with Pearson coefficient of 0.905, also there is very weak relationship with Pearsons correlation -coefficient of 0.45 that exist between the cost limit of 3-bedroom on four floors and 1-bedroom bungalow. However, from Table 1.10 averagely strong relationship is recorded as well in mapping 2/3-bedroom duplex with 4- bedroom duplex the analysis came up with Pearsons correlation coefficient of 0.787. Similarly, an average strong relationship occurred between 1-bedroom bungalow and 4-bedroom duplex; 3 bedroom on 4-floors and 2/3-bedroom bungalow with Pearsons coefficient of 0.764 and 0.586 respectively. Econometric value analysis of the three different methods is presented in Tables 1.11

and 1.12; there is weak correlation in the Individual-rate loading and Back-end loading when mapped with Front-end loading while positive correlation exists in mapping of Individual rate loading with Back-end loading this indicates closeness in the attribute as a result of incorporation of inflation buffer in the structure of the two models. However, the Econometric Back-end loading contingency coefficient from Table 1.13 is high with 0.967 and Kendall's tau coefficient of 1.00 at 99% confidence interval using Monte Carlo technique and closely followed by Individual-rate loading contingency coefficient of 0.957 and Kendall's coefficient of 0.909. This indicates better output as obtained from the generated econometric model whose weights are neural network modified.

1.14 Conclusions: An econometric model that incorporates neural network generated parameters has been developed in this study, builders and contractors can therefore use the econometric-neural network based model in determining the magnitude of the cost implication of the elements to be able to prepare and submit a valid bid. The model describes different dichotomies obtainable in a typical bill of quantities vis-à-vis early constructible element and late constructible elements. Sub-structural elements up to initializing elements of superstructure are regarded as early constructible elements while those billed to be executed later as project progresses are termed late constructible elements. Gleaning facts from data analyzed Sub-structural works which are often scheduled to be executed early on project carries high cost N2,939,503 followed by Frame and Roofs with N1,673,190 and N1,318,148 respectively. A builder can bill the component with their actual cost having being guaranteed of early released of fund for project execution. Meanwhile, elemental works often scheduled to come later on the project for execution should not be treated in this way, however there should be an anticipated cost loading on their elemental cost to cushion the effect of occurrence of uncertainties that may arise before execution, therefore model that incorporates an economic index will be most desirable for good effect. Econometric model like the one generated in this study will therefore accommodate factoring of upward lading time dependent factors on the elements. This takes account of present value of the cost using period 'n' in consideration as a base for reference, for instance services and soil drainage that are often billed to occur later on project, which has tender cost of N786, 350 has a relative cost of N865, 938.80 produced by econometric model having being factored upward for period of six (6) months. Speculated period was used in context of this analysis, this will therefore provide a builder an opportunity to load a cost implication of unseen circumstance even if the money would be reimbursed later. This fact thus situates the neural network modified model as a tool that could be used in cost prediction over a specified period.

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1.15 List of Tables

Table 1.1: Factoring Elemental Cost Centers Influence on Project Cost

S/N	Elements	Cost Rating On Scale (1) To Ten (10)			
C.		4-Bedroom Duplex	2/3- Bedroom Bungalow	1- Bedroom Apartment	3&4-Bedroom, 4

					Floors
ELT1	Substructure	10^{+4}	10^{+12}	10^{+19}	8
ELT2	Frame & Walls	10^{+9}	10^{+3}	10^{+2}	10^{+25}
ELT3	Stair Cases	2	---	---	3
ELT4	Upper Floor	9	---	---	4
ELT5	Roofs	7	10	10^{+4}	4
ELT6	Windows	5	4	5	5
ELT7	Doors	6	5	5	5
ELT8	Finishing	10^{+4}	10^{+12}	10^{+10}	10^{+5}
ELT10	Fittings	2	3	---	6
ELT11	Services	7	7	6	7
ELT12	Soil Drainage	2	2	7	6
ELT13	Preliminaries	4	4	5	7
ELT14	Contingencies	3	2	3	3
ELT15	Value Added Tax (5%)	5	5	5	1

