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Risk Classification Model for Design and Build Projects

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Abstract: The purpose of this paper is to investigate if the various risk sources in Design and Build projects can be classified into three risk groups of cost, time and quality using the discriminant analysis technique. Literature search was undertaken to review issues of risk sources, classification of the identified risks into a risk structure, management of risks and effects of risks all on Design and Build projects as well as concepts of discriminant analysis as a statistical technique. This literature review was undertaken through the use of internet, published papers, journal articles and other published reports on risks in Design and Build projects. A research questionnaire was further designed to collect research information. This research study is a survey research that utilized cross-sectional design to capture the primary data. The data for the survey was collected in Nigeria. In all 40 questionnaires were sent to various respondents that included Architects, Engineers, Quantity Surveyors and Builders who had used Design and Build procurement method for their recently completed projects. Responses from these retrieved questionnaires that measured the impact of risks on Design and Build were analyzed using the discriminant analysis technique through the use of SPSS software package to build two discriminant models for classifying risks into cost, time and quality risk groups. Results of the study indicate that time overrun and poor quality are the two factors that discriminate between cost, time and quality related risk groups. These two discriminant functions explain the variation between the risk groups. All the discriminating variables of cost overrun, time overrun and poor quality demonstrate some relationships with the two discriminant functions. The two discriminant models built can classify risks in Design and Build projects into risk groups of cost, time and quality. These classifications models have 72% success rate of classification of risks in Design and Build projects. These models are strongly recommended for use of clients, Design and Build contractors and Risk Managers for the management, control and mitigation of future risks in new Design and Build projects. These models will offer appreciable improvements in risk management and mitigations which can enhance better management of future Design and Build projects. This study also recommends that clients and contractors using Design and Build approach should watch out for emerging issues of cost overrun and poor quality in their projects as these can dictate classification of newly encountered risks.

Keywords: Risk classification, model, Design and Build projects

1. Introduction

Risk is inherent in all human Endeavour's and construction projects are no exceptions as they involve activities that are prone to different types of risks. Projects that are procured by Design and Build method are equally subjective to different types of construction risks. Many researchers in construction management and other related fields of study have defined risk in various terms. Risk has been defined as uncertainty of an outcome which can result in positive opportunity or negative impact (OGC, 2003). According to Boehm and Port (2006) as cited in Salako (2010) risks are situations or possible events that can cause a project to fail as to meet its goals. They range in impact from trivial to fatal and in likelihood from certain to improbable. Every building procurement method has its own basic characteristics that define and dictate its framework. When a procurement method is chosen and selected for a specific project, the characteristics of such procurement methods dictate the likely risks and levels of uncertainties involved. What is hence, most important is to identify and assess these inherent risks as to formulate appropriate risk management structure to deal with these risks.

Design and Build procurement method is one in which a design-build contractor is given the responsibility of carrying out both the design and construction of the project for the client. Several clients are now dissatisfied with the traditional procurement method because of its slowness and expensive nature. They are now attracted to Design and Build procurement because of its speed of project completion, cost reductions, simplified contracting and creation of single point responsibility. Furthermore, Engineers are intrigued by Design and Build procurement because it allows them to use their close client relationships to capture larger percentage of construction revenues. Contractors also like Design and Build procurement because of its flexibility and profit potentials. According to Ashcraft et al (2002) these converging interests are now fueling a trend towards further use of Design Build method for more project delivery in most countries of the world and Nigeria is no exception.

Design and Build procurement method is prone to several risks. Some of these risks are borne by the design-build contractor and the client and in some cases are shared by both parties. However, Salako (2010) has documented thirty-five (35) sources from which Design and Build risks can emanate. These thirty-five risk factors are further classified into three main categories of cost, time and quality related factors. In the same vein, Varaman (2002) attempted a classification of Design and Build risks in America to arise from fifteen sources found in the US. These sources can further be classified into seven sources as insurance, design-errors and omissions, liabilities of the construction entities and designers, catastrophes (force majeure events) different site conditions and environmental pre-existing conditions, responsibility for health and safety issues and lack of fulfilling obligation from a member of the team. These seven classifications also encapsulate the earlier three classifications by Salako (2010) and indeed wider in scope. This paper examines the issues of risk classification in Design and Build projects from cost, time and quality related factors in Nigeria. It proposes a classification model for classifying the various types of risks impacting on Design and Build projects from discriminating variables of cost and time overruns and poor quality.

2. Risk in Design and Build Projects

Risks are inherent in construction projects irrespective of the size and environmental location of the project. In Design and Build projects as indicated by Seng and Yusof (2006) that the contract of this method transfers more of the risks to the contractor than any other construction contract. Among a variety of risks the Design-Build contractor usually takes on are mainly speculative risks. Risks in Design and Build projects can emanate from cost, schedule, quality and management of the project. These risks can exist from start to finish of the construction process. In Tsai and Yong (2010) risks in Design and Build were measured from proposal surveying, scheme Designing, procurement contracting and construction process which are receiving stages of a construction project. This infers that risks in a Design and Build project can be measured in all stages of this project. Risk treatment in construction has been focused on risk distribution between the owner and contractor using suitable contractual clauses. According Seng and Yusof (2006) this distribution has been only one sided and more on the contractor side to assume most of the responsibilities of the risks than the client. Both Tsai and Yong (2010) and Seng and Yusof (2006) reported different studies in which risk allocations of different procurement methods were compared between the client and the contractor. Fig. 1 indicates results of these studies where in Design and Build method the contractor shares more of the risks than the client. The reason for this is because he is in charge of design, procurement, engineering and construction of the project as the client is mainly expected to pay for all these services after the completion of the project that is "to turn the key."

