Technical risk factors of international construction

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Abstract: Construction is one of the strongholds for development in every country. The objective of the research is to identify the critical technical risk factors encountered by engineering firms on the global milieu. Based on questionnaire surveys, statistical analyses and previous studies on risk management, 23 risks were selected and ranked as technical factors that hinder construction projects. The relative importance index (RII) was used to determine the rank of each factor surveyed. The study revealed that industrial disputes, shortage in power supply, shortage in supply of water and problems of partner difference practice of construction globally were among the highly ranked technical risks. The study is beneficial as it adopts case studies in Africa to elicit the technical effects on the international frontlines. With the ranking of the technical risk factors, international construction firms can adequately enhance critical planning, avoid casualties and engage in economically viable projects. The study will be useful for analysing and investigating the hypothesised relationships technical risk variables that influence performance of international joint ventures. The risk factors displayed in the study can be used in supporting data for many other research development studies in the area of construction, risk analysis and global construction development studies.

1 Introduction

A lot of attention and research have been given to previous work done in the past on risk assessment of international projects. Most of them come out with almost the same conclusion about the risks being faced by various construction industries and different mitigation measures are spelt out to address these threats. Research materials of risk assessment for other countries were studied to build up information but the approach of risk assessment on the African continent was taken into consideration in terms of cultural and historical disparity.

The paper begins with a review of literature on previous studies about risk assessment, gives the method of research and data analysis, presents a discussion of the results obtained and concludes, using the results obtained from the study. It also gives various practical recommendations necessary to amend and reduce technical risks at the construction sites. The technical risk factors specified in the study can help latent risk factors become conspicuous and easy to mitigate and assess its correlative repercussions for the construction industry.

2 Literature review

Project risk management includes the processes concerned with identifying, analysing, and responding to project risk. It includes maximising the results of positive events and minimising the consequences of adverse events. Fig. 1 provides an overview of the major processes. Risks can be classified as operational or technical. An operational risk is the inability of the customer to work with core team members. A technical risk is the inability to build the product that will satisfy requirements.

2.1 Classification of risks

Risks can be classified into the different types and each of the classification viewed from different angles as illustrated above in Fig. 2. Some of the different classifications of risks are:

• Technical and technology risks: The ability to overcome the technical and technological risks of the project. In this type of risk many experienced or old workers who are not technologically

skilled but are still handling various aspects of the construction may pose as a serious risk.
• Financial risk: The ability to overcome the financial risk of the project through to final completion and operation. This risk factor involves issues or concerns associated with the financing of the project, including the execution period and operations or equity financing.
• Procurement-contractual risk: This risk factor involves issues or concerns associated with the contractual and procurement approaches-systems-processes used for both project execution and operation.
• Political risk: This risk factor involves issues or concerns associated with the local, regional, and national political and regulatory situation confronting the project.
• Environmental risk: It involves issues or concerns associated with the ecologically and environmental problems, concerns, and activities confronting the project during the project execution and the project operation.

2.2 Previous research studies on risk assessment

Akintoye and MacLeod (1997) [1] basically researched the construction industry's perception of risk associated with its activities and the extent to which the industry uses risk analysis and management techniques with the help of a questionnaire survey of general contractors and project managers. The authors concluded that risk management is essential to construction activities in minimising losses and enhancing profitability.

