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Research paper

Evaluation of Risk Management Capability of Public-Sector Participants in Build-Operate-Transfer Highway Projects in Nigeria

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Abstract

Risks are inherent in BOT highway projects and have serious impact on its delivery. This paper seeks to evaluate the risk management capability of the public-sector participants involved in the execution BOT highway projects in Nigeria. Questionnaire survey was adopted to elicit information from experts who are active stakeholders in BOT highway construction in Nigeria. The population of the study comprises of government officials, contractors, concessionaires, bankers, consultant engineers and quantity surveyors, and academics. The study adopted stratified random sampling. Seventy-two (72) responses were obtained from One hundred and ten "110" questionnaires administered. The study adopted fuzzy synthetic evaluation (FSE) method in the analysis of data because of its ability to handle multi attributes and multi criteria nature of the problems. The result indicated that their risk management capability is below average, though not too poor. It was found that low awareness of risk management and its importance is responsible for low overall risk management capability of the public sector and this has hindered efficient and effective project delivery by the public-sector participants. The study concluded that there is need for public-sector participants to give more attention to risk management practice and application, embrace formal risk management with considerable training to further improve their risk management capability.

Keywords: *Build-Operate-Transfer; Capability; Construction; Management; Risk.*

1. Introduction

Deng T (1) defined highway infrastructure as the lifeline of any nation which should be healthy, efficient and safe. Obozuwa D.E. Obozuwa (2) described how developed nations globally are boosting their economies through huge expenditures on infrastructures. The dilapidating conditions of basic infrastructure in many countries has been attributed to slow economic growth and development, which is getting worse on daily basis (3). The present situation in Nigeria is worrisome as only 38.9% is paved, of total highway of 196,200 km, serving a population of over 180 million people (4). This is grossly inadequate as it increases man-hour loss on day-to-day human activities. Several procurement methods have been adopted to reduce this inadequacy of highway infrastructures but little or insignificant improvement (5). Highway construction projects requires huge capital and take considerable time to complete (6, 7). The burden of executing maintenance work on the existing highways and construction of new has been a serious for government in both developed and developing countries. Baum & Tolbert (8) posited that domestic savings are not enough for governments to execute highway projects globally. The reason identified for this menace is poor revenues accruing to government and rising expenditures. It is estimated that Nigeria needs around $200b over the next two years to meet Vision 20:2020, a development plan to ensure that Nigeria emerges one of the best twenty economies in the world (9). Risk management capability of public sector participants needs urgent attention to ensure that risk allocation is optimally done between the two parties. This will bring about efficient delivery of highway projects.

2. Literature Review

2.1 Risk Management Capability and Maturity Models

Ren & Yeo (10) defined maturity models "as systematic framework to carry out a comparative evaluation (strategically) leading the organization to continuous improvement, requiring a deep understanding of the current position of an organization and the one that it aspires to be in the future". Maturity models have evolved over time. They consist of a few stages in which the complexity level increases from one to another in the searching for perfection. Hopkinson (11) described a risk maturity model as a tool designed for assessing the risk management capability of an organization. He developed a "formalized and systematic risk management maturity models to assess current risk management capability of organizations".

Yeo & Ren (12) posited that several risk management maturity models that have evolved over the years. Brookes & Clark (13) described a "maturity model as a way for organizations to implement a formal approach to risk management or as a reference to compare current practices held by the company". Yeo & Ren (12) proposed a model which was made up of four maturity levels

"(Naive, Novice, Normalized, and Natural) and measured the four attributes: culture, process, experience and application". Ren & Yeo (10) adopted a five-level evaluation model. These consist: initial, repeatable, defined, managed and optimized. This model was achieved in 2009 with the same structure of the model kept. All these models are tools that allow an organization to implement formal risk processes. They also help in identifying priorities for process improvement, which helps in the determination of adequacy of risk management process in an organization. This helps to produce action plans for developing or enhancing their risk management process maturity level.

Studies conducted by Ren & Yeo (10), Zou et al.(14) and Salawu & Abdullah (15) have highlighted the significance of adopting formalized risk management maturity models in measuring risk culture and awareness, risk management resources, risk management practice and application and risk management resources. These studies evolved many risk management maturity models to evaluate maturity level of organizations handling construction projects. However, Hopkinson (11) posited that different organizations have varied risk management maturity levels on different attributes. Therefore, adequate knowledge of the maturity levels on each attribute of risk management capability gives an insight into identifying the areas of strengths and weaknesses of organizations.