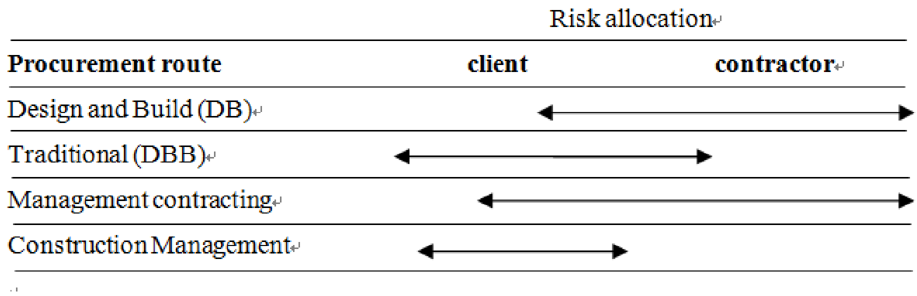

Fig. 1. Allocation of risk in each type of procurement contract (Seng and Yusof, 2006)

Furthermore, in accordance to Oztas and Okmen (2004) as well as Banik (2001) studies as cited in Salako (2010) the followings are identified as risks in Design and Build projects. All these thirty-five risks can also be best classified into a risk structure as indicated in the studies of Tsai and Yong (2010) for Design and Build Projects.

1. Permit and approvals
2. Site access/right of way
3. Different site conditions (unforeseen site conditions)
4. Weather conditions (exceptional inclement weather)
5. Unidentified utilities
6. Catastrophes
7. Establishment of project cost
8. Constructability of design
9. Quality control and assurance
10. Redesign if over budget
11. Construction defects (inadequate quality of works and need for correction)
12. Government Acts and Regulation
13. Tax rate exchange
14. Environmental risks
15. Labour disputes
16. Safety
17. Inflation
18. Third party litigation
19. Design errors or omissions
20. Warranty of facility performance
21. Financial failure – any party (lack of payment)
22. Owner and contractor experience
23. Level of design completion
24. Design and Builder selection
25. Contract and award method
26. Delayed payment (delay progress payments)
27. Indemnification and hold harmless
28. Change order (change in quality/scope of work)
29. Design Changes
30. Delay in design
31. Bureaucracy
32. Difficulties/delay in availability of materials, equipment and labor

33. Exchange rate fluctuation/devaluation (country's economic and political situation)
34. Accidents
35. Inadequate specification

These risk classifications is in agreement with Tsai and Yong (2010) risk structure classifications in Design and Build presented in Table 2.

3. Risk management in Design and Build projects

Risk management is the procedure to control the level of risk and mitigate its effects. According to Salako (2010) effective management of risks is critical to the success of any Design and Build project. Traditionally, contractors in the past are known to use financial mark-ups to cover risks in projects but as project competition becomes higher contractors have to device more awareness of risk and strategize on assessing, modeling, analyzing and mitigating the risks. According to Baker, Ponniah and Smith (1999) as cited in Salako (2010) there are five systematic steps in managing risk as (1) Risk identification (2) Risk Estimation (3) Risk Evaluation (4) Risk Response and (5) Risk Monitoring. The first two stages of risk management that is Risk Identification and Estimation can be summarily referred to as Risk Analysis. Also Risk analysis and Risk Evaluation are known as Risk Assessment. Risk Assessment with Risk Response and Monitoring can be grouped as Risk Control. These stages of risk management can be summarized in Table 3.

Table 1. Classification of the identified risks in Design and Build projects into a risk structure

A. Natural Phenomenon	18. Accidents
1. Weather conditions (exceptional inclement weather)	19. Safety
2. Catastrophes (fire, earthquake, windstorm)	20. Delayed payment (delay progress payments)
B. Economics/finance	21. Design and Builder selection
3. Inflation	22. Owner's experience
4. Financial failure – any party (lack of payment)	23. Designer and Builder selection
5. Exchange rate fluctuation/devaluation	24. Charge order (change in scope of work/quality)
6. Tax rate charge	25. Design changes
C. Politics/Government/Society	**H. Designer**
7. Government Acts and regulations	26. Permits and approval
8. Bureaucracy	27. Establishment of a project cost
D. Industrial Characteristics	28. Constructability of design
9. Labour disputes	29. Redesign if over budget
10. Third party litigation	30. Errors or omissions
E. Contract	31. Level of design completion
11. Contract and award method	32. Contract and award method
12. Indemnification and hold harmless	33. Delay in Design
F. Construction	34. Inadequate specifications
13. Different sites conditions (unforeseen site conditions)	**I. Contractor**
14. Unidentified utilities	35. Warranty of facility performance
15. Construction defects (inadequate quality of works and need for correction)	36. Contractor's experience
16. Quality control and assurance	**J. Job Site**
G. Safety/Environment	37. Site access/right of way
17. Environmental risks	38.
	K. Client

3.1. Risk Effects on Design and Build Projects

According to XL Capital (2009) as cited in Salako (2010) that Design and Build projects has been classified as the most hazardous project by professional liability under writers. This is simply because combination of design activities, on site supervision and participation in the actual construction project by the contractor exposes him/her to a high degree of control over the entire project. Any emanating risk problems from these sources will be allocated to the Design and Build contractor. Effects of risks on Design and Build projects are indicated as cost overruns, time overruns and unsatisfactory quality of finished project. These are the views of XL capital (2009) and Banik (2001). Salako (2010) further stressed that summarily, effects of risk on Design and Build project can be documented as failure to keep within the cost estimate, failure to achieve the required completion date and failure to achieve the required quality and operational requirements. For the success of any Design and Build project these factors need to be considered at the inception of the project and also efficiently and effectively managed throughout the Design and Build process.

3.2. Theoretical Concepts of Discriminant Function Analysis

Discriminant analysis is a statistical technique for predicting group membership based on a linear combination of independent variables. This method combines independent variables into a single new variable known as discriminant function. Theoretical concepts of discriminant function analysis has been documented by past works of Kinnear and Gray (2001), Stockburger (2007), Poulsen and French (2010) as well as Statsoft (2003).