Shen *et al*. (1997) [2] identified the most serious project delay risks and the effective actions for managing these risks. Practitioners' risk management actions and their effectiveness have been investigated through a questionnaire survey. It revealed that methods where practitioners' experience and subjective judgment are used are the most effective and important risk management action, and that methods using quantitative analytical techniques have been rarely used due to limited understanding and experience. The findings also suggest a need to promote the application and awareness of various analytical techniques for risk management in a proper context in the Hong Kong construction industry.
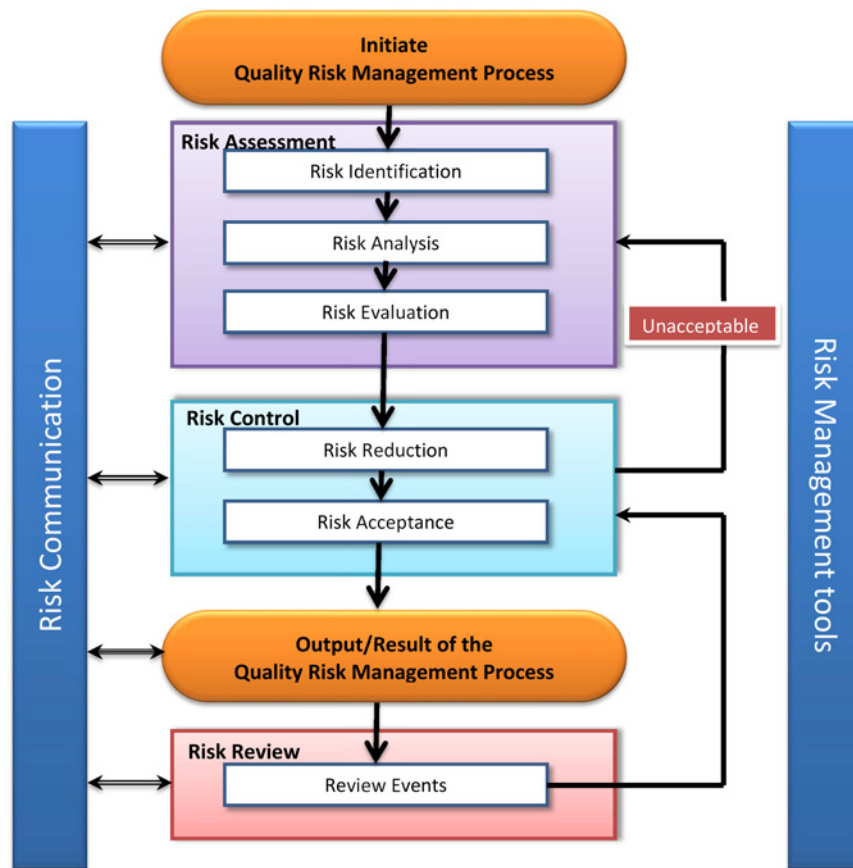
Fig. 1 *Overview of a typical quality risk management process*
Source: ISO 31000, ISO 28002

Thomas and Toakley (1999) [3] studied the use of risk management in the conceptual phase of the construction project development cycle in the Australian construction industry through a survey. It was found that while most respondents were familiar with risk management; its application in the conceptual phase was relatively low, even though individuals were willing to embrace change.

Adnan *et al.*'s (2009) [4] research sought to identify and evaluate key risk factors and their preventive and mitigating measures in building projects in Palestine. It also advanced to investigate the severity and allocation of each identified risk factor according to the contractors' perspective. A questionnaire survey was conducted and a total of 44 critical risk factors were identified and categorised into nine groups. Research findings identified financial failure of the contractor to be the most important risk factor followed closely by two factors namely, working in dangerous areas and border closure. The results also indicated that close supervision is seen as the most effective risk mitigating method. The paper recommended that contracting companies should identify and adequately quantify project risk factors. He added to this that a risk premium to quotation and time estimation has to be supported by governmental owner organisations and other agencies in the local construction sector. Training courses should also be provided to construction professionals on how to deal with and minimise risks in building projects.

Visser and Joubert (2008) [5] research project initiated to define the most important construction risks from the insurance stakeholders' point of view in South Africa. The risk management functionality in terms of the formal risk culture, risk framework and risk practices within the participating construction organisations were tested through a comprehensive questionnaire. Analysis of the completed questionnaires indicated that the results were consistent

and repeatable. It was found that construction companies generally have weak risk management cultures, frameworks and practices, even though risk management awareness was relatively high at the construction project level. This seemed to emanate from the separation of project- and enterprise-related risks. The most important risks in the new proposed model were (i) the loss of key employees and business intelligence, (ii) contractual related failure, (iii) unfavourable financial market conditions and (iv) failures of key contractors and clients.