Source: 2011 Survey

Table 1.2 Risk Entropy Schedule on Selected Project Elements

PROBABILITY		4-Bedroom Duplex	2&3-Bedroom Bungalow	1-Bedroom Apartment	3 /4-Bedroom, 24 Units 4 Floors
	EXTREME 9-20	14(1.4Sub) 15(1.5Finish) 19(1.9Frame) 7(0.7Serv) 9(0.9Uppflr) 7(0.7Roof)	13(1.3Sub) 13(1.3Frame) 10(1.0Roof) 12(1.2Finish)	20(2.0) Finishing) 19(1.9Substructure) 12(1.2 Frame) ------ ------- 14(1.4Roof)	20^{+} (2.0) Frame 15(1.5 Finishing)

	HIGH 6-8	5(0.5Wind) 6(0.6 Doors)	7(0.7Services)	6(0.6Services) 7(0.7Soildrg)	8(0.8 Sub) 6(0.6 Fittings) 6(0.6 Soildrhg)) 7(0.7 Services) 7(0.7 Services)
	MEDIUM 3-5	3(0.3 Contig) 4(0.4 Prelm) 3(0.3 Contg)	3(0.3 Fittings) 5(0.5 VAT) 4(0.4 Wind) 5(0.5 Doors) 4(0.4 Prelim)	5(0.5 Window) 5(0.5 Prelim) 3(0.3 Doors) 5(0.5 Soildrg) 5(0.5 VAT)	3(0.3 Staircs) 4(0.4 Upperflr) 4(0.4 Upperflr) 5(0.5 Windw) 5(0.5 Doors) 3(0.3 Contig)
	LOW 0-2	2(0.2 Stair) 2(0.2 Soildrg) 2(0.2 Fittgs)	2(0.2soildrain) 2(0.2Conting)		
		1	2	3	4

IMPACT/CONSEQUENCE

Source: 2011 Survey

Table 1.3 Table Cost Schedule for 2-Bedroom Bungalow

		1	2	3	
	Project	A	B	C	
Cost Centers		B.O.Q Initial Valuet[Tender cost] [~~N~~]	As-Built Cost [~~N~~]	Cost Variation(B-A) ~~[N]~~	Percent Var
Project 1-20	1	3,085,100	4,236,000	1,150,900	36
Residential	2	3,171,800	5,800,000	2,628,200	83
Building	3	2,610,000	4,800,000	2,190,000	84
2009	4	3,165,000	4,350,000	1,185,000	37

	5	2,145,000	4,325,000	2,180,000	102
	6	3,174,953	4,286,350	1,111,397	35
	7	2,750,000	5,850,000	3,100,000	113
	8	2,700,850	5,121,000	2,420,150	90
	9	3,150,000	6,265,000	3,115,000	99
	10	2,766,000	5,223,000	2,457,000	89
	11	2,510,000	6,371,000	3,861,000	154
	12	3,268,000	6,250,000	2,982,000	91
	13	2,250,325	5,675,000	3,424,675	152
	14	3,520,000	6,600,000	3,080,000	88
	15	2,100,000	5,125,000	3,025,000	144
	16	3,173,000	5,652,000	2,479,000	78
	17	3,173,000	7,650,000	4,477,000	141
	18	2,580,315	6,131,000	3,550,685	138
	19	2,420,500	5,643,000	3,222,500	133
	20	3,143,000	7,266,000	4,123,000	131