According to Kinnear and Gray (2001) the efficiency of discriminant function is tested with a statistic known as Wilks' Lambda (^). This statistic indicates significant difference among the target groups. Discriminant function analysis idea can be expressed as follows. Let Y_i be the Dependent variable while V_i be the independent variables such that $V_1, V_{2 \ldots\ldots} V_n$ be the n independent variables. The essence of Discriminant function analysis is to find a linear function Y_i of the combinations of the independent variables such that:

$$Y_i = \beta + \beta_1 V_1 + \beta_2 V_2 + \ldots + \beta_n V_n \quad (1)$$

Table 2. Project risk structure

A. **Natural Phenomenon**	H. **Safety/Environment**
A01 Earthquake	H01 Environment damage/pollution
A02 Fire	H02 Accident-related loss
A03 High gale	H03 Traffic or work hour restriction
A04 Rainfall	H04 Third party's objection
B. **Economics/Finance**	I. **Client**
B01 Increased materials cost	I01 Feasibility study
B02 Exchange rate fluctuation	I02 Unreasonable demand
B03 Difficulty of financing	I03 Reference by subcontractors
B04 Low market demand	I04 Relation with the third party
B05 Strong Competitor	I05 Late payment
C. **Politics/society**	I06 Reliance on architect /consultant
C01 Change of laws	I07 Jobsite superintendent being incompetent
C02 War/revolution/riot	I08 Financial problem/bankruptcy
C03 Bribery/corruption	I09 Difficulty in choosing business dealer
C04 Language/cultural barrier	J. **Designer**
C05 Lobby (Legal/illegal)	J01 Constructability
C06 Rigid bureaucracy	J02 Vague drawing specifications
D. **Industrial characteristics**	J03 Incomplete construction area
D01 Monopolized bidding	J04 Incompetent supervision skills
D02 Labour union	J05 Frequent design change
E. **Contract**	J06 Lack of fair stance
E01 Unequal contractual provisions	K. **Contractor**
E02 Dispute among entities	K01 Stringent contractual terms
E03 Unjust arbitrator	K02 Deficit contracting
E04 Inadequate insurance coverage	K03 Short of manpower or experience
E05 Defect warranty	K04 Higher cost than bid taking
E06 Misjudged cost estimation	K05 Short of capital/equipment
F. **Construction**	K06 Local jobsite particularity
F01 New technology implementation	K07 Shortage in machine tools and workers mobilization due to clashes of several projects
F02 Too high quality standard	
F03 Faulty job field survey	
F04 Inadequate construction planning	K08 Low safety awareness
F05 Inadequate procurement planning	K09 Erroneous allocation of human resource
G. **Job site**	K10 Lack of trustworthy support by subcontractor
G01 Incompetent planning	K11 Low working morale
G02 Incompetent management	K12 High personnel mobility
G03 Incompetent coordinator	

Table 3. Risk management process

	Risk process	Management procedure
1.	Risk Identification	This involves listing all potential areas where risk may occur very early on a project. It involves identifying, characterizing and assessing threats.
2.	Risk Estimation	Once risks have been identified, they are assessed as to their potential severity of loss and to the probability of occurrence.
3.	Risk Evaluation	Risk is evaluated from risk= Rate of occurrence X impact of the event. Composite risk index = impact of risk event x probability of occurrence
4.	Risk Response	These are four methods of risk treatments as Avoidance (eliminate, withdraw from or not become involved). Reduction (optimize – mitigate) Sharing (transfer – outsource or insure) Retention (accept and budget)
5.	Risk Monitoring	This involves proposing applicable and effective securing controls for managing the risk. This should contain a schedule for control, implementation and responsible persons for the actions.
6.	Implementation	It follows all the planned methods of mitigating the effect of the risks. It involves purchasing insurance policies for the risks that have been decided to be transferred to an insurer, avoid all the risks that can be avoided, without sacrificing the entity's goals, reduce others and retain the rest.

The function Y_i is the discriminant function. Scores on the discriminant function are spread out to all categories of the dependent variables. In this paper, the discriminant function analysis is derived from three categories of risk of cost, time and quality related groups. There are 19 independent variables that constitute the cost risk group, 21 independent variables that constitute the time risk group while 10 independent variables make up the quality risk group. These independent risk factors are now combined together using discriminant function analysis technique to produce two discriminant functions.

However, Stockburger (2007) indicates that the main purpose of discriminant function analysis is to predict group membership while Statsoft (2003) also indentifies several purposes of discriminant function analysis. Such purposes include classification of cases into groups using a discriminant prediction equation, testing theory by observing whether cases are correctly classified as predicted, investigating differences between or among groups and to determine the most parsimonious way to distinguish among groups. Some of these purposes identified by Statsoft (2003) for discriminant function analysis are also explored in this study. According to Kinnear and Gray (2001) there are three types of discriminant analysis (DA) technique in use which are direct, hierarchical and step wise. Kinnear and Gray's (2001) study emphasizes that direct DA involves all the variables entering the equations at once, in hierarchical DA, the variables enter the equation according to a schedule set by the researcher whereas in stepwise DA statistical criteria are used in determining when the variables will enter the equations. This third type of DA is generally in use. This study also utilizes this stepwise DA technique for its analysis. Using the stepwise DA method there are various statistics for weighing the addition and removal of variables from the prediction equation. Wilks' Lambda (^) is the most commonly used statistics for this purpose and its significance is measured with an F- test. At each step of adding a variable to the analysis the variable with the largest F is included and while variables that are to be removed are those that fall below a critical level should be removed from the analysis. When the process of adding and subtracting variables is completed, the variables remaining in the analysis are used to build the discriminant function. The first discriminant function built provides the best means of group membership while later functions built also contribute to the prediction process. Discriminant function analysis has its own assumptions. It is assumed that the independent variables used in DA will be quantitative in nature while in some cases use of qualitative variables is allowed. The data for DA must be multivariate normal that is the sampling distribution of any linear combination of predictors is also normally distributed. It is also required to watch out for outliers where extreme values must be eliminated. There must be homogeneity of variance – covariance matrices and it is also important to avoid multicollinearity that is, high correlation among the independent variables. Furthermore, no variable must be exact linear-function of any other variables that is known as singularity. Most of these assumptions are kept in this study.

