Direct risk factors and cost performance of road projects in developing countries

Contractors' perspective

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Abstract

Purpose – Globally, road projects are notorious for riskiness, which often results in cost overruns. In developing countries, these risks are amplified by economic instabilities and institutional failures. Majority of road projects in these countries are awarded to notedly inept indigenous contractors. Currently, research on the relationship between risks and cost performance of road projects has predominantly focussed on the client's perspective. Effects of risks on contractors' cost performance (profit) are inadequately investigated in literature. The purpose of this paper is to determine the relationship between direct risks and cost performance of road projects by indigenous contractors of developing countries from the contractors' perspective.

Design/methodology/approach – The multivariate structural equation modelling technique was used to analyse purposively obtained data from indigenous contractors that recently completed road projects in Nigeria.

Findings – It was observed that a significant positive relationship exists between the aggregate project risk, i.e. project risk index of cost (PRIC) and cost performance of the projects. Significant positive relationships were also found to exist between identified cost risk centres and PRIC and between risk factors and cost risk centres. The risk centre site environment and location contributes the most to PRIC.

Research limitations/implications – Indigenous contractors of developing countries are to analyse the identified risk factors and centres prior to bidding for road projects and carefully manage them during project execution.

Originality/value – Future studies of risks in road project should aim to obtain project risk indices of costs for the projects.

Keywords Risk management, Cost overrun, Cost performance, Road projects

Paper type Research paper

Introduction

Roads are critical to harnessing the potentials of developing economies by linking different clusters of economic activities. As the main means of transportation in developing countries, roads account for the movement of about 95 per cent of freight and persons in Nigeria (Pison Housing Company, 2013). Road construction remains one of the biggest areas of construction business opportunity in sub-Saharan Africa. Nigeria, for instance, has about 195,500km of roads and only 31 per cent (60,000km) of this was reported to be tarred (Pison Housing Company, 2013; Izuwah, 2017). Ahmad (2008) estimated that Nigeria required

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$14bn for road infrastructure in the years 2008-2014. In the last three years, Nigeria budgeted ₦224.12bn (2016), ₦ 279.94bn (2017) and ₦344bn (2018) (Budgit, 2016; Budgit, 2017; Udoma, 2018) ($1= ₦361) for road construction and maintenance. This represents a vast opportunity for contractors, especially, the local firms. With a rapidly growing focus on indigenous construction capacity, many benefits will accrue to local firms if they optimised their profitability through cost-risk management in road projects.

Road construction is a particularly risky endeavour. Love *et al.* (2014) blamed poor risk management for the notoriety of road projects for cost overruns. Even in the developed world, overruns in road projects are up to 182 per cent in some cases (Odeck, 2004; Love *et al.*, 2014). When the arduous economic environment of developing countries is factored in, higher cost overruns may result since construction organisations are constantly under the influence of their economic environments (Baloi and Price, 2003). Recent studies suggest that differences in transport infrastructure cost overruns can be explained partly by geo-economic differences and region specificity of cost performance (Cantarelli *et al.*, 2012; Chileshe and Yirenkyi-Fianko, 2011). Effects of risk factors on the cost performance of road projects in developing countries of sub-Saharan Africa, therefore, deserve specific research attention. This study's quest is to explain how direct risk factors affect local contractors' profitability in developing countries.

Ofori (2000) noted the constraining effects of inflation, social unrest, high-energy costs and falling exchange rates on the construction industry of developing countries. With the low level of capacity within indigenous construction firms in sub-Saharan Africa (Laryea, 2010; Baloi and Price, 2003), it is clearly important to ascertain the influence of risk factors on the profitability of such firms in road projects. Indigenous contractors are predominantly small and medium-sized sole proprietorship generally known for poor project performance. In most cases, the firms lack project-planning abilities and hardly deploy known risk management techniques during projects execution. Thus, even direct risk factors that are normally within contractors' control are poorly managed by indigenous contractors of developing countries with attendant negative effects on the contractors' profitability.

Previous studies give inadequate attention to measuring the relationship between contractors' cost performance (profitability) and project risks. Inadvertently, research focus has dominantly been on risk and cost performance from the clients' perspective. Even at that, studies measuring the effects of risks on cost performance are very few. Odeck (2004) estimated cost overrun in road projects using estimated cost, delay in completion, completion time, year and region as predictor variables. Risk factors were not selected as determinants of cost overrun in the study. Chileshe and Yirenkyi-Fianko (2011) sought the opinion of contractors, clients and consultants on the frequency and severity of risks in the Ghanaian construction industry. It was revealed that the financial risk "delayed payment" is an important risk factor agreed to by the three groups of respondents – clients, contractors and consultants. The extent to which this risk affected Ghanaian indigenous contractors' cost performance remained uninvestigated. Baloi and Price (2003) discussed the global risk factors affecting the cost performance of construction projects and concluded that Fuzzy Set Theory is a veritable tool for modelling the risk factors. This method will, however, be unsuitable for measuring the effects of risks on cost performance. Perera *et al.* (2009) focussed on risks in road construction projects in Sri Lanka. It concluded that risks associated with defective design, late approvals, late handing over of site, and unforeseen ground conditions have negative impacts on contractors' cost performance, although the extents of the relationships between the risk factors and cost performance were not measured.