To have better understanding of risk management capability of subway contractors in China, Mu et al.(16) employed risk management maturity models in assessing the overall maturity level in different attributes. The findings revealed the subway contractors' risk management maturity to be between low and medium. Salawu & Abdullah (15) examined the risk management capability of the contracting organization handling DBB highway projects in the Nigerian construction sector. The technique, attributes and maturity levels of the existing risk management maturity models were employed to assess the risk management capability of contractors handling highway projects in Nigeria. The four maturity levels of organizations in different risk management capability attributes was based on four level descriptive scale. This includes; "naïve (level 1), novice (level 2), managed (level 3) and optimized (level 4). The descriptive scale was transformed to numerical rating scale in the range 0.0-0.25 naïve, 0.26-0.50 novice, 0.51-0.75 managed and 0.76-1.00, optimized". However, the findings revealed that different organizations have different maturity and risk management capability. Table 1 shows risk management capability attributes by different researchers.

Table 1: Attributes of risk management capability adopted by researchers

Researchers	Risk management capability attributes by different researchers			
	Culture & Awareness	Experiences	Risk Management Process	Applications & practice
Hilson (1997)	Culture	Experience	Process	Practice
Ren & Yeo (2004)	Attitude, Leadership Culture & Commitment	-	Identification Analysis Mitigation	Knowledge Management and Stakeholders Relationship
Ren & Yeo (2009)	Culture	Experience	Process	Application
Zou, et al (2010)	Culture	People and leadership	Identification Analysis	Application & practice
Hopkinson (2011)	Culture	-	Identification Analysis	Project Management
Mu et al (2014)	Attitude & Culture	-	Identification Analysis Response	Application & practice
RMRDPC (2002)	Definition culture	Experience	Process	Application
IACCM BRM3 2003	Culture	Experience	Process	Application

Source: [15]

2.2 Risk Allocation and Risk Management Capabilities in BOT Highway Projects

Risks associated with BOT highway projects are more due to a larger number of stakeholders. It also involves many agreements with varied interest (17). Hence, it is very important to have adequate knowledge of the parties' risk management capability, as this will ensure efficient and effective risk allocation. Thomas et al.(18) posited that the goal of risk allocation in projects is premised on allocating risks to the party with the best capability of managing the risk, should it eventuate. Risk management capability of the parties in BOT has a significant impact on the cost of bearing risks. Thus, it should be a key determinant of risk allocation. Improper allocation of project risks has dire consequence on the performance of BOT highway projects. This may eventually hinder the essence of the embarking on the projects, which is to obtain value for money (19). Optimal risk allocation is hinged on minimizing project costs and reducing the impact of risks by allocating each risk to the party in the best position to control them (20-23). This is premised on the principle that "the party with the best capability of management with respect to a particular risk, has the best opportunity to reduce the likelihood of the risk if it eventuates and to control the consequences of the risk, if it materializes, and thus should assume it" (24-26).

2.3 Fuzzy Synthetic Evaluation.

Ameyaw & Chan (27) defined Fuzzy mathematics as "a modern mathematics that is used to handle ill-defined and complex fuzzy phenomena, given that incomplete and vague data characterize real-world problems". Fuzzy set theory helps in "expressing imprecise, vague and qualitative information in a precise and quantitative way" (27). Fuzzy logic is an aspect of applied mathematics developed by Zadeh in 1965. Since information required in most construction and risk management researches are subjective, Boussabaine (28) opined that fuzzy logic is appropriate. Fuzzy synthetic evaluation involves using degrees of membership on fuzzy sets, and so it recognizes partial membership of elements in a fuzzy set (22).