Kgositsile (2009) [6] investigated and ascertained the relationship that exists between the corporate culture and performance of South African construction firms. A comprehensive literature review that identifies the key corporate culture dimensions that are essential for business success was undertaken. A questionnaire containing questions relating to the aforementioned corporate culture dimensions was prepared and administered to senior managers of construction firms. The results of the survey were analysed through the use of statistical tools. The results of the survey confirmed that a positive correlation exists between corporate culture and business performance. However, in the context of South African construction firms, the magnitude of the influence of corporate culture on business performance is inversely proportional to the size of the firms. The role and influence of the construction industry in the South African economy is pivotal. Not only is the industry responsible for the provision of much needed infrastructure, it also provides income to thousands of people under its employ. The paper offered recommendations on how corporate culture may be best developed to create high performance.

Laryea and Mensah (2010) [7] state of health and safety on construction sites in Ghana was investigated using first hand observation of 14 construction project sites in 2009 and 2010. At each site, the construction project, workers and the physical environment of the

PROJECT RISK MANAGEMENT

i. Risk Identification

1. Inputs
   - a. Project Description
   - b. Other Planning outputs
   - c. Historical Information
2. Tools and Techniques
   - a. Checklists
   - b. Flow Charting
   - c. Interviewing
3. Outputs
   - a. Sources of risks
   - b. Potential risk events
   - c. Risk symptons
   - d. Inputs to other processes

ii. Risk Quantification

1. Inputs
   - a. Stakeholder Risk tolerance
   - b. Sources of risks
   - c. Potential Risk events
   - d. Cost estimates
   - e. Activity duration estimation
2. Tools and Techniques
   - a. Expected Monitary Value
   - b. Statistical Sums
   - c. Simulation
   - d. Decision Trees
   - e. Expert Judgement
3. Outputs
   - a. Opportunities to pursue and threats to respond to
   - b. Opportunities to ignore and threats to accept

iii. Risk Response Development

1. Inputs
   - a. Opportunities to pursue and threats to respond to
   - b. Opportunities to ignore and threats to accept.
2. Tools and Techniques
   - a. Procurement
   - b. Contingency Planning
   - c. Alternative Strategies
   - d. insurance
3. Outputs
   - a. Risk Management Plan
   - b. Inputs to other processes
   - c. Contingency Plans
   - d. Reserves
   - e. Contractual Agreements

iv. Risk Response Control

1. Inputs
   - a. Risk Management Plan
   - b. Actual Risk Events
   - c. Additional Risk Identification
2. Tools and Techniques
   - a. Workarounds
   - b. Additional Risk response development
3. Outputs
   - a. Corrective Action
   - b. Updates to risk management plan

Fig. 2 *Project Risk Management showing detail of steps*
Source: ©1996 Project Management Institute, 130 South State Road, Upper Darby, PA 19082 USA

site were inspected and evaluated against health and safety indicators taken from the literature. The results revealed a poor state of health and safety on Ghanaian construction sites. The primary reasons are a lack of strong institutional framework for governing construction activities and poor enforcement of health and safety policies and procedures. Also, Ghanaian society does not place a high premium on health and safety of construction workers on site. Interviews with workers indicated that injuries and accidents are common on sites. However, compensation for injury is often at the discretion of the contractor although collective bargaining agreements between Labour unions and employers prescribe obligations for the contractor in the event of injury to a worker.

2.3 Competitive advantage of international firms – China's advantage

This study was undertaken using Ghana as a case study to find out risk factors of international construction firms. China is rapidly expanding its constructional influence globally especially on the continent of Africa. The Chinese firms were chosen for the case study because they are the prevalent international firm now in many countries especially the third world and have many competitive advantages. Chinese project managers have affirmed to the fact that competitiveness of Chinese firms results from their increasing knowledge of culture, low labour costs; hands-on management style; high degree of organisation; general aptitude for hard work.