Alhomidan (2013) aimed to identify the factors responsible for cost overrun in Saudi Arabian road projects from a contractor's viewpoint. Its findings indicated that internal administrative problems, payments delay, delays in decision-making and poor communication between parties are the most severe factors affecting cost performance in road construction projects. The study noted that the most critical factors are within the control of the contractors, which accords with the perspective of this study.

Chandra (2015) revealed that the factors affecting project success can be grouped under: natural risks, design risks, resource risks, legal and regulatory risks and construction risks. The current study focuses solely on the groups of risks that have direct influences on contractors' cost performance, with the objective of evaluating the relationships between cost risk centres and the profitability of road construction projects.

Direct construction risks

Risks have been variously categorised in literature. Kangari (1995) categorised risks into most important and least important risks. Most important risks were noted as those with direct bearing on the projects such as safety, quality, design and labour risks. The least important risks were those having indirect bearings on the projects including change in government, permits and ordinance risks and inflation. Chandra (2015) categorised risks into natural, design, resource, financial, legal and construction risks. Perera *et al.* (2009) summarised risks in road projects under technical and contractual risks, economic, financial and political risks, managerial risks and external and site conditions risks. Tah and Carr (2000) identified risks as being either internal (within the contractor's control) or external (beyond the contractor's control). On the same basis, Baloi and Price (2003) classified risks affecting cost performance as organisation-specific, global or acts of God. The essence of categorising risks is to adopt the proper tool for explaining the risk phenomena. This study's interest is on direct risks. Direct risks have direct effects on the outcome of projects, while indirect risks are those that affect the project by first affecting the direct risks. Direct risks are primary risks, while indirect risks are secondary risks to the project. Indirect risks are generally global (economy or society-wide) in impact, while direct risks are project specific.

Risks associated with project design will be consequential on the current project, and not on all projects going on in the same country. Majorly, design risks affect the buildability of a scheme. Poorly designed projects will cost more as a result of change orders and reworks. Direct input resources such as labour, materials and equipment are also domains for direct risks. Labour risks manifest in the form of unavailability of critically needed manpower, or requirements of unexpected local content policy. To a exemplify, contractors in the Niger Delta Region of an Nigeria are often forced to retain the services of local artisans in the region when executing projects, whether or not such artisans are qualified for the jobs. Unexpected increases in labour costs result from such situations which lead to net negative project cost performance.

Contractor's cost performance

Cost performance has been predominantly studied from the client's perspective. Cost performance is fundamentally the ratio of the final project cost to the initial cost (Sullivan *et al.*, 2017). The initial cost may be the cost based on which the decision to build was made, the consultant's estimate prior to tender or the agreed contract sum with the contractor (Welde and Odeck, 2017). The actual project cost could be the final account sum or the value on a practical completion certificate (Love *et al.*, 2012). Each of these definitions conceives the cost from the client's viewpoint. Literature evidence shows that clients are more risk evasive than contractors, although the latter pass the cost of risks back to the clients wherever possible (Ahmed *et al.*, 1999). Whereas some studies have shown that risk factors affect cost performance of projects, enough has not been revealed on how the profitability of road projects to contractors are affected by construction risks. The distinction of cost performance viewpoints is particularly important because risk allocation is often skewed against contractors in the conditions of the contract. This concern is worse for small and medium-sized contractors in developing countries like Nigeria having high mortality rates (Ogbu, 2018). Despite this, the contractors' attitude towards risk is important in their determination of the optimum bid prices (Asgari *et al.*, 2016). In this study, the contractors' road project cost performance was measured as the percentage difference between the estimated and final costs of the project to the contractor.

Conceptual model of the study

Appropriate management of risks will need a careful consideration of the risk centres or categories of the risks. Past studies identified many risk centres some of which are indirect to the projects, and therefore, fall outside the scope of the present study. Four direct risk centres were identified from the literature as having direct effects on road project outcomes, namely, site environment and location, market/financial/socio-economic, contractor resource and design/management risks. Each of these risk centres is affected by many risk factors. Conceptually, risk factors do not affect cost performance directly. Rather, they do so by affecting their own cost centres. Frequently, different measures will be required to manage risks emanating from different cost centres. Design/management risks are better managed by the client ensuring that designs are done by diligent experts based on proper site investigations. However, the control of design/management risks may not forestall the occurrence of risks associated with the contractor's resources.