A fuzzy set has varying degree of membership in a range interval between 0 and 1. This represents the extent to which each element belongs to the set. Fuzzy mathematics involves the use linguistic variables in the modelling of vagueness in human cognitive process. Ameyaw & Chan (27) described linguistic variables as words usually expressed in natural language such as; very cold, cold, hot and very hot that describe the fuzzy concept. These linguistic variables need to be converted to numbers which can be modelled to proffer solution to problems. Boussabaine (28) stated that fuzzy synthetic evaluation makes decision-making process easier with the modelling tools in its procedures. This is achieved by analyzing multi-level and multicriteria problems attributable to vagueness. Fuzzy synthetic evaluation can assist project managers to proffer solution construction related problems emanating from uncertain and vague facts, when represented linguistic form.

In addition, the responses from experts on their perceptions on probability of occurrence and severity of impact of risk factors are typically are mostly shrouded in vagueness (29). Fuzzy synthetic evaluation is appropriate for handling problems which are laced with ambiguity, subjectivity and imprecise judgments. FSE also entails the use of mathematical operators to deal with vagueness associated with problems in fuzzy domain (30, 31), and can quantify the linguistic facet of available data and preferences for individual or group decision-making (32). Thus, fuzzy synthetic evaluation is deemed appropriate for risk allocation in this study. It is designed to group raw data into several different categories according to predetermined quality criteria, which can be normally described using a set of functions that are designed to reflect the absence of sharp boundaries between each pair of adjacent criteria (28). FSE also provides a synthetic evaluation of an object relative to an objective in a fuzzy decision environment with multiple criteria (16, 33). Thus, making it imperative to adopt FSE in this research. Highway construction projects have numerous risk information which are mostly generated from experts whose judgement are subjective. Since, these information are imprecise and vague, its use involves evaluation of risk management capability of public-sector participants involved in BOT highway projects in Nigeria.

3. Methodology/Materials

The purpose of this quantitative study is to evaluate risk management capability of public-sector participant involved in BOT highway projects in Nigeria. The study adopts questionnaire survey method. Several authors used questionnaire survey (27) and (15) to explore risk management capability of construction organization in Nigeria. This study began with extant review of literatures in risk and construction management domains. Similarly, attributes and variables of risk maturity models and risk management capability were established. This paper is an integral part of an ongoing research on allocation of risks in BOT highway projects. A few numbers of variables were identified from literatures and previous studies. A pilot study was conducted to refine and possibly get more insight from the practitioners. The refined questionnaires were administered on the experts in Lagos and Abuja. The experts include: government agencies, highway engineers, quantity surveyors, concessionaires, registered contractors and selected financial institutions who have participated in BOT projects. One hundred and ten "110" questionnaires were administered on the respondents between March and August 2017. 72 questionnaires were validly returned, yielding a response rate of 65%. Collection of data was personally done by the researcher through a cross-sectional survey using stratified random sampling. The data collected was analysed using IBM SPSS 22 version and Mathematical Laboratory (MATLAB 2017b).
The methodology adopted for this study involved a set of procedures for achieving the risk management capability of the public-sector participants involved in BOT highway projects in Nigeria.

Step 1: Compute the Mean Scores and Membership Function for RMC Dimension
Mean score for each of the question items are computed from the respondents' ratings using formula:

$$\mathrm{Mi} = \frac{\sum_{1}^{w}=1\, wifi}{\sum_{1}^{w}=1\, f\, i|} \tag{i}$$

Where
Wi = respondents' preferences, *i* = response category of maturity levels and *fi* is the frequency

Step 2: Development of Weightings for the Dimensions and Attributes
Hence this study computed weightings for the dimensions and four attributes by applying Equation (2). The derived mean ratings and weightings for the 23 question items and the mean rating and weightings for the four attributes of organizational risk management capability.

$$\mathrm{Wi} = {Mi}\Big/{\textstyle\sum_{1}^{n} Mi} \tag{ii}$$

Where
Wi = relative weight of each dimension/attribute *i*= 1…… n dimensions
Mi = mean score of a given dimension/attribute for all the respondents
Σ *Mi* = summation of the mean ratings of all the dimensions a particular attribute or attributes for RMC