Source: 2011 Survey

Table 1.4 Monetary Entropy Dynamics

Project	Tender Sum [₦]	Construction Cost[₦]	Cost Variation	Variation Probability	Entropy	Entropy Level
Prj 1	3,085,100	4,236,000	1,150,900	38.00	0.373	0.368
Prj 2	3,171,800	5,800,000	2,628,200	70.00	0.829	0.155
Prj 3	2,610,000	4,800,000	2,190,000	84.00	0.839	0.147
Prj 4	3,165,000	4,350,000	1,185,000	37.00	0.375	0.368
Pj 5	2,145,000	4,325,000	2,180,000	102.00	0.984	0.016
Prj 6	3,174,953	4,286,350	1,111,397	35.00	0.350	0.367
Prj 7	2,750,000	5,850,000	3,100,000	113.00	0.887	0.107
Prj8	2,700,850	5,121,000	2,420,150	90.00	0.896	0.098
Prj9	3,150,000	6,265,000	3,115,000	99.00	0.989	0.011
Prj 10	2,766,000	5,223,000	2,457,000	89.00	0.889	0.105
Prj 11	2,510,000	6,371,000	3,861,000	154.00	0.650	0.280
Prj 12	3,268,000	6,250,000	2,982,000	110.00	0.910	0.086
Prj 13	2,250,325	5,675,000	3,424,675	152.00	0.657	0.276
Prj 14	3,520,000	6,600,000	3,080,000	88.00	1.143	-0.153

Prj15	2,100,000	5,125,000	3,025,000	144.00	0.694	0.254
Prj16	3,173,000	5,652,000	2,479,000	78.13	1.280	-0.316
Prj17	3,173,000	7,650,000	4,477,000	141.00	0.710	0.243
Prj18	2,580,315	6,131,000	3,550,685	138.00	0.730	0.230
Pr9	2,420,500	5,643,000	3,222,500	133.00	0.750	0.216
Prj20	3,143,000	7,266,000	4,123,000	131.00	0.762	0.207

Source: 2011 Survey

Table 1.5 Cost schedule of 4- Bedroom Duplex

		1	2	3	
	Project	A	B	C	
Cost Centers		B.O.Q Initial Value [N]	As-Built Cost [N]	Cost Vartn	Perctg
Project 1-41	1	16,043,869	22,676,000	6632131	29
Residential	2	16,500,603	23,565,000	7064397	30
Building	3	16,225,501	24,113,000	7887499	33
2009	4	16,400,521	27,654,000	11253479	41
	5	17,100,438	22,221,000	5120562	23
	6	17,300,113	28,450,000	11149887	39
	7	16,800,073	30,500,000	13699927	45
	8	17,220,134	26,350,000	9129866	35
	9	16,210,687	25,800,120	9589433	37
	10	18,500,936	23,450,000	4949064	21
	11	16,360,084	20,650,000	4289916	21
	12	15,850,172	28,335,000	12484828	44
	13	16,000,163	22,850,000	6849837	30
	14	15,000,151	26,321,000	11320849	43
	15	15,600,148	26,321,000	10720852	41
	16	16,725,133	36,225,000	19499867	54
	17	17,890,112	27,338,000	9447888	35
	18	18,500,000	38,650,000	20150000	52
	19	19,223,000	25,773,000	6550000	25
	20	16,720,000	23,443,000	6723000	26