No risk centre is solely responsible for the "total" cost-related risk of a project. This has to be obtained by aggregating the effects of risks from all the cost-related risk centres of the project. In this study, the joint effect of the risks from different cost centres is expressed as the project risk index of cost (PRIC). Ultimately, it is this "aggregate" cost risk that affects the cost performance of a road project as depicted in Figure 1.

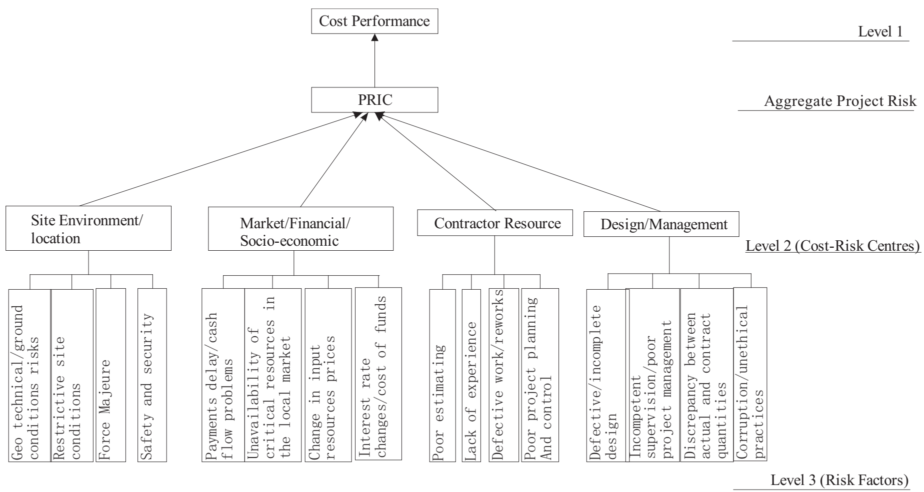

Figure 1.
Conceptual model of the study

Based on the foregoing, the study hypothesises as follows:

H1. No significant relationship exists between risk factors and risk centres of road projects.

H2. No significant relationship exists between each cost-related risk centre and the PRIC.

H3. No significant relationship exists between PRIC and cost performance of road projects.

Methodology

Philosophical underpinnings of the study

Data were obtained quantitatively for this study. Ontologically, the relationships between the variables and concepts of this study are objectivist since they are independent of social conceptions of them (Bracken, 2010). However, the knowledge of this reality can solely be obtained through meanings given to the phenomena by those involved in the projects, particularly, the indigenous contractors (Carbonari, 2018). Thus, an interpretive epistemological strategy was adopted in obtaining the views of the respondent contractors about the factors affecting their cost performance. The project cost performances of the contractors (measured as the percentage difference between the estimated and final costs of the projects to the contractors) were obtained based on their actual project data which entails a positivist approach. The approach used in this study accords with Dainty (2008), which advocated for methodological pluralism in construction management research.

Preliminary survey

Although numerous studies have identified risk factors that could affect cost performance of road projects (Baloi and Price, 2003; Alhomidan, 2013; Chandra, 2015; Amusan *et al.*, 2018; Perera *et al.*, 2009; Ahmed *et al.*, 1999), the risk factors covered by this study were obtained from Khodeir and Mohamed (2015) due to their comprehensiveness. However, the risk factors were reduced from 63 in the original work by Khodeir and Mohamed (2015) to 48 after they underwent a validity review by 4 construction management academics. Some of the initial variables were expunged or merged with other very similar variables and few new ones were added to reflect the context of the study. The factors removed were either considered vague or repetitive of already existing factors within the list.

Risk factors were grouped into four risk centres, namely, site environment and location, market/financial/socio-economic, contractor resource and design/management risks.

The names of contractors were sourced from the Ministries of Works of Niger and Edo States of Nigeria. Following the approach in Wiguna and Scott (2006), a preliminary questionnaire containing the 48 factors was prepared and sent to 103 contractors. Out of this, 81 of the contractors responded. The respondents were requested to rank the degree of importance of each risk factor to project cost performance on a Likert scale of 1 (unimportant) to 5 (very important). The questionnaire targeted the chief executive officers, site engineers/managers and construction managers in the firms. Using the relative importance index (RII), the variables were ranked under each category, and the first four highest-ranking variables were selected for incorporation in the main questionnaire of the study. According to Wiguna and Scott (2006), this approach helps to remove insignificant risk factors and reduce the factors to a more manageable size in the later analyses. A reliability test of the questionnaire instrument yielded acceptable alpha levels of 0.946 (site environment and location), 0.965 (market/financial/socio-economic), 0.965 (contractor's resources) and 0.991 for design/management factors.