Stage 3: Computation of Membership Function for RMC Dimensions
In this research, 23 question items on the dimensions and four attributes of risk management capability (RMC) are the set of basic criteria for the fuzzy synthetic evaluation and so K = {k1, k2, k3…. k23}. The rating scale is defined as X = (x1, x2, …. x4). Where x1 = 0.13 = naive x2 = 0.38 = novice, x3 = 0.63 = managed, and x4 = 0.88 = optimized as shown in Table 3.1. Hence, membership function for each question item is derived by computing the proportion of the respondents' scores from the SPSS output as described below:

$$\mathrm{MF} = \frac{P1}{native}, \frac{P2}{novice}, \frac{P3}{managed}, \frac{P4}{optimized} = \frac{P1}{0.13}\frac{P2}{0.38}\frac{P3}{0.68}\frac{P4}{0.88} \tag{iii}$$

Where
MF = membership function
P = proportion of the total respondents that selected a particular maturity level.
For example, if respondents' ratings for a question item indicated that P1 = 30%, P2 = 25%, P3 = 35% and P4 = 10% of the total respondents selected naïve, novice, managed and optimized maturity level respectively. Then membership function of the item is computed as:

$$\mathrm{MF} = \frac{P1}{native}, \frac{P2}{novice}, \frac{P3}{managed}, \frac{P4}{optimized} = \frac{0.30}{0.13}\frac{0.25}{0.38}\frac{0.35}{0.68}\frac{0.10}{0.88}$$

$$= (0.30, 0.25, 0.35, 0.10)$$

Step 4: Computing Trapezoidal Membership Function for attribute Index and Risk Management Maturity

The set of criteria is K = (k1, k2.... k23) and set of rating alternative if X (x1, x2….x4). Hence, trapezoidal membership functions (TMF) of the attribute index for all the four attributes of risk management capability and the risk management maturity (RMM) were computed using Model 3 of the fuzzy synthetic evaluation. The model 3 was chosen because it is suitable for handling the multi-criteria condition of the risk management capability attributes and the difference in the weighting of each criterion.

The model was used in Xu, Chan, & Yeung (2010) . Model 3 is denoted as shown in equation (4):

$$\text{Model 3: } M\ \{\bullet, (+)\},\ \ bj = \min\left(1; \textstyle\sum_{1}^{m} Wi \wedge rij\right) \tag{4}$$

Where:
j(i) = trapezoidal membership functions (TMF) for 'AI' or TMF for 'RMC'
Wi = relative weight of a dimension or attribute *i* = 1….n dimension or attributes.

Equation (4) was applied with MATLAB to compute the trapezoidal membership functions (TMF) for all the attributes and the overall risk management capability for public and private sector participants.

Step 5: Defuzzification of Trapezoidal Membership Functions
Trapezoidal membership function (TMF) obtained for the attributes and the risk management maturity indices (RMMI) are defuzzified to obtain the maturity level of the construction organizations for the 4 attributes and the overall RMM. The formula stated below was used for the Defuzzification process.

$$C = \sum_{1}^{n} = (W\ X\ R_K)\ X\ L \tag{5}$$

Where
C = crisp value (maturity level) of the TMF for the attributes of the RMM
W = relative weight of a particular dimension that make up an attribute;
R_K = degree of membership for each attribute
L = is the mid-point of the rating scales for each of the maturity levels
(naïve = 0.13, novice = 0.38, managed = 0.63 and optimized = 0.88) as shown in column 4 of Table 2.

Table 2: Maturity levels and rating scale of the attributes and dimensions of risk management capability

	Linguistic variable: Risk management maturity		
Linguistic Values	Symbol	Rating Scale	Mid – Point
Naïve	NA	0 - 0.25	0.13
Novice	NO	0.26 – 0.50	0.38
Managed	MA	0.51 – 0.75	0.63
Optimized	OP	0.76 – 1.00	0.88

Source: [15]

4. Results and Findings

4.1 Description of Respondents' Demographic Information

The demographic details of the respondents. 11% of the respondents are HND holders, 57% are BSc holders, 26% are MSc/MBA holders while 06% are PhD holders. 86% of the respondents are fully registered members with their professional associations. The respondents comprise of 25% working in client organization, 22% in consulting, 19% in contracting, 17% in concession company, 12% in banking and 6% in academics. 75% of the respondents have over six years' experience in BOT highway projects. Over 50% of the respondents have handled 3 projects and above. This shows that the information supplied by the respondents can be considered appropriate and adequate for the study.