Source: 2011 Survey

Table 1.6 Monetary Entropy Dynamics

Project	Tender Sum [N]	Construction Cost[N]	Variation Limit	Variation Probability	Entropy	Remark
Prj 1	16,043,869	22,676,000	6632131	40.20	2.49	-2.272
Prj 2	16,500,603	23,565,000	7064397	42.90	2.34	-1.989
Prj 3	16,225,501	24,113,000	7887499	49.00	2.06	-1.49
Prj 4	16,400,521	27,654,000	11253479	69.00	1.46	-0.553
Prj 5	17,100,438	22,221,000	5120562	30.00	3.34	-4.03
Prj 6	17,300,113	28,450,000	11149887	65.00	1.55	-0.679
Prj 7	16,800,073	30,500,000	13699927	82.00	1.23	-0.255
Prj8	17,220,134	26,350,000	9129866	53.00	1.89	-1.203
Prj9	16,210,687	25,800,120	9589433	60.00	1.69	-0.887
Prj10	18,500,936	23,450,000	4949064	27.00	3.74	-1.319
Prj11	16,360,084	20,650,000	4289916	27.00	3.82	-5.120
Prj12	15,850,172	28,335,000	12484828	79.00	1.27	-0.304
Prj13	16,000,163	22,850,000	6849837	43.00	2.34	-1.989
Prj14	15,000,151	26,321,000	11320849	76.00	1.33	-0.380
Prj15	15,600,148	26,321,000	10720852	69.00	1.46	-0.553
Prj16	16,725,133	36,225,000	19499867	117.00	0.86	0.130
Prj17	17,890,112	27,338,000	9447888	53.00	1.90	-1.220
Prj18	18,500,000	38,650,000	20150000	109.00	0.92	0.077
Prj19	19,223,000	25,773,000	6550000	35.00	2.95	-3.192
Prj20	16,720,000	23,443,000	6723000	41.00	2.49	-2.272

Source: 2011 Survey

Table 1.7 Project Particular 2&3-Bedroom Bungalow

S/N	Element	Tender Cost[N]	Tagged Project Cost[N]	Relative Percent	Relative Probability	Relative Entropy
B.						

ELT1	Substructure	2,669,340	11,674,519.50	22.865	0.23	2.34
ELT2	Frame & Walls	1,519,415	11,674,519.50	13.015	0.08	2.49
ELT3	Roofs	1,197,000	11,674,519.50	10.253	0.10	2.47
ELT4	Windows	517,650	11,674,519.50	4.434	0.23	2.34
ELT5	Doors	544,500	11,674,519.50	4.664	0.05	2.52
ELT6	Finishing	2,541,535	11,674,519.50	21.770	0.05	2.52
ELT7	Fittings	298,800	11,674,519.50	2.560	0.39	2.18
ELT8	Services	786,350	11,674,519.50	6.736	0.15	2.42
ELT10	Soil Drainage	274,000	11,674,519.50	2.347	0.43	2.14
ELT11	Preliminaries	500,000	11,674,519.50	4.283	0.24	2.33
ELT12	Contingencies	270,000	11,674,519.50	2.313	0.43	2.14
ELT13	Value Added Tax (5%)	555,929.50	11,674,519.50	4.762	0.21	2.37
	Σelt(Summation)					2.57

Source: 2011 Survey

Table 1.8 Project Cost and Corresponding Neural Network Based-Entropy 2&3-Bedroom Bungalow

Project	Tender Cost	Tagged Cost	Neural Output	Relative Entropy
Prj 1	3085100	4236000	5,272,837	0.60
Prj 2	3171800	5800000	7,219,654	0.44
Prj 3	2610000	4800000	5,974,886	0.44
Prj 4	3165000	4350000	5,535,606	0.57
Prj 5	2145000	4325000	5,455,724	0.39
Prj 6	3174953	4286350	5,454,607	0.59
Prj7	2750000	5850000	7,392,422	0.37
Prj8	2700850	5121000	6,516,743	0.42
Prj9	3150000	6265000	7,972,545	0.40
Prj10	2766000	5223000	6,669,763	0.42
Prj11	2510000	6371000	8,107,435	0.31
Prj12	3268000	6250000	7,953,456	0.41

Prj13	2,250,325	5675000	7,177,588	0.32
Prj14	3520000	6600000	8,347,503	0.42
P rj15	2100000	5125000	6,481,963	0.322
Prj15	3173000	5652000	7,148,498	0.442
Prj16	3173000	7650000	9,675,515	0.328
Prj17	2580315	6131000	7,754,324	0.33
Prj18	2420500	5643000	7,112,028	0.34
Prj19	3143000	7266000	9,173,691	0.34

Source: 2011 Survey

Table 1.9 Econometric Factor Adjusted-Project Elements (2&3-Bedroom Bungalow).