Main survey

The purposive sampling technique was used to administer the main questionnaire on 36 Nigerian contractors who completed road projects in Niger and Edo States of Nigeria within the past five years. The approach was chosen due to the absence of comprehensive data of projects of the category required in this study. The major objective was to relate the level of riskiness of each project (numbered 1 to 36) to its cost performance. Section A of the questionnaire captured the respondent's construction industry work experience and professions (Figures 2 and 3, respectively). A majority (72.22 per cent) of the respondents have CIWE of >10years and they were predominantly civil engineers (47.22 per cent). In section B of the questionnaire, the respondents were asked to rank the probability of occurrence of the risks on their projects using a Likert scale of 1 (very unlikely) to 7 (extremely likely), and to rank the impact of the risks on cost performance on a Likert scale of 1 (very low) to 5 (very high). In section C, the respondents were asked to carry out pairwise comparisons of the importance of the four risk categories (Level 2 in Figure 2) to cost performance and to do the same for the four risk factors under each of the four cost-risk centres (Level 3 in Figure 2).

A weight signifying the importance of the third level variables (risk factors) to their respective cost-risk centres was computed using the pairwise comparison method expounded in Wiguna and Scott (2006). Hastak and Shaked (2000) noted that the weight associated with each variable represents its relative importance within its hierarchy with respect to the specificities of the project.

Figure 1 shows the hierarchies of the variables of the study. In pairwise comparison, variables in any given level are compared in terms of their importance/contribution to the variable in the next higher level. This means that variables in Level 2 were compared pair-wisely (six comparisons in all since there are four variables) in terms of their

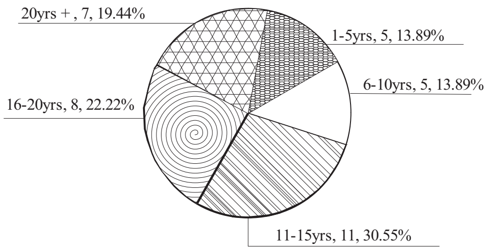

Figure 2.
Respondent's construction industry work experience

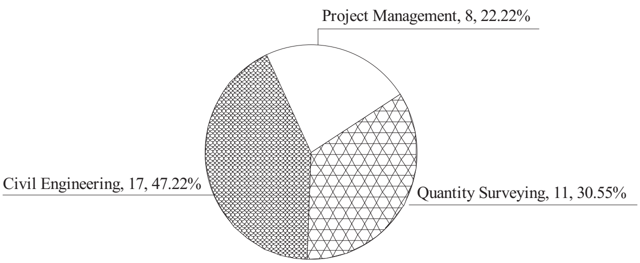

Figure 3.
Respondents of the study by profession

contributions to the variable in level 1 (cost performance). The same approach was used for Level 3 (risk factors) under each cost-risk centre. The comparisons were based on a scale of 1 (equal importance) to 9 (extremely more important) (Saaty, 1995). The variable considered more important is the one towards which the respondent scored. A typical section of the questionnaire issued to the respondents for this purpose is shown in Table I.

The responses obtained from the respondents were used to compute relative importance weights (principal eigenvectors) for the cost-risk centres, and the risk factors using the methods described in Saaty (1980) and used in Dias and Ioannou (1996).To get the relative importance weight (w) of the risk factors (level 3 variables) to their respective cost-risk centres, the principal eigenvector of each risks factors (level 3 variable) was multiplied by the principal eigenvector of its cost-risk centre. This study proxied the risk factors and cost-risk centres by their relative importance weights.

Based on the data collected on each project as described above, the risk index of cost of each of the projects was computed as typically shown in Table II using project number 18. The PRIC measures the quantum of risks in the project that pose threats to a contractors' cost performance.

PRIC was computed for each project using the formula in equation (1) which Wiguna and Scott (2006) used to compute project risk index of time:

$$PRIC = \sum_{i=1}^{n} w_i \ x \ P_i \ x \ I_i \tag{1}$$

where:

PRIC = project risk index of cost;
w = relative importance weight of each risk factor (obtained by pair-wise comparison);
P = probability that risk would occur;
I = impact on cost if the risk did occur; and
i = risk factors (1. . ..n).