4.2 Weighting Functions of the Responses

The weightings for the responses were obtained by applying Equation (ii) in Section III. This is presented in Table 3. The weightings obtained forms part of the evaluation process.

Table 3: Weighting functions of the responses

Id Code	Public Party			
	Mean Ratings	Weightings	Means for Group	Weightings for Each Group
B11A	2.16	0.212		
B12A	2.03	0.199		
B13A	2.00	0.196		
B14A	2.06	0.202		
B15A	1.94	0.190		
Culture and Awareness			10.19	0.233
B21A	1.95	0.173		
B22A	1.92	0.171		
B23A	1.89	0.168		
B24A	1.89	0.168		
B25A	1.78	0.158		
B26A	1.81	0.161		
Practice and Application			11.24	0.257
B31A	1.95	0.259		
B32A	1.86	0.247		
B33A	1.98	0.263		

B34A	1.75	0.232		
Risk Management Resources			7.54	0.173
B41A	1.86	0.126		
B42A	1.94	0.132		
B43A	1.97	0.134		
B44A	1.97	0.134		
B45A	1.81	0.123		
B46A	1.69	0.115		
B47A	1.87	0.127		
B48A	1.61	0.109		
Risk Management Process			14.72	0.337
Total			43.69	1.000

The membership functions of the public-sector participants were derived from the responses of the experts through Equation (iii). This is shown in Table 4.

Table 4: Membership Functions of Public-sector participants

Id Code	Membership Function (Public)
B11A	[0.02 0.81 0.17 0.00]
B12A	[0.05 0.87 0.08 0.00]
B13A	[0.05 0.91 0.05 0.00]
B14A	[0.06 0.81 0.13 0.00]
B15A	[0.13 0.81 0.06 0.00]
B21A	[0.14 0.77 0.09 0.00]
B22A	[0.16 0.77 0.08 0.00]
B23A	[0.14 0.83 0.03 0.00]
B24A	[0.14 0.84 0.02 0.00]
B25A	[0.25 0.73 0.02 0.00]
B26A	[0.22 0.77 0.03 0.00]
B31A	[0.08 0.89 0.03 0.00]
B32A	[0.19 0.77 0.05 0.00]
B33A	[0.08 0.88 0.03 0.02]
B34A	[0.27 0.72 0.02 0.00]
B41A	[0.17 0.81 0.00 0.02]
B42A	[0.11 0.86 0 02 0.02]
B43A	[0.08 0.89 0.02 0.02]
B44A	[0.06 0.92 0.00 0.02]
B45A	[0.23 0.73 0.02 0.02]
B46A	[0.38 0.58 0.03 0.02]
B47A	[0.17 0.80 0.02 0.02]
B48A	[0.42 0.56 0.00 0.02]

Source: Authors (2018).

The trapezoidal membership functions for dimensions and the attributes of public-sector participants is presented in Table 5. The weightings and the TMFs for dimensions are inputted into MATLAB 2017b to get the TMFs for the attributes, using (Equation -4).

Table 5: Trapezoidal membership function (TMF) for dimensions and the attributes of public-sector participants

S/N	Dimensions	Weightings	TMFs for Dimensions	TMFs for Attributes
1	Q1	0.212	[0.02 0.81 0.17 0.00]	
2	Q2	0.199	[0.05 0.87 0.08 0.00]	
3	Q3	0.196	[0.05 0.91 0.05 0.00]	
4	Q4	0.202	[0.06 0.81 0.13 0.00]	
5	Q5	0.190	[0.13 0.81 0.06 0.00]	
	Culture and Awareness			[0.0608 0.8407 0.0994 0.0000]
6	Q6	0.173	[0.14 0.77 0.09 0.00]	
7	Q7	0.171	[0.16 0.77 0.08 0.00]	
8	Q8	0.168	[0.14 0.83 0.03 0.00]	
9	Q9	0.168	[0.14 0.84 0.02 0.00]	
10	Q10	0.158	[0.25 0.73 0.02 0.00]	
11	Q11	0.161	[0.22 0.77 0.03 0.00]	
	Practice and Application			[0.1735 0.7848 0.0440 0.0000]
12	Q12	0.259	[0.08 0.89 0.03 0.00]	
13	Q13	0.247	[0.19 0.77 0.05 0.00]	
14	Q14	0.263	[0.08 0.88 0.03 0.02]	
15	Q15	0.232	[0.27 0.72 0.02 0.00]	
	Risk Management Resources			[0.1513 0.8192 0.0326 0.0053]
16	Q16	0.126	[0.17 0.81 0.00 0.02]	
17	Q17	0.132	[0.11 0.86 0 02 0.02]	
18	Q18	0.134	[0.08 0.89 0.02 0.02]	
19	Q19	0.134	[0.06 0.92 0.00 0.02]	
20	Q20	0.123	[0.23 0.73 0.02 0.02]	
21	Q21	0.115	[0.38 0.58 0.03 0.02]	
22	Q22	0.127	[0.17 0.80 0.02 0.02]	
23	Q23	0.109	[0.42 0.56 0.00 0.02]	
	Risk Management Process			[0.1941 0.7773 0.0138 0.0200]