When DA is carried out with the Statistical Package for Social Sciences (SPSS) several outputs are produced. First output is about the data and number of cases in each category of the grouping variable. Next, is Group statistics showing the number of cases for each independent variable at each level of the grouping variable and their means and standard deviations are also displayed. A univariate ANOVA statistics is further produced showing the statistical significant difference among the grouping variable means for each independent variable. In this ANOVA statistics computation, the smaller the Wilks' Lambda value computed for an independent variable the more important is that independent variable to the discriminant function. Furthermore, a summary table showing which variables entered the prediction equation as well as those removed from the analysis with values of Wilks' Lambda and their associated probability levels are also included in this output. Next outputs of variables from this analysis which are variables that are entered in each step of the DA as well as variables not in the analysis are also displayed.

Statistics of the built discriminant functions are also presented as summary of Canonical discriminant functions which indicate their Eigen values as well as their Wilks' Lambda values. In this output the percentage variance accounted for by each discriminant function is shown while their test of significance is shown in Wilks' Lambda's table. In the Eigen value table, the larger the Eigen value of a discriminant function the more of the variance in the dependent variable is explained by this discriminant function. An output of the structure matrix is also presented which shows the correlation between the independent variables and their respective discriminant functions. The last of the outputs presented in SPSS discriminant analysis is the classification results which indicate the success rate for predictions of membership of the dependent grouping variable's categories using the discriminant functions built in the analysis.

3.3. Research Study

Design and Build procurement method has been used significantly for a lot of projects in Nigeria like residential building projects, roads and infrastructural projects. Some of these projects have encountered various types of risks that mar the outcome of these projects which require risk management skills. Effects of some of these risks on the performance of the projects as well as the risk impact classifications are investigated in this study to propose a risk classification model for Design and Build projects.

3.4. Research Methodology

Extensive literature review was undertaken on identifying sources and types of risks in Design and Build projects. Risk classification and impact on Design and Build projects were also reviewed. Based on the literature search a research questionnaire was designed to elicit information from respondents such as Architects, Builders, Engineers, Quantity Surveyors and Design and Build Contractors who have been involved in Design and Build projects in the country. Forty (40) questionnaires were sent to these respondents for the survey.

Data for this survey were collected through the use of these questionnaires in Nigeria. These questionnaires elicited information about the types of risks inherent in Design and Build projects, effect of these risks on performance of Design and Build projects in terms of cost, time and quality, how some of these risks are allocated between parties as well as their mitigation and management. In ensuring the effect of these risks on Design and Build projects the actual and estimated durations of the projects, the actual and final cost of these projects were also measured separately to confirm whether there were cost and time overruns. Quality performance factors were also measured separately.

In analyzing the data from this survey, each of these questionnaires were one by one coded and information from these questionnaires were extracted into data sheets. These data information were later input into the SPSS software for statistical analysis. For the risk classification model, data from cost and time overruns and poor quality measured separately in the questionnaires as well as data from risk impact measured as very high impact, high impact, average impact, low impact and no impact were used for the discriminant analysis for building the classification model of this study. Any of these categories of the independent variables within the categorization of impact on cost, time and quality with a score of average impact (score = 3) and above up to very high impact (score = 5) were taken as cost and time overruns while for quality it was taken as poor quality for building the model.

3.5. Risk Classification Model for Design and Build Projects

Sources of risks in Design and Build projects can emanate from over thirty-five (35) sources which are further classified into ten (10) main areas. Impact of these variables were measured as very high impact (score=5), high impact (score=4), average impact (score=3), low impact (score=2) and also no impact (score=1). Respondents were asked to rate the level of impact of cost, time and quality risk factors on their recently completed Design and Build projects. For building the risk classification model Discriminant Function Analysis (DFA) techniques was used for the data collected from the survey questionnaire. For the stepwise Discriminant analysis, 19 independent variables grouped as cost related risk factors, 21 independent variables grouped as time related risk factors as well as 10 independent variables grouped as quality related risk factors were used for the analysis. These independent variables are indicated below:

Cost Related Risk Factors

i. Charges in quantity/scope of work
ii. Inflation
iii. Exchange rate fluctuation/devaluation
iv. Owner and contractor experience
v. Contract and award method
vi. Differing site conditions
vii. Constructability of design
viii. Quality control and assurance
ix. Owner delays (lack of payment)
x. Errors or omissions revealed during construction
xi. Government Acts and regulations
xii. Financial failure
xiii. Warranty of facility performance
xiv. Inadequate specifications
xv. Bureaucratic problems
xvi. Difficulties/delays in availability of materials, equipment and labour
xvii. Construction defect
xviii. Safety and accidents
xix. Catastrophes

Time Related Risk Factors

i. Changes in quantity/scope of work
ii. Permits and approvals
iii. Differing site conditions
iv. Site access/right of ways
v. Design changes
vi. Difficulties/delay in availability of material equipment and labour

vii. Owner delays (lack of payment/delayed progress)
viii. Construction defect
ix. Owner and contractor experience
x. Delay in design/redesign over budget
xi. Exceptional in element weather
xii. Constructability of design
xiii. Inadequate specifications
xiv. Contract award method
xv. Government Acts and regulation
xvi. Third party delay and default
xvii. Bureaucratic problem
xviii. Safety and Accidents
xix. Financial failure
xx. Errors or omission revealed during construction
xxi. Catastrophes

Quality Related Factors

i. Quality control and assurance
ii. Constructability of design
iii. Construction defect
iv. Owner and contractor experience
v. Inadequate specification
vi. Contract and award method
vii. Warranty of facility performance
viii. Differing site condition
ix. Errors or omission revealed during construction
x. Catastrophes

For the Discriminant analysis, respondent ratings of very high impact (5), high impact (4) and average impact (3) were recoded as 1 to mean cost and time overruns and poor quality while low impact (2) and no impact (1) were recoded as 0 – which implies no cost and time overruns and good quality. The respondent ratings for all the cost, time and quality related risk independent variables were used to build the Discriminant function. These independent variables discriminate any new risk case classification into any of the three risk groups.