Almost every country has a cuisine of Chinese food and this exposes these Chinese to relevant cultural differences in the particular setting. As companies come in to these countries for construction purposes, transfer of such information spreads easily as they locate these restaurants. Many do not however allude to relatively cheap capital, which is perhaps the single biggest challenge that their competitors face, as part of their comparative advantage. State owned enterprises can secure the necessary funds for advance payment and performance bonds from their head offices in China. They and other smaller private companies can also secure loans at flexible rates from Chinese banks such as the Bank of China, the China Development Bank and the China Exim Bank. Chinese worksites are usually highly organised and all the personnel, from the executive to the regular labourer, invariably live and work on the site full time. This 'hands on' style of management saves considerable time and provides management with a profound understanding of the project and the ability to handle challenges as they occur Fig. 3.

While local and foreign construction companies operate on profit margins of 15–25%, Chinese companies usually operate on margins of under 10%, thereby making them extremely competitive. An executive representative of a large state owned enterprise (SOE) interviewed in Tanzania (and speaking on condition of anonymity) disclosed that his company and many other SOEs operate on profit margins as low as 5%. There have also been reports of a large Chinese SOE in Ethiopia slicing projected profit margins to as low as 3%.
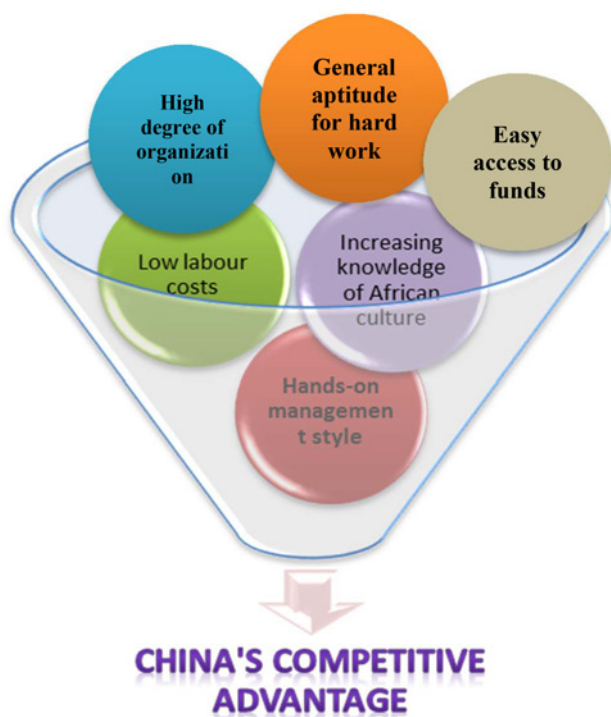

Fig. 3 Showing China's competitive edge over other foreign companies

Chinese companies may occasionally undercut competitors by up to 50% on the price of the overall bid. However, such low prices are the exception rather than the rule. This was observed with the losing bid by a Chinese company based in Guinea for a road construction project in Sierra Leone that was twice as high as the winning bid from an Italian company. The differences between Chinese bids and the traditional market players' are usually considerably less than perceived, especially where private Chinese companies are concerned. Chinese companies are also quickly earning a reputation for good quality and timely work, rendering them popular in both the public and private sectors. Some centres also provided limited logistical support assisting with the organisation of accommodation, transportation and, in some instances, telecommunications. Such services are usually offered for a fee. The Economic and Commercial Counsels, which are attached to Chinese Embassies but have a larger degree of autonomy than other desks, restrict their assistance to providing information. They also authenticate and provide translations of official documents issued in China – such as company registrations and academic qualifications.

3 Research methodology

3.1 Risk identification methods

There are two methods to determine risk, namely the quantitative and the qualitative approach. The quantitative approach relies on statistical calculation to determine risk, its probability of occurrence, and its impact on a project. A common example of the quantitative approach is decision tree analysis, applying probabilities to two or more outcomes. Another approach is the Monte Carlo simulation, which generates value from a probability distribution and other factors. The qualitative approach relies on judgments, using criteria to determine outcome. Common qualitative approach is a precedence diagramming method, which uses ordinal numbers to determine priorities and outcomes.

A risk management process is shown in Fig. 1 which consists of a general risk assessment overview. This includes risk identification, analysis and evaluