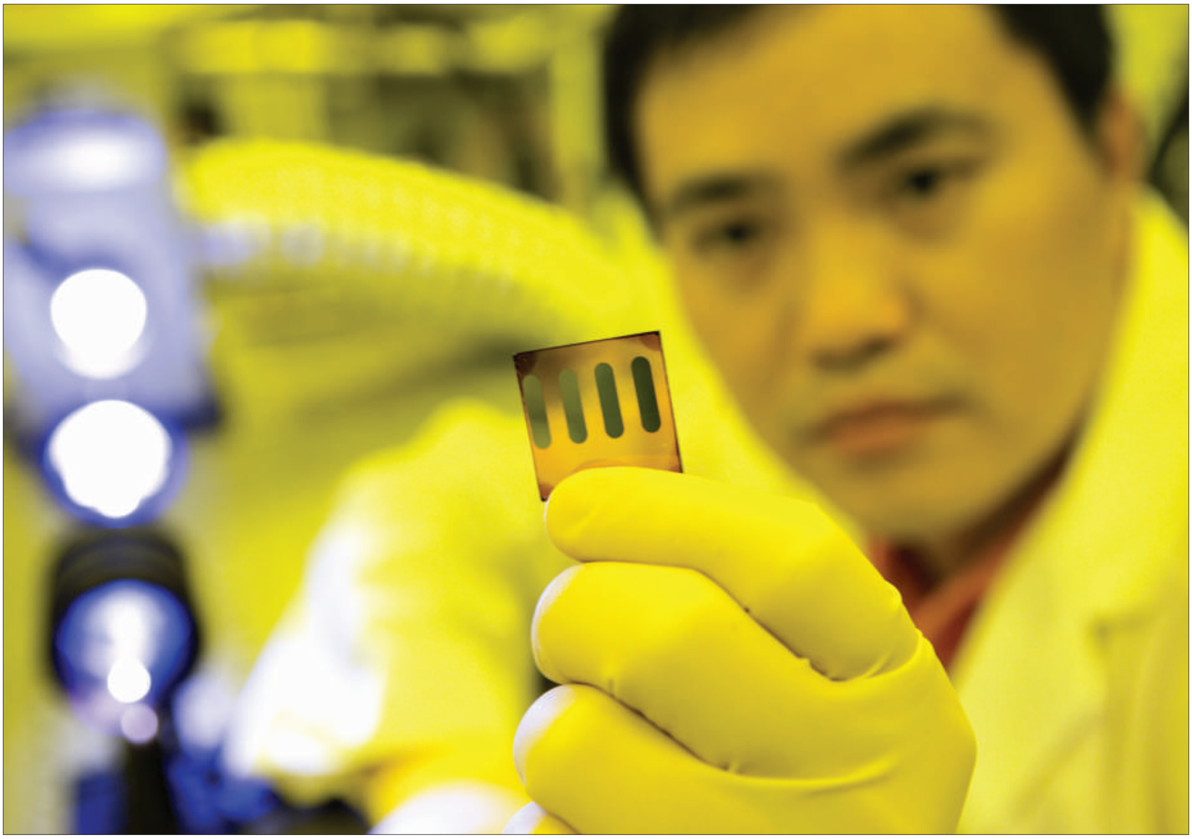

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Mathematical Expressions for Explaining Project Delays in Southwestern Nigeria

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ABSTRACT
This study was carried out to develop mathematical framework for explaining civil engineering project delays in Southwestern Nigeria with the aim of finding solution for their reduction. The study area was the Southwestern states of Lagos, Oyo, Ogun, Ondo, Osun and Ekiti. The sample sizes of 70, 30 and 50 were obtained for contractors, clients and consultants categories, respectively. Three types of respondents (engineer, architect and quantity surveyor) were selected in each category, making a total of 450 respondents. Multi-stage sampling was adopted for selected participants. Data were collected using questionnaires and interview techniques. The parameters for the mathematical expressions were obtained by multiple linear regression analysis method. The results showed that out of 3407 civil engineering projects handled only 24 were completed on time, 1571 were delayed and 1812 abandoned and 17.4, 5.6 and 77.0% of delayed projects were handled by the foreign, indigenised and indigenous organizations, respectively. The regression analysis showed that a unit increase in funding and payment contributed a proportion of 0.273 to the delay of projects, while 0.213 and 0.209 were due to contractor and client factors, respectively. It is concluded that mathematical expressions can explain project delays in Southwestern Nigeria and help to reduce them.