*TMF= Trapezoidal membership function, W= relative weightings for each of the dimensions and/or attributes

Source: Authors (2018).

To obtain the crisp value of the risk management capability attributes, the trapezoidal membership functions was used to multiply the rating scale of the attributes and dimensions of risk management capability, using (Equation-5). Thus, the attribute indices were obtained and presented in Table 6.

In Table 6, the computed attribute indices (AI) for the public party on the risk management capability is presented. The results indicated that public party organization's culture and awareness is 0.391, risk management practice and application is 0.353, risk management resources0.357 and risk management process is 0.384 respectively.

Table 6: Attributes indices and risk management capability of public party

S/N	Risk Management Capability Attributes	Attribute Index (AI)
1	Organization culture and awareness	0.391
2	Risk management practice and application	0.353
3	Risk management resources	0.357
4	Risk management process	0.384
	RMMI	**0.368**

Table 6 presents the indices of the different attributes of risk management capability of public sector participants. It shows that the indices fall within the range of 0.250 and 0.500. This implies public sector participants operates at "novice" level of maturity. The result implies that the public-sector participants are inconsistent in risk management practice, have little understanding of risk management process and are not proactive in their risk management culture. The organization is unaware of the need and value for risk management and has no structured approach to dealing with risk. The organization is not experimenting the application of risk management. No attempt is made to identify risks in the project or to develop mitigation or contingency plans. The normal method for dealing with problems is to react after a problem occurs with no proactive thought.

The public sector participants have lower risk management capability than the private counterpart. The reason for this could be attributed to low awareness on risk management on the part of officials at all tiers of government in Nigeria. Risk management has not been given the deserved attention by the government (34). The low overall risk management capability level observed in this study agrees with the findings of Zou et al. (14) on the overall risk management capability level of the construction organization in the Australia. The results obtained in this study agrees with (35) who found that few organizations are currently at Level 4, and many organizations at either Levels 2 and 3, and a significant number at Level 1.

5. Conclusion

The public-sector participants are 100% 'novice' in all the attributes of risk management capability. This is an indication that there is less awareness on the part of public-sector participants. They are less proactive in risk management because they don't see the benefit of carrying out formal risk management. There is need to initiate improvement to bring about desired level of capability for public sector participants. The optimized stage brings about effective management of risks and achievement of value for money which is the main goal of public-private partnerships.

The main contribution of this paper is in the establishment of the risk management capability of the public-sector participants in Nigeria. This will enhance improvement which will lead to optimal risk allocation, as the capability of each participant is a major factor for risk allocation. This study is not without limitations. Firstly, it focusses on only risk management capability of public-sector participants in Nigeria. Therefore, the findings will not be applicable to other infrastructure in the country. Secondly, this study was undertaken in Abuja and Lagos because of their strategic locations and the fact that BOT highway projects are still at infant stage. Also, these current findings are limited in scope and fall short of predicting risk management capability of public-sector participants in other developing countries as some risks are project and country specific.

On future research, this work has set the foundation for empirical research into risk management capability of public private partnership projects in Nigeria. There is need to evaluate the risk management capability of private-sector participants. This will surely enhance optimal risk allocation between public and private-sector participants. This will go a long way to support the country's effort at attracting more private investment into the highway sectors and ensure successful implementation of BOT projects.

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