	Element	Tender Cost[₦]	Tagged Project Cost[₦]	Front-end Loading	Individual-rate loading	Back-end Loading
B.						
ELT1	Substructure	2,669,340	11,674,519.50	3,012,567.00	737,298.40	2,939,503.90
ELT2	Frame & Walls	1,519,415	11,674,519.50	3,397,217.00	419,672.62	1,673,190.00
ELT3	Roofs	1,197,000	11,674,519.50	3,505,064.80	987,525.00	1,318,148.40
ELT4	Windows	517,650	11,674,519.50	3,735,654.40	142,980.11	570,041.41
ELT5	Doors	544,500	11,674,519.50	3,726,665.30	150,396.40	599,609.10
ELT6	Finishing	2,541,535	11,674,519.50	3,058,058.00	701,997.38	2,798,763.80
ELT7	Fittings	298,800	11,674,519.50	3,8018,925.70	82,531.60	329,041.60
ELT8	Services	786,350	11,674,519.50	312,645,694.00	217,198.00	865,936.80
ELT10	Soil Drainage	274,000	11,674,519.50	3,817,228.70	75,681.54	301,731.54
ELT11	Preliminaries	500,000	11,674,519.50	3,741,563.90	138,105.00	550,605.00
ELT12	Contingencies	270,000	11,674,519.50	3,818,567.90	74,576.7.00	297,326.70
ELT13	Value Added Tax (5%)	555,929.50	11,674,519.50	3,722,838.70	153,553.30	612,195.20

Source: 2011 Survey

Table 1.10 Cost Limit Component Validation

Elements and Statistical Parameters	4-bedroomdupl	2/3-bdrmbunglw	1-bdrm bung	3-bdrm,3-floors

		ex			
4-bedrmdplx Corr.	Pearsons	1.00	-	-	-
	Sig.(2-tailed)	0.00	-	-	-
2/3-bedrmbung Corr.	Pearsons	0.787	1.00	-	-
Tailed)	Sig.(2-	0.001	0.000	-	-
1-bedrm bunglw Corr.	Pearsons	0.764	0.905	1.000	-
Tailed)	Sig.(2-	0.001	0.000	0.000	-
3-bdrm on 4flrs Corr.	Pearsons	0.791	0.586	0.485	1.000
Tailed)	Sig.(2-	0.001	0.028	0.079	0.000

Source: 2011 Survey

Table 1.11 Correlation Matrix

	Statistical Properties	Front loading	Indivdual rate loading.	Back-end loading
Correlation	Frontloading	1.000		
	Indivdualratload	-.471	1.000	
	Backendload	-.468	.715	1.000
Sig. (1-tailed)	Frontloading		.143	.145
	Indivdualratload	.143		.035
	Backendload	.145	.035	

Source: 2011 Survey

Table 1.12 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.111	70.382	70.382	2.111	70.382	70.382
2	.604	20.119	90.502			

3	.285	9.498	100.000			

Source: 2011 Survey **Extraction Method: Principal Component Analysis.**

Table 1.13 Econometric Loading Attributes

Monte Carlo Technique 99% Confidence Interval		Value	Asymp. Std. Error[b]	Approx. Sig.	Sig.	Lower Boundary
Individual-rate Loading	Contingency Coefficient	.957	.233	1.000	1.000[a]	1.000
	Kendall's tau-c	.909	.000	.000	.000[a]	.000
Econometric Front-end Loading	Contingency - Coefficient	.95	.233	1.000	1.000[a]	1.000
	Kendall's tau-c	-1.00		.000	.000[a]	.000
Econometric Back-end Loading	Contingency - Coefficient	.967	.233	.233	1.000[a]	1.000
	Kendall's tau-c	1.00			.000[a]	.000

Source: 2011 Survey