Key words: Construction project, management policy, project risk, delay factors, completion time

INTRODUCTION
Mathematical expressions are numerical representations of phenomena. These numbers can be used to find out important things about them. Some of the natural occurrences are easy to visualize, such as how long is that ladder or how many of my students are native English speakers, compared to Spanish speakers. But some are more abstract, such as, how do people feel about a particular issue. At first, this may seem to have nothing to do with numbers, but there are ways to make the conversion. For instance, we can ask them to rank their feelings on a scale of 1 to 10. Mathematical representations simply means taking some phenomenon which may or may not be easy to quantify and thinking of it in terms of numbers or categories. This can make the information easier to understand and work with. While, Amu and Adesanya (2007) observed the general consideration of failed construction projects in Southwestern Nigeria to include project delays, the emphasis of this study is to provide mathematical expressions for explaining these delays.

Olaloku (1987) reported that construction industry occupies an important position in the structure of the Nigerian economy, but as the quantum of projects has increased, so has the number of abandoned projects, mostly resulting from time delays in the project activities. To effectively manage the risks in construction projects, it is necessary for organizations to identify important risk and to provide a tool to measure their effects (Ismail *et al*., 2008). The concentration of delayed developmental projects is particularly high in the Southwestern geopolitical area, where civil engineering projects activities are most intense.

Causes of delay in civil engineering projects are generally considered to include: cash flow difficulties; outright shortages of funds; poor communication among members of the project team; bribery; corruption and nepotism and inefficient use of project time, to mention a few. The study of Amu *et al*. (2005) revealed that unfavourable site conditions and force majeure were the highest and lowest of the incidental factors causing delays to the timely completion of construction projects in some selected states in Nigeria. Several of the factors of delay enumerated above have formed subjects of studies (Mansfield *et al*., 1994; Frimpong *et al*., 2003; Odeh and Battaineh, 2002; Al-Moumani, 2000; Chan and Kumaraswamy, 1997) which could broadly come under the big headings as: Client-caused delays, Contractor-caused delays, Consultant-caused delays and Extra-contractual delays.

The construction industry consists of structures and systems of activities, which interact under the catalyst of construction operators to attain desired construction goals (Aniekwu, 1995). The whole process is fraught with many unknowns, which are further complicated by special factors in a developing country like Nigeria. The problems of the industry are multi-faceted and various scholarly works have focused on the problems of the construction industry in Nigeria. Wahab (1977) has identified various constraints responsible for the low productivity of the Nigerian contractor. Edmonds and Miles (1983) identified another set of problems, which they attributed to the fact that the contractual framework and procedures under which the domestic contractor works in the developing countries are not suitably adapted to local conditions.

Okpala and Aniekwu (1988) noted delays and cost over-runs as the principal factors responsible for the high cost of construction in the Nigerian construction industry and derived a mathematical framework for the assessment of the varying importance of different variables. Aniekwu and Okpala (1987) through a survey involving consultants in the construction industry, identified a set of factors termed systemic factors, which adversely affect the construction industry in Nigeria and arise from the application of systems not suitable to the local environment. However, the focus of this paper is not on project delay, but on the mathematical expressions to explain these delays.

The mathematically expressions in this study is a way of explaining the various delays, with a view to improving productivity in the construction industry which has an important role in promoting national competitiveness and thereby defending living standards and achieving a satisfactory rate of growth (Walker, 1995). The benefit from such improvement would include increased attractiveness of a location such as the Southwestern area in the study for investment in new plants or projects and lower cost to domestic industry.

SCOPE OF RESEARCH AND DATA COLLECTION

In obtaining the mathematical expressions, eleven delay factors were considered. These factors were selected based on the field experiences of project participants in the study area and they explain the peculiar situations of the project environments. The factors are: funding and payment, equipment, personnel, design faults and defective contract documents, construction supervision, administration, planning and programming, client, contractor, consultant, material and external. The field survey covered the Southwestern states of Lagos, Oyo, Ogun, Ondo, Osun and Ekiti in Nigeria for six months. The primary data were obtained using structured and unstructured (open ended) questions included in the questionnaire designed to elicit information from respondents on factors causing delay of civil engineering projects. In an earlier study, Amu and Adesanya (2007) discussed a detailed information about sampling and sampling methods.

A total of 450 questionnaires were distributed and 293 replies were received, representing a response rate of 65%. This response rate is satisfactory for such studies in the area (Shash and Abdul-Hadi, 1992). The respondents were required to provide information on the quantum of projects handled and delayed in the preceding 10 years and the factors responsible for the delays.