3.6. Findings and Discussions

Profession of respondents that participated in the study is presented in Table 1. Results from Table 1 indicate that 31% of the respondents are Quantity Surveyors, 27% are Architects, 19% are Civil Engineers, 12% are Builders, 8% are Mechanical/Electrical Engineers while the remaining 3% are Accountants.

Most of the respondents for this study are Quantity Surveyors and Architects. Quantity surveyors are professionals working in the construction industry who normally prepares cost estimates of building and civil engineering projects from drawings and specifications. They are also involved in cost monitoring and control of the projects. An Architect is also a professional working in the construction industry. He is involved in planning, designing and proper sighting of buildings. He supervises the construction of the project on behalf of the client. Both professionals have very important duties and responsibilities for the Design and Build process (as shown in Table 4).

Experience of respondents that participated in this study is presented in Fig. 2. It is indicated in Fig 2 that 23% of the respondents have less than six years experience, 46% of the respondents have 6-10 years experience, 8% of the respondents have 11-12 years experience and 23% of the respondents have above 20 years experience. Since most respondents have between 6-10 years experience in Design and Build project execution, such experience can enhance quality information for the study.

Table 4. Profession of respondents

Profession	Frequency	Percentage (%)
Architect	7	27
Mech/Elect. Engineers	2	8
Builder	3	12
Civil Engineer	5	19
Quantity Surveyor	8	31
Accountant	1	3
Total	26	100

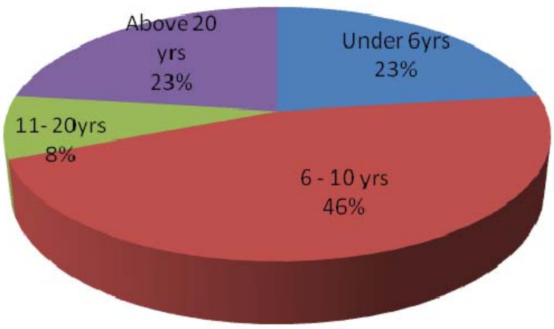

Fig. 2. Experience of respondents that participated in Design and Build project

In classifying risks in Design and Build projects into groups, a step wise discriminant analysis was undertaken for the risk groups and its independent variables. Results of the analysis are presented in Tables 5, 6, and 7.

From the results presented in Table 5 for choice of risk groups there are 19 independent variables contained in cost related risk group, 21 independent variables make up the time related risk group while only 10 independent variables make up the quality related risk group. Only three impacts of risk in terms of cost overrun, time overrun and poor quality highly discriminate the choice of the risk groups. Also, from the above table only cost overrun in cost related risk group, time overrun in time related risk group and poor quality in quality related risk group have higher means (X = 2.53, 2.29, 2.70) than their other discriminating variables in their risk groups.

From the results presented in Table 6, time overrun and poor quality have lower Wilks' Lambda values (Wilks' Lambda = 0.06, 0.07) also with highest F – values (F = 348.93, 334.27) than cost overrun with higher Wilks' Lambda value (Wilks' Lambda = 0.13) but lower F-value (F = 164.56). Time overrun and poor quality with smaller Wilks' Lambda values are more important to the discriminant function of this analysis than cost overrun. Also from the ANOVA Table the Wilks' Lambda values are also significant by the F-test for cost overrun, time overrun and poor quality. This implies that a significant difference exists between the risk group means of cost, time and quality related factors.

Table 5. Descriptive results of discriminant analysis of risk groups

Risk groups	Discriminating variable	Mean	S.D	N
Cost related risk factors	Cost overrun Time overrun Poor Quality	2.53	0.77	19
Time related risk factors	Cost overrun Time overrun Poor Quality	2.29	0.46	21
Quality related risk factors	Cost overrun Time overrun Poor Quality	2.70	0.67	10

Table 6. Test of equality of group means

Discriminating variables in risk groups	Wilks' Lambda	F	df1	df2	Sig (P<0.05)
Cost Overrun	0.13	164.56	2	47	0.00
Time Overrun	0.06	348.93	2	47	0.00
Poor Quality	0.07	334.27	2	47	0.00

Table 7. Summary of Canonical Discriminant functions

Function	Eigen value	% of variance	Cumulative%	Canonical correlation
1	21.23	58.9	58.9	0.98
2	14.84	41.1	100	0.97

Table 8. Test of Significance of Eigen value for each discriminant function

Test of functions	Wilks' Lambda	Chi- Square (χ^2)	DF	Sig.
1 through 2	0.003	269.76	6	0.00
2	0.063	127.08	2	0.00

From the results shown in Table 7, Canonical discriminant functions 1and 2 have their Eigen values (Eigen values = 21.23, 14.84) higher than one, (Eigen value = 1) which implies that both functions explain more of the variance between the risk groups. The third column of this Table shows that discriminant function 1 explains 58.9% of the variance between the risk groups while discriminant function 2 only accounts for 41.1% of the variance. The last column of this Table indicates the canonical correlation of the discriminant functions to the independent variables. Functions 1 and 2 have correlation (r = 0.98, 0.97) higher than the critical value (r = 0.60) hence both functions are important for the classification of the independent variables to the three risk groups.

Results of the test of significance of the canonical discriminant function are presented in Table 8. Results shown in Table 8 indicate that for test of significance of the Eigen value for function 1 through to 2 the probability value (p= 0.00) is lower the critical value (p= 0.05) hence this Eigen value is significant for the discriminant function 1 while also for test of significance of Eigen value for function 2 indicates that the probability value (p=0.00) is also lower than the critical value (p= 0.05) hence both Eigen values for both functions 1 and 2 are both significant. The chi-square values (χ^2 = 296.76, 127.09) which is a statistics for measuring these tests of significance of the Eigen values are quite higher than the tabulated values (χ^2_{tab} = 14.49, 7.37), hence both tests of the Eigen values are significant. Wilk's Lambda is used to test if there is relationship between the discriminant function and the independent variables. Associated with each Wilk's Lambda is a chi-square statistics to measure the significance of this relationship. If this chi-square statistic corresponding to Wilk's Lambda is statistically significant it concluded that a relationship exists between the discriminant function and the independent variables. By the results in Table 8, there is significant relationship between the discriminant functions 1 and 2 and the independent variables of cost, time and quality related groups.