Measurement of cost performance

To measure cost performance of the projects, the respondents were asked to state the approximate percentage of cost increase or decrease (decrease to be stated with a negative sign) between their net cost estimate for the project and their final expenditure on the project. All the percentages obtained in this regard were positive. Descriptive statistics of the projects' cost performances are shown in Table III. The project with the least cost growth had 37 per cent cost overrun, while the highest had 111 per cent cost

Risk factors	9	7	5	3	1	3	5	7	9	Risk factors
Site environment and location										
Geo-technical risks/ground conditions						√				Restrictive site conditions
Geo-technical risks/ground conditions								√		Force majeure
Geo-technical risks/ground conditions									√	Safety and security
Restrictive site conditions			√							Force majeure
Restrictive site conditions		√								Safety and security
Force majeure								√		Safety and security

Table I.
Comparison of risk factors

Table II. Analyses PRIC for project 18

CODES	RISKS	Importance on cost (w)	Probability (P)	Impact on cost (I)	Risk level of cost (RL)
	Categories				
SiteEnv	*Site Environment and Location*				
x1	Safety and security	0.0403	5	2	0.4032
x2	Restrictive site conditions	0.0143	1	5	0.0716
x3	Force majeure	0.1359	4	4	2.1746
x4	Geo-technical risks/ground conditions	0.0763	5	4	1.5262
Market	*Market/Financial/Socio-Economic*				
x5	Payments delay/cash flow problems	0.0550	2	3	0.3299
x6	Unavailability of critical resources in the local market	0.0184	2	1	0.0368
x7	Change of input resource prices	0.0353	3	3	0.3174
x8	Interest rate changes/cost of funds	0.0105	5	2	0.1055
Contractor	*Contractor Resource*				
x9	Poor project planning and control	0.0241	3	3	0.2170
x10	Lack of experience	0.0898	2	3	0.5389
x11	Defective work/Reworks	0.1290	3	5	1.9349
x12	Poor estimating	0.0747	4	3	0.8968
Design	*Design/Management*				
x13	Defective/Incomplete design	0.0532	3	1	0.1595
x14	Incompetent supervision/poor project management	0.1461	2	2	0.5843
x15	Discrepancy between actual quantities and contract quantities	0.0388	1	5	0.1938
x16	Corruption/unethical practices	0.0583	4	3	0.6991
PRIC	*Project Risk Index of Cost*				*10.1896*

Table III. Descriptive statistics of cost performance of the contractors

	N	Minimum	Maximum	Mean	SD
CP	36	0.37	1.11	0.6449	0.16772
Valid N (listwise)	36				

overrun. The mean cost overrun was 64.49 per cent. This result tallies with Love *et al.* (2014), which revealed that variations in the cost performance of projects can vary as wide as −91.6 and 183 per cent. The mean cost overrun (64.49 per cent) found in this study exceeds the average cost overrun for road projects globally which Flyvbjerg *et al.* (2003) estimated as 20 per cent with a standard deviation of 30. In Korea, Lee (2008) noted that the largest cost overrun for road projects is 50 per cent. These last two results were based on measures obtained from the client's perspective. The result of the present study implies that the project cost performance of indigenous contractors in developing countries is worse than the global cost performance of road projects viewed from the clients' perspective. It is possible that when a cost overrun occurs in a project due to variations, the contractors end up doing the extra work at less profit margin than the profit margin included in the contract originally.

Structural equation modelling (SEM)

SEM enables simultaneous examination of multiple relationships between dependent and independent variables (Vinodh and Joy, 2012). Besides estimating the values of parameters such as factor loadings, variances and covariances of the variables in the model, SEM also assesses the fit of a given set of data to the hypothesised confirmatory factor analysis model (Hox and Bechger, 1998). Essentially, this study aims to confirm the contribution of cost-related risk centres and their factors to the cost performance of road projects from a contractor's perspective. Thus, the theoretical model (Figure 1) was tested using the gathered data. At first, as often the case in structural equation modelling (Doloi *et al.*, 2011), the model fit parameters were poor. Consequently, some variables with low beta (β) values (*X*2, X6, X9, X11 and X15) were dropped from the analysis, and following the modification indices, covariance lines were drawn between the unobserved error terms wherever theoretically permissible. Chen *et al.* (2012) reported that this approach is the most widely used in the refinement of structural equation models. Table IV shows the goodness of fit measures of the final model and Figure 3 shows the final model and the standardised coefficients obtained. The values of the ratio of chi-square to degrees of freedom and GFI were 1.097 and 0.769 respectively. These indices show that the final model has an acceptable fit. Further, the root mean square error of approximation (RMSEA) value of 0.053 at $p < 0.05$ indicates the acceptability of the model at a high confidence level (Browne and Cudeck, 1993; Eybpoosh *et al.*, 2011). Other important indices of fit such as the comparative fit index (CFI), Tucker-Lewis index (TLI), and incremental fit index (IFI) likewise gave acceptable values of 0.963, 0.949, and 0.967 respectively. The lowness of the normed fit index (NFI) (0.724) and relative fit index (RFI) (0.625) could be as a result of the sample size (36) of the study. According to Hooper, Coughlan and Mullen (2008), NFI underestimates fit for small sample sizes. The acceptably high value of the TLI gives the confidence to accept the model as well fitted since the TLI is the non-normed version of the NFI, and its value in this study accords with the recommendation of Hu and Bentler (1999).