The mathematical expressions for the eleven factors considered in this study were developed using the multiple linear regression analysis of the factors of delay (X_1-X_n) with the number of projects delayed in the preceding 10 years. The coefficients for the expressions are the unstandardized coefficients (B_1-B_n) with a constant (B_o).

RESULTS AND DISCUSSION

The broad characteristics of the organizations surveyed are presented in Table 1 by states, from the six states involved the quantum of responses ranges from 61 to 77%, the average is 68%, while on the whole, 65% responses were received. This level of responses can quite clearly be considered satisfactory in terms of confidence as to rehability of information provided (Mansfield *et al*., 1994).

Organization here refers to the construction companies, consulting companies, clients such as the government institutions such as universities, teaching hospitals, state ministries, local governments and agencies among others who are responsible for big projects. The table presents data as to the quantum of responses, age spread of the organizations, the nature of organization (whether they are indigenous, foreign or indigenised), the type of professionals that responded to the questionnaire and the type of ownership of the projects.

Table 1: Broad characteristics of surveyed organizations by states

Organization characteristics	Detail	Lagos	Oyo	Ogun	Ondo	Osun	Ekiti	Total
No. contacted	NA	195	75	60	45	39	36	450
No. responded	NA	118	49	38	31	29	28	293
Percentage of respondents (S/N 2/1%)	NA	61	65	63	69	74	77	65
Age of organization	<10 years	3	6	-	14	10	2	35
	11-20 years	27	23	-	4	6	22	82
	> 20 years	88	20	38	13	13	4	176
Nature of organization	Indigenous	54	45	38	28	29	28	222
	Foreign	53	-	-	-	-	-	53
	Indigenised	11	4	-	3	-	-	18
Profession of respondents	Engr.	71	30	30	19	19	17	186
	Arch.	8	7	-	12	10	6	43
	Q.S.	15	7	8	-	-	5	35
	Technician	24	5	-	-	-	-	29
Type of stakeholder	Client	25	4	13	9	9	7	67
	Consulting	35	14	8	6	8	6	77
	Construction	58	31	17	16	12	15	149

NA: Not applicable

Majority of the firms can be said to be reasonably old. A total of 258 (or 88%) have been in existence for more than 10 years, indeed some 60% are 20 years old or more. This is considered satisfactory in terms of the experience of respondents required for this type of work. A total of 76% respondents were from the indigenous organizations, 18% were the foreign types, while only 6% were indigenised. The distribution of foreign and indigenous organizations in Lagos is almost the same, it should be noted that all the 53 foreign respondents in the study were from Lagos, none from the other states. Indigenous organizations dominated in all the states with a total number of 222 respondents. This distribution is accepted for the benefit of the indigenous organizations.

Engineer respondents dominated the survey, with a total number of 186 (63%), architect 15%, quantity surveyor 12 and 10% technicians. Characteristically, Lagos respondent engineers were 71, Oyo and Ogun were 30 each and the least of 17 were from Ekiti state. No architect responded in Ogun state and also, no quantity surveyor responded in both Ondo and Osun states. This pattern is adequate for information about project delay which is primarily the responsibility of the engineers.

A total of 149 respondents, representing 51% were from the construction organizations, 77 were consultants, while 67 were clients. This distribution of stakeholder is satisfactory because the contractors are very relevant in the issue of project delay.

The largest number of participants, a total of 195 (or 43%) were from Lagos State, 75 from Oyo, 60 from Ogun, 45 from Ondo, 39 from Osun, while the least was 36 from Ekiti State. This is considered adequate as a reflection of the concentration of construction activities in the States, which indirectly reflect their population patterns.

As would be expected, companies and organizations in Lagos were fairly old, this was responsible for the pattern of age of organization shown, organizations of over 20 years were the highest respondents in Lagos, they were 88 in number, 27 respondents were from organizations between 11-20 years, while 3 respondents were from organizations less than 10 years.

Mathematical expression for the main factors: Table 2 shows the result of multiple linear regression analysis of the main factors of delay with the number of projects delayed in the preceding 10 years. The coefficients for the modelling are the unstandardized coefficients (B) with a constant 0.928.