Results of the structure matrix showing the correlation between the discriminating variables and their discriminant functions are presented in Table 9. Results in Table 9 indicate that both discriminant functions 1 and 2 show some degree of correlation with their respective discriminating variables. Function 1 indicates positive correlations with cost overrun (r=0.219) and poor quality (r=0.574) while it shows negative correlation with time overrun (r= -0.789) this implies that both cost overrun and poor quality contributes positively to the discriminant function while time overrun has negative contribution to the function.

Similarly, function 2 indicates positive correlation with time overrun (r=0.331) and poor quality (r=0.698) while it demonstrates negative correlation with cost overrun (r=- 0.635). This also indicates that time overrun and poor quality has positive contributions while cost overrun has negative contribution to discriminant function 2. Both functions have relationships with the three discriminating variables.

Table 9. Structure matrix showing correlation between Discriminating Variables and Discriminant Functions

Discriminating	Function	
variables	1	2
Cost overrun	0.219	-0.635
Time overrun	-0.789	0.331
Poor quality	0.574	0.698

The coefficients for building the classification models are presented in Table 10. From the results in Table 10 the two discriminant function equations for predicting the classification of risks in Design and Build projects are given as:

$$DF1 = 0.219COR + 0.514PQ - 0.789TOR \quad (2)$$

$$DF2 = 0.331TOR + 0.698PQ - 0635COR \quad (3)$$

For discriminant Eq. (1), if a Design and Build project has no issues of cost overruns and poor quality risks apprehended in the project, the risk classification will majorly be time overrun related issues that would impact negatively on the project. Similarly, for discriminant function 2, if there is no serious threats of cost overruns and poor quality risk factors the classification will also be time overrun risk factors that will be impacting positively on the project.

Table 10. Canonical Discriminant Functions' Coefficients

Discriminating	Discriminant function	
variables	1	2
Cost overrun (COR)	0.219	-0.635
Time overrun (TOR)	-0.789	0.331
Poor quality (PQ)	0.574	0.698

Analysis of the classification of risks in Design and Build projects is also presented in Table 11. From the results presented in Table 11, 16 of the 19 cases of cost overruns are correctly predicted as cost related risk factors indicating 84.2% prediction rate, 15 of the 21 cases of time overruns were correctly classified as time related risk factors by the discriminant functions representing 71.43% success rate while five cases out of 10 poor quality cases were correctly classified by the discriminant function representing 50% success rate for the discrimnant function. However, some constants are detected in the data that is not resulting in total 100% classification success. However, 72% of the original group cases were correctly classified by this discriminant function modeled in this study.

4. Conclusions

This study reveals that time overrun and poor quality discriminate more between the risk groups of cost, time and quality related factors. The two discriminant functions explain more of the variance between the risk groups. These two classification models built have 72% success rate. Based on the empirical evidence from the results of the study it can be concluded that the two main variables that best separate or discriminate risks into its groups are impact of cost and quality on Design and Build projects. Relationship exists between the two discriminant functions and the independent variables of cost and time overruns and poor quality. These two classification models have high success rates.

This study proffered that clients and contractors using Design and Build method for their project execution should watch out for cost overrun and poor quality as both factors can help to classify newly encountered risks in their projects. These two evolving models are strongly recommended for clients, Design and Build contractors and risk managers for identifying and classifying risks in Design and Build projects. These emerging classification models can be used as early warning systems for managing, controlling and mitigating risks in Design and Build projects. Replication of this study with larger sample size in other countries of the World could help in testing this theory and whether such risk groups in Design and Build could be well predicted.

Table 11. Classification results of the grouping of risk in Design and Build projects

Discriminating variables	Predicted group membership		
	Cost related factors	Time related factors	Quality related factors
Cost overrun	16	0	0
Time overrun	0	15	0
Poor quality	0	0	5
Constants	3	6	5
Total	19	21	10
Cost overrun	84.20	0	0
Time overrun	0	71.43	0
Poor quality	0	0	50
Constants	15.80	28.57	50
Total	100	100	100

**72% of the original group cases carefully classified.

References

Ashcraft, H. W., Hanson, B., Marcus, V., and Rudy (2002). Understanding Design/Build risk. retrieved on 25th January, 2011 from www.terrarg.com/images/pdfs/designbuildrisk.pdf.

Adnan, H., Jusoff, K., and Salim, M. K. (2008). The Malaysian Construction Industry's Risk Management in Design and Build, *Modern Applied Science*, 2(5), 27-33.

Banik, G. A. (2001). Risk allocation in Design-Build Contracts, *Proceedings of Associated school of Constructions (ASC) Conference*, University of Denver, Colorado, USA, 125-136.

Babatunde, S. O., Opawole, A., and Ujaddughe, I. C. (2010). An Appraisal of project procurement methods in the Nigerian Construction Industry. *Civil Engineering Dimension, 12*(1), 1-7.

Chang, A. S., Shen, F., and Ibbs, W. (2010). Design and Construction co-ordination problems and planning for design –build project new users, *Canadian Journal of Civil Engineering, 37*, 1525-1534. doi: 10.1139/L10-090

Cho, K., Hyun, C. T., Koo, K., and Hong, T. (2010). Partnering Process Model for Public –Sector Fast Track Design and Build Projects in Korea. *Journal of Management in Engineering, 26* (1), 19-29. doi: 10. 1061/(ASCE) 0742-597X(2010)26:1(19)

Kinnear, P. R. and Gray, C. D. (2001). *SPSS For Windows Made Simple. Release 10. East Sussex*, UK Psychology Press, Taylor and Francis Group.

Lam, E. W. M., Chan, A. P. C and Chan, D. W. M. (2008). Determinants of Successful Design-Build Projects. *Journal of Construction Engineering and Management, 134*(5), 333-341.