Table V shows that the standardised coefficient estimates for the hypothesised relationships are significant at $p < 0.05$. Thus, the null *H1* to *H3* are rejected, and it is concluded that significant relationships exist as depicted in Figure 4.

Discussion of findings

Figure 4 shows that the model fits well after removal of the insignificant risk factor variables *restrictive site conditions (X2), unavailability of critical resources in the local market (X6), poor project planning and control (X9), defective work/reworks (X11), and discrepancy*

Goodness of Fit (GOF) Measure	Recommended level of GOF measure	Final SEM
X^2/degree of freedom	1 to 2	1.097
Goodness of fit index (GFI)	0(no fit) – 1 (perfect fit)	0.769
Adjusted Goodness-of-fit index (AGFI)		
Root mean sq. error of approximate (RMSEA <0.05)	<0.05 (very good) – 0.1 (threshold)	0.053
Comparative fit index (CFI)	0(no fit) – 1 (perfect fit)	0.963
Tucker-Lewis index (TLI)	0(no fit) – 1 (perfect fit)	0.949
Normed fit index (NFI)	0(no fit) – 1 (perfect fit)	0.724
Incremental fit index (IFI)	0(no fit) – 1 (perfect fit)	0.967
Relative fit index (RFI)	0(no fit) – 1 (perfect fit)	0.625

Source: Adopted from Doloi *et al.* (2011)

Table IV. Results of goodness of fit measures

Dependent	Direction of relationship	Independent	Estimate	p
Standardised regression weights				
SiteEnv	←	x1	0.268	0.048
SiteEnv	←	x3	0.357	0.009
SiteEnv	←	x4	0.392	0.004
Market	←	x5	0.181	0.037
Market	←	x7	0.714	***
Market	←	x8	0.418	***
Contractor	←	x10	0.348	0.02
Contractor	←	x12	0.298	0.047
Design	←	x13	0.368	***
Design	←	x14	0.166	0.02
Design	←	x16	0.793	***
PRIC	←	SiteEnv	0.522	***
PRIC	←	Market	0.303	0.032
PRIC	←	Contractor	0.327	0.009
PRIC	←	Design	0.306	0.029
CP	←	PRIC	0.351	0.027

Note: CP = Cost Performance; *** = $p < 0.01$

Table V.
Standardised regression weights of the variables of the study

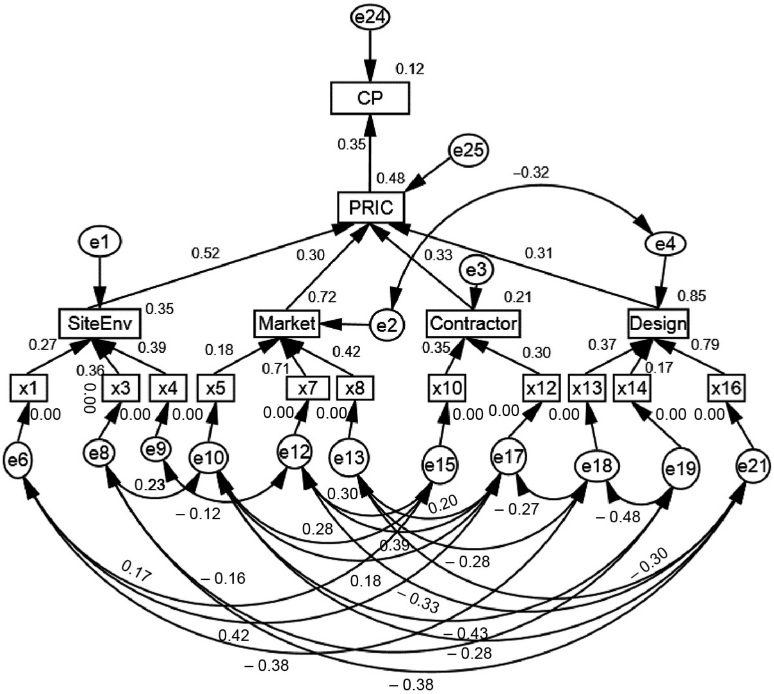

Figure 4.
Final model of the study

between actual and contract quantities (X15). The expunged variables are not meaningfully significant to their respective cost centres. Road construction sites are mostly unrestrictive as a result of government's intervention in clearing obstacles, including demolishing buildings and other privately-owned structures extending beyond the official setback for such structures. The insignificance of X6 may be stemming from the adequate availability of the basic materials needed for road construction in Nigeria within economic haulage distance to the areas of the study. Mansfield *et al.* (1994) noted that the shortage of materials is among the factors responsible for delays in road projects in Nigeria. Apparently, unavailability of materials in the local market mainly affects the project duration rather than its cost, especially, where, as often the case, the consultants choose to relax implementation of the time management clauses of a condition of contract.

Both X9 and X11 (under contractor's resources cost-risk centre) were non-significant contributors to the contractor's resource risk centre. Mansfield *et al.* (1994) noted inadequate planning as one of the precursors to cost overrun in Nigerian projects. However, Ogwueleka (2011) did not identify project planning and control as one of the critical success factors influencing project performance in Nigeria. Based on the data for this study, poor project planning and control is not a significant contributor to the contractor's resource risk centre. Likewise, the effects of rework on the cost-risk of the contractors surveyed are negligible. According to Hwang *et al.* (2009), rework adds about 5 per cent to direct construction cost of projects. The sampled contractors may consider the effects of rework as negligible as a result of this. The low rank of *discrepancy between actual and contract quantities* results from the use of an admeasurement contract in the Nigerian public sector, which implies that contractors are paid for the actual quantities of work executed on site. Thus, the contractors no longer consider it a significant risk for differences to exist between contracted and actual quantities of work items.

Relationship between site environment and location and project risk index of cost

The three main variables accounting for site environment and location cost risks are *safety and security* (x1)*, force majeure* (x3) and *geotechnical/ground conditions risks* (x4). Of these three, geotechnical/ground condition risks contribute the most risk (β = 0.392). Even with prior soil investigations, ground conditions are difficult to predict. It is likewise improbable that consultant engineers will entertain every one of a contractor's claim on removal and replacement of unsuitable materials. In road projects, earthworks (which are based on ground conditions) are often washed away by floods. Quantities of materials required to execute the work increase as a result without any certainty of compensatory payment from the client for such losses. Chileshe and Yirenkyi-Fianko's (2011) observation that the rainy season in Ghana makes ground conditions an important source of risk corroborates this result. The equally significant effect of force majeure (β = 0.357) reinforces this result. Alhomidan (2013) contrastingly classified weather condition and natural disaster risks as low-level risks, perhaps, due to different climatic conditions between sub-Saharan Africa and Saudi Arabia. Safety and security (β = 0.268) are significant due to the general insecurity being experienced in Nigeria, especially, the spate of killings and kidnappings in the country. Overall, site environment and location have a significant effect on PRIC (β = 0.522), which supports the finding of Enshassi *et al.* (2009) that the state of a site is strongly related to a contractor's performance.

Relationship between market/financial/socio-economic risks and project risk index of cost

Change of input resource prices (x7) (β = 0.714) is the most important variable to the market/financial/socio-economic risk centre. Contractors now recognise the danger in removing the fluctuation clause in the contract for most road projects. A similar finding by Perera *et al.* (2009) showed that increases in input resource prices accounted for more than 50 per cent increase in the contract sums of two projects in Sri-Lanka. Interest rate changes/cost of funds (β = 0.418) also significantly affect the market/financial/socio-economic risk centre, which supports the finding of Chandra (2015) that exchange rate fluctuations significantly contribute to financial risks. Essentially, this factor measures the ease with which loans are obtained by contractors, as well as the interest paid for using a commercial bank's funds. Public clients are notorious for delayed payments (Kaliba *et al.*, 2009). Delayed payments/cash flow problems equally significantly affect this risk centre (β = 0.181). In view of this, the respondents assigned significance to both the probability and severity of interest rate risks. Chileshe and Yirenkyi-Fianko (2011) and Laryea (2010) showed that there is a concurrence among project participants that high cost of funds as a result of poor financial markets impacts project performance. This study's results on the significance of payments delay/cash flow problems to this risk centre also align with other previous studies (Abd El-Razek *et al.*, 2008; Ye and Rahman, 2010).

Overall, there is also a significant relationship between Market/Financial/Socio-Economic Risks and PRIC (β = 0.303). This supports the observation by Mahamid and Bruland (2012) that road project costs are frequently underestimated, and points to contractors' growing discontent with the accuracy of their own estimates of road works and clients' payment delays.

Relationship between contractor resource risks and project risk index of cost

Major contributors to contractors' resource risk centre are lack of experience (x10) (β = 0.303) and poor estimating (x12) (β = 0.298). Experience is key to accurate estimating for road works due to their many risks (Smith *et al.*, 2000). The results corroborate findings from earlier studies in which the importance of estimating and contractor experience to project performance were observed (Mansfield *et al.*, 1994; Long *et al.*, 2004). Further, previous studies on road work estimating emphasise the difficulties in computing the cost of earthworks which constitute a significant portion of the overall cost of road projects (Zaia *et al.*, 2017; Hola and Schabowicz, 2010). Lack of experience and poor estimating risks may be resulting from persisting estimating incompetence within indigenous construction firms in Nigeria due to engagement of unqualified personnel (Ofori, 2000), or from intentional strategic misrepresentation of cost information for winning projects (Flyvbjerg *et al.*, 2002). In either case, the contractor may not recover the cost of the error. The contractor resource cost-risk centre has a significant effect on the overall PRIC (β = 0.327). Obviously, risks associated with the level of competence and experience within the firm impact the total project risk and, therefore, justify the consideration of the two variables as important prequalification criteria (Plebankiewicz, 2010).

Relationship between design and management risks and project risk index of cost

Significant risk factors under the design and management risk centre are defective/incomplete design (β = 0.368), incompetent supervision/poor project management (r^2 = 0.166), and corruption/unethical practices (β = 0.793). Discrepancies between the design information and site conditions are commonly observed in road projects. Frequently, this issue emanates from the time lag between design of the infrastructure and commencement of operations on site, or the hastiness in the design process due to time constraints. Findings in this study show contractors' scepticism about the competence of road project leadership in the study area. This corroborates the findings of Mansfield *et al.* (1994) which blamed poor contract management for cost escalation. Findings in this study show that corruption/

unethical practices contribute the most to the design and management cost-risk centre. The contractor-respondents to this study express wariness at the clients' teams' professional ethics. Corrupt practices often occur during tender evaluation, vetting of claims, valuation for an interim payment, final account preparation amongst others (Owusu *et al.*, 2019). Corrupt consultants request different gratifications from contractors that end up reducing contractors' profit margin or leading to a loss. Results from this study amplify the call for enforcement of public procurement guidelines in public projects (Zadawa *et al.*, 2018). A significant relationship exists between the design and management risk centre and PRIC ($\beta = 0.306$). Generally, the PRIC increase by 0.306 units for every unit increase in the design and management risk centre.

Project risk index of cost and cost performance of projects

When related to the cost performance of the projects, a unit change in PRIC accounts for as much as 0.351 increase in the cost overrun of a project. Although this result shows that contractors' cost performance in a project is not solely dependent on the existence of direct risks, it does confirm that the presence of such risks leads to poor cost performance. This result supports Wiguna and Scott' (2006) conclusion that project risk index of time affected schedule performance since time and cost are related project performance measures. Baloi and Price (2003) stated that global risk factors (risk factors beyond the contractor's control) pose serious challenges to construction companies, while this study confirms that direct risks are equally critical to the projects' cost performance. This outcome accords with previous studies indicating a direct relationship between risk levels and cost overrun in building and civil engineering projects (Love *et al.*, 2012; Creedy *et al.*, 2010). However, future researchers may evaluate the relative contributions of global and direct risk factors to cost performance of projects to show which of these two categories contributes more to contractors' cost performance.

Conclusion

Whereas road projects are generally prone to cost overruns, research explaining the relationship between risks and contractor-reported cost performance in road projects in the context of developing countries is inadequate. Furthermore, studies on cost performance tend to concentrate more on the client's perspective, ignoring the contractor's perspective of cost performance. This study investigated how direct risk factors (which are usually within contractors' control) affect the profitability of their projects. Three relationships were analysed in this study: the relationship between risk factors and cost-risk centres of road projects; relationship between cost-risk centres and project risk indices of cost (PRIC); and relationship PRIC and cost performance of road projects. For the sampled projects, it was discovered that the overrun in the road contractors' budget ranged from 37 per cent to 111 per cent, with a mean overrun of 64.49 per cent. Consequently, the contractors should meticulously ensure that their bids are based on accurate estimates and that they execute only variations for which they will be paid by the client. The conceptual model of the study is acceptable, albeit, some of the initially selected risk factors were eliminated. The risk factors: *restrictive site conditions, unavailability of critical resources in the local market, poor planning and control, defective work*/*reworks, discrepancy between actual and contract quantities* were eliminated from the study for insignificant contribution to their respective cost-risk centres. The contractors should not prioritise these risks. However, further studies should check the impact of these risks on the cost performance of other kinds of construction projects.

Findings from the study show that cost-risk centres contribute differently to the overall risk of a project (represented by PRIC). In terms of contribution to the total cost-risk of the projects, *site environment and location* > *contractor resource* > *design and management* > *market*/*financial*/*socio-economic* risks. This order of importance should inform the contractors' treatment of these risks. Future studies should look at project risks as a sum of risks emanating from risk centres, and not treating project risk centres in isolation.

Eleven risk factors affecting four cost-risk centres as shown in Figure 4 account for most direct risks affecting the cost performance of road projects in the study area. The risk factors are safety and security, force majeure, geotechnical risks/ground conditions (site environment and location risks), payments delay/cash flow problems, change of input resource prices and interest rate changes/cost of funds (market/financial/socio-economic risks), lack of experience, poor estimating (contractor resource risks), defective/incomplete design, incompetent supervision and corruption/unethical practices (design/management risks). Contractors should carefully evaluate these risk factors before and after tendering for road projects, and make adequate provisions for their curtailment and management.

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