Table 2: Model of the main factors of project delay

Factor	Name	Unstandardized coefficient B	Standardized coefficient Beta	Sig.
	Constant	0.928		0.697
X1	Funding and payment	0.326	0.273	0.000
X2	Equipment	-8.225E-02	-0.088	0.274
X3	Personnel	0.262	0.313	0.001
X4	Design faults	-0.160	-0.258	0.013
X5	Construction supervision	-0.126	-0.177	0.067
X6	Admin, planning and programming	-1.825E-02	-0.044	0.698
X7	Client	0.195	0.209	0.027
X8	Contractor	0.170	0.213	0.053
X9	Consultant	-1.985E-02	-0.039	0.764
X10	Materials	-5.712E-02	-0.070	0.412
X11	Exterual	-0.171	-0.245	0.002

The mathematical expression is written as:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 \text{---------------} B_{11}X_{11} + U \quad (1)$$

Where:
Y = No. of projects delayed in the preceding 10 years (Unitless dependent variable)
B_0 = Constant
B_1-B_{11} = Unstandardized coefficients of the factors
X_1-X_{11} = Delay factors (independent variables)
U = Unexplained error of term

Substituting the values in Table 2,

$$Y = 0.928 + 0.326X_1 - 8.225E\text{-}02X_2 + 0.262X_3 - 0.160X_4 - 0.126X_5 - 1.825E\text{-}02X_6 + 0.195X_7 + 0.170X_8 - 1.985E\text{-}02X_9 - 5.712E\text{-}02X_{10} - 0.171X11 \quad (2)$$

(Mathematical expression for the main factors of delay).

Interpreting the equation: Y (No. of delays in the preceding 10 years) = 0.928 (unitless), if all the other factors do not exist. The validity of this equation can only be tested to predict the number of projects that will be delayed in the next 10 years. This is due to the fact that measurements in this study were based on projects delayed in the preceding 10 years. This constitutes a time limitation to the testing of this expression, because any improvement towards reducing the magnitude of the delay factors can only be measured in the next 10 years.

A unit increase of X_1 (funding and payment factor) will lead to a corresponding increase of 0.326 in Y if all other factors are constant, a unit increase of X_7 (client factor) will lead to a corresponding increase of 0.195 in Y if all other factors are constant. Also, a unit increase in X_8 (contractor factor) will lead to a corresponding increase of 0.170 in Y if all other factors are constant. Administration factor (X_6) has a negative impact. Personnel factor $(X\ )_3$ could also contribute positively to Y, but respondents did not consider it very important.

The mathematical equation is applicable to construction projects that are bound within the risk factors of delays considered. It is possible to reduce the number of projects that are delayed by putting up actions that will reduce the magnitudes of the factors presented in the expression.

Relative importance of the main factors: As shown in Table 2, the standardized coefficient (Beta) is a measure of the relative importance of each of the independent variables on the dependent variable. From the equation, it is shown that funding and payment (X_1), personnel (X_3), client (X_7) and contractor (X_8) are the only positive relatively important factors of delay, excluding administration factor that was highly rated by respondents. It is however important to note that factors X_1 and X_3 are significant at < 0.05 level of significance and that funding and payment (X_1) has a perfect significance.

Mathematical expression and relative importance of the predominant factors: From earlier results, even though four factors were highly mentioned as causing delay of projects, yet administration, planning and programming factor was excluded by the regression analysis, retaining three, which in order of importance are: funding and payment, client and contractor.

Moreover, funding and payment factor was indicated as the only perfectly significant of all the factors.

Table 3 shows the result of the regression analyses for funding and payment factor, from the model, it is possible to write the mathematical expression for funding and payment factor as:

$$Y_f = B_0 + B_1X_1 + B_2X_2 \text{----------------------} B_6X_6 + U \quad (3)$$

Where:

Y_f = No. of projects delayed in the preceding 10 years (Unitless)
B_0 = Constant
B_1-B_6 = Unstandardized coefficients of the factors
X_1-X_6 = Delay factors (independent variables)
U = Unexplained error of term

Substituting the values in Table 3:

$$Y_f = 3.900 - 0.578X_1 - 0.582X_2 + 0.608X_3 + 0.749X_4 - 0.146X_5 + 0.243X_6$$

Interpreting the equation: Y (No. of delays) = 3.900 (unitless), if all the other factors do not exist.

A unit increase of X_1 (price fluctuation factor) will lead to a corresponding negative increase of 0.578 in Y if all other factors are constant, a unit increase of X_4 (client's cash flow difficulty factor) will lead to a corresponding increase of 0.749 in Y if all other factors are constant. Nevertheless, factors X_3, X_4 and X_6 are positive relatively important, while X_3 is significant at <0.05 level of significance while X_4 (client's cash flow difficulty) is the only perfectly significant factor.

In Table 4, the mathematical expression for the client factor is written as:

$$Y_{clt} = B_0 + B_1X_1 + B_2X_2 + \text{-------------------} B_6X_6 + U \quad (4)$$

Where:

Y_{clt} = No. of projects delayed in the preceding 10 years (Unitless)
B_0 = Constant
B_1-B_6 = Unstandardized coefficients of the factors
X_1-X_6 = Delay factors (independent variables)
U = Unexplained error of term

Table 3: Model of funding and payment factors of delay

Factor	Name	Unstandardized coefficient B	Standardized coefficient Beta	Sig.
	Constant	3.900	0.020	
X1	Price fluctuations	-0.578	-0.141	0.016
X2	Contractor's financial difficulty	-0.582	-0.127	0.032
X3	Corruption and bribery	0.608	0.182	0.002
X4	Client's cash difficulty and non-availability of fund	0.749	0.226	0.000
X5	Improper nse of project fund	-0.146	-0.048	0.440
X6	Non-existence of a law preventing the award of a contract for which enough fund is not available	0.243	0.069	0.255

Table 4: Model of client factors of delay

Factor	Name	Unstandardized coefficient B	Standardized coefficient Beta	Sig.
	Constant	0.379	0.805	
X1	Client-initiated variations	-0.114	-0.034	0.626
X2	Unrealistic contract dnrations and requirements imposed by client	-0.138	-0.041	0.567
X3	Unspecified sequence of completion by client	-0.975	-0.273	0.000
X4	Unnecessary interference by client	0.446	0.108	0.133
X5	Inadequate funding and payment of completed work	1.100	0.203	0.002
X6	Slow decision-making by client	0.508	0.126	0.061

Table 5: Model of contractor factors of project delay

Factor	Name	Unstandardized coefficient B	Standardized coefficient Beta	Sig.
	Constant	1.530	0.278	
X1	Defective site management programmes	-0.293	-0.064	0.371
X2	Inadeqnate construction methods	1.337	0.333	0.000
X3	Improper planning	0.293	0.075	0.396
X4	Mistakes during construction	-1.089	-0.305	0.000
X5	Lack of relevant experience	0.335	0.077	0.316
X6	Delay from subcontractors and nominated suppliers	0.682	0.167	0.007
X7	Contractor's deficiencies in planning and scheduling at pre-construction stage	-0.454	-0.109	0.107

Substituting the values in Table 4

$$Y_{clt} = 0.379 - 0.114X_1 - 0.138X_2 - 0.975X_3 + 0.446X_4 + 1.100X_5 + 0.508X_6$$

Interpreting the equation: Y (No. of delays) = 0.379 (unitless), if all the other factors do not exist.

A unit increase of X_1 (client-initiated variations factor) will lead to a corresponding negative increase of 0.114 in Y if all other factors are constant, a unit increase of X_5 (inadequate funding factor) will lead to a corresponding increase of 1.100 in Y if all other factors are constant. Factors X_3 and X_5 are the only significant ones and X_5(inadequate funding and payment of completed work) has the highest positive relative importance and significant at 0.002 level of significance.

Table 5 shows the result of the regression analysis on the contractor factors, the mathematical expression could be written as:

$$Y_{cnt} = B_0 + B_1X_1 + B_2X_2 + \text{-------------------} B_7X_7 + U \quad (5)$$

Where:

Y_{cnt} = No. of projects delayed in the preceding 10 years (Unitless)
B_0 = Constant
B_1-B_7 = Unstandardized coefficients of the factors
X_1-X_7 = Delay factors (independent variables)
U = Unexplained error of term

Substituting the values in Table 5:

$$Y_{cnt} = 1.530 - 0.293X_1 - 1.337X_2 - 0.293X_3 - 1.089X_4 + 0.335X_5 + 0.682X_6 - 0.454X_7$$

Interpreting the equation: Y (No. of delays) = 1.530 (unitless), if all the other factors do not exist.

A unit increase of X_1 (defective site management programmes factor) will lead to a corresponding negative increase of 0.293 in Y if all other factors are constant, a unit increase of X_6 (delay from subcontractors factor) will lead to a corresponding increase of 0.682 in Y if all other factors are constant. Factors X_2, X_3, X_5 and X_6 are positive relatively important, but X_2 is the only significant factor in the group. Since, significance level is determined at <0.05, hence factor X_1 (defective site management programmes) that was highly rated by the respondents is not significant from this model.

CONCLUSION

The results of this research has generally supported the trend that funding and payment is the most important factor contributing to project delay. However, the mathematical expression in this study for explaining delay is a new contribution to knowledge on the subject matter.

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