Lin, N., Li, D., Dong, T., and Qin, Z. (2010). A new framework for designing e-government procurement in China based Ontology and Business Component (Report). *Journal of Service Science and Management,* published online at www.scirp.org/journal/PaperDownload.aspx? IssueID=415&Issue

Migliaccio, G. C., Gibson, G. E., and O'Connor, J. T. (2009). Procurement of Design –Build Services: Two-Phase Selection for Highway Projects, *Journal of Management in Engineering, 25*(1), 29-39.

Office of Government (2003). OGC's Glossary of Terms and Definition for PPM Portfolio. Retrieved on 25th January, 2011 from www.prince.official site.com/nmruntime/saveasdialog.asp?

Ojo, S. O. (2009). Benchmarking the Performance of Construction Procurement Methods against Selection Criteria in Nigeria. *Civil Engineering Dimension*, 11(2), 106-112.

Ojo, S. O. and Aina, O. O. (2010). Developing a Decision Support System for the Selection of Appropriate Procurement Method for a Building Project in Nigeria. *Global Journal of Researches in Engineering*, 10(2), 18-30.

Poulsen, J. R. and French, A. (2010). Discriminant Function Analysis (DA). retrieved on 1st January, 2010 from www.online.sfsu.edu/~efc/classes/biol710/discrim/discrim.pdf.

Rosner, J. W., Thal Jr., A. E., and West, C. J. (2009). Analysis of the Design-Build Delivery Method in Air-Force Construction Projects. *Journal of Construction Engineering and Management, 135*(8), 710-717.

Salako, O. A. (2010). *Effect of risk on Performance of Design and Build Projects in Lagos State (unpublished M.Sc. Thesis)*, University of Lagos, Lagos, Nigeria.

Seng, N. W. and Yusof, A. M. (2006). The Success Factors of Design and Build Procurement method: A Literature Visit, *Proceeding of the 6th Asia – Pacific Structural Engineering and Construction Conference (APSEC) held at Kuala Lampur, Malaysia, September 5 – 6*, C-1 – C-11.

Songer, A. D. and Molenaar, K. R. (1996). Selecting Design and Build: Public and Private sector Owner Attitudes. *Journal of Management in Engineering*, 12(6), 47-53.

Songer, A. D. and Molenaar, K. R., and Robinson, G. D. (2010). Selection factors and success criteria for Design and Build in U.S and UK. retrieved on 1st January, 2010 from www.Colorado.edu/engineering/civil/db/papers/ usuk.

StatSoft, Inc., (2003). Discriminant Function Analysis. retrieved on 1st January, 2010 from www.statsoft.com/textbook/stdiscan.html

Stockburger, D.W (2007). Multivariate Statistics: Concepts, Models and Application. retrieved on 21st July, 2007 from www.Mlto3m.

Tsai, T. C. and Yang, M. L. (2010). Risk Assessment of Design-Bid-Build and Design-Build Building Projects, *Journal of the Operations Research Society of Japan*, *53*(1), 20 – 39.

Vanaman, D. (2002). Design-Build Risks. Retrieved on 25th January, 2011 from www.pbworld.com/services/ in/downloads/design-build-risk.pfd.

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Appendix

QUESTIONNAIRE TO EVALUATE THE EFFECT OF RISK ON PERFORMANCE OF DESIGN AND BUILD PROJECTS

SECTION A: PERSONAL DATA

1. Profession of respondent
{} Architect {}Mechanical Engineer {} Builder {}Project Manager {} Civil Engineer
{} Quantity Surveyor {} Electrical Engineer {} Others (Please specify)…………………………..

2. a. Professional body affiliated to
{}NIA {}NIQS {} PMI {}NIOB {}NSE
{} Others (Please specify)…………………………………………………….
b. Grade of membership (please indicate)……………………………………….

3. Length of Post-qualification experience
{} Under 6 years {} 6-10years {} 11-20years {} 20-30years
{} Above 30 years

4. Total years of experience in the Construction Industry
{} Under 11 years {} 11-20years {} 20-30years {} Above 30 years

5. Highest Academic Qualification obtained
{} OND {} HND {} B.Sc. {} PGD {} M.Sc./MPM {} Ph.D.
{} Others (Please specify)………………………………………………………………….

6. Position within your organisation (please indicate)……………………………………….

7. Type of Respondent
{} Client {} Contractor {} Consultant {} Others (please specify)………………………………

SECTION B: QUESTIONS RELATED TO YOUR ORGANISATION

8. Number of employees
{} Under 10 {} 11 – 50 {} 51-100 {} Over 100

9. Number of Professional Staff
{} Under 5 { }6-10 {}11-20 {}21-30 {} Above 30

10. Number of Years in Operation
{ } Less than 5 years { } 6 - 15 years { } 16 - 30 year: { } Over 30 years

11. Average Job Turnover (in terms of average annual total projects value in the last 5 years) { } Less than N500 million { } N500m - Nl billion {} Nl billion - N5 billion { } Over N5 billion

SECTION C: PROJECT CHARACTERISTICS

12. Category of Client
{ } Private Individual { } Corporate Body
{ } Government { } Religious Body
{ } Educational Institution {} Manufacturing Company
{ } Property Development Company { } International Organization
{ } Private Sector Organization {} Others (Please specify)

13. Who are the supervising consultants involved (Please tick as applicable)
{} Architect {} Quantity Surveyor {} Civil/Structural Engineer {} Project Manager
{} Mechanical/Electrical Engineer {} Others (Please specify)………………………………………

14. Estimated construction duration ....Months
15. Actual construction duration ....Months
16. Initial project value ………………………………………………………..
17. Actual project value ………………………………………………………..
18. Indicate your level of satisfaction with the achieved quality of the project at the completion stage, where, 5=Very Highly Satisfied, 4== Highly Satisfied, 3= Averagely Satisfied, 2= Slightly Satisfied and 1= Not Satisfied.

S/N	QUALITY PERFORMANCE FACTORS	LEVEL OF SATISFACTION				
		Very - Highly Satisfied	Highly Satisfied	Averagely Satisfied	Slightly Satisfied	Not Satisfied
1	Workmanship of constructors of the project					

2	Conformance with specification by the contractor					
3	Overall quality of the building facility					

SECTION D: IMPACT OF RISK ON COST, DURATION AND QUALITY

19. Please state the impact {effect) of each of the following risk factors on the cost of your selected project. Mark the appropriate column that applies.

		IMPACT ON COST				
S/N	**RISK FACTORS IN DESIGN AND BUILD**	**Very-High Impact (5)**	**High Impact (4)**	**Average Impact (3)**	**Low Impact (2)**	**No Impact (1)**
1	Differing site conditions (Unforeseen site conditions)					
2	Changes in quantity / scope of work					
3	Bureaucratic problems					
4	Owner delays (lack of payments/delayed progress payment)					
5	Difficulties/delays in availability of materials, equipment and labour					
6	Construction defect (Inadequate quality of work and need for correction)					
7	Safety and Accidents					
8	Inadequate specifications					
9	Constructability of design					
10	Government acts and regulations					
11	Errors or omission revealed during construction					
12	Financial failure- any party					
13	Catastrophes (earthquake and fire)					
14	Owner and contractor experience					
15	Contract and award method					
16	Inflation					
17	Exchange rate fluctuation/devaluation					
18	Quality control and assurance					
19	Warranty of -facility performance					
	Others (please list and rank)					

20. Please state the impact {effect) of each of the following risk factors on the duration of your selected project. Mark the appropriate column that applies.

		IMPACT ON DURATION				
S/N	**RISK FACTORS IN DESIGN AND BUILD**	**Very High Impact (5)**	**High Impact (4)**	**Average Impact (3)**	**Low Impact (2)**	**No Impact (1)**
1	Permits and approvals					
2	Site access / Right of ways					
3	Differing site conditions (Unforeseen site conditions)					
4	Exceptionally inclement weather					
5	Changes in quantity / scope of work					
6	Design changes					
7	Delay in design/Redesign if over budget					
8	Third party delay and default					
9	Bureaucratic problems					
10	Owner delays (lack of payments/delayed progress payment)					
11	Difficulties/delays in availability of materials, equipment and labour					
12	Construction defect (Inadequate quality of work and need for correction)					
13	Safety and Accidents					
14	Inadequate specifications					
15	Constructability of design					

16	Government acts and regulations					
17	Errors or omissions revealed during construction					
18	Financial failure- any party					
19	Catastrophes (earthquake, fire etc)					
20	Owner and contractor experience					
21	Contract and award method					
	Others (please list and rank)					

21. Please state the impact (effect) of each of the following risk factors on the quality of your selected project. Mark the appropriate column that applies.

		IMPACT ON QUALITY				
S/N	**RISK FACTORS IN DESIGN AND BUILD**	**Very High Impact (5)**	**High Impact (4)**	**Average Impact (3)**	**Low Impact (2)**	**No Impact (1)**
1	Constructability of design					
2	Owner and contractor experience					
3	Inadequate specifications					
4	Warranty of facility performance					
5	Errors or omissions revealed during construction					
6	Construction defect (Inadequate quality of work and need for correction)					
7	Quality control and assurance					
8	Catastrophes (earthquake* fire etc)					
9	Differing site condition (unforeseen ground conditions)					
10	Construction defect (Inadequate quality of work and need for correction)					
	Others (please list and rank)					

LIST OF CHANGES MADE TO VERSION 2 OF RISK CLASSIFICATION MODEL FOR DESIGN AND BUILD PROJECTS ACCORDING TO REVIEWER'S COMMENTS OF 8TH MAY, 2011TO PRODUCE VERSION 3.

Dear Editor,
The following changes were effected on the previous version of this paper corrected by Reviewers and sent to me on 8th, May, 2011.

Comment No — Effected Changes in Newly submitted Version.

1. All the headings in the previous Abstract section such as "Purpose of study, Methodology, Findings, Research Limitation/Implication, Practical Implication and Originality/Value have all been removed. The new version now contains an Abstract section with only one heading and just in one paragraph as shown in page 2of the submission.
2. The sentence in the previous Abstract that is complained to be too long has now be modified to read: "Results of the study indicate that time overrun and poor quality are the two factors that discriminate between cost, time and quality related groups. These two discriminant functions explain the variations between the risk groups. All the discriminating variables of cost overrun, time overrun and poor quality demonstrate some relations with the two discriminant functions".
3. The manuscript was given to another colleague to read and correct all typographical mistakes and errors found in the paper.
4. The roles and definitions of Quantity Surveyor and Architect as used in this paper are included in the Findings and Discussion section of the paper in page 15.
5. Equation 1 in page 10 has been written in academic format as Y_i to represent Dependent variable, V_n to represent independent variables $V_1, V_{2 \ldots\ldots} V_n$ and the discriminant function as:
$$Y_i = \beta + \beta_1 V_1 + \beta_2 V_2 + \ldots\ldots\ldots\ldots\ldots\ldots.. + \beta_n V_n \quad (1)$$
6. The meaning of Chi-Square as used in Table 8 of page 17 of the new version is explained in page 18, paragraph one that for each Wilk's Lambda value is associated a Chi-Square statistic to measure the significance of the relationship between the discriminant function and the independent variables. In the results of this study a significant relationship is found between the discriminant functions and the independent variables.
7. A conclusion section has been provided in the new version where all the previous sections of "conclusions to the study, recommendations of the study and future research direction" are now being re-summarized as Conclusion of the study.
8. Ten additional journal paper references of 2008-2011 have been sourced and read to improve the previous reference section. References in the former paper were thirteen (13) in number before but now ten additional ones are now included to beef up the references to twenty-three (23). Included references are Adnan et al. (2008), Babatude et al. (2010), Chang et al. (2010), Cho et al.(2010), Lam et al.(2008), Lin

al.(2010), Magliaccio et al. (2009), Ojo (2009), Ojo and Aina (2010) and Rosner et al. (2009). All these are reflected in pages 20-21of the corrected version.

9. The Questionnaire section has now been re-summarized to three pages shown in pages 22-24 of the newly corrected version of the paper. Questions that are important for achieving the objective of this study are the only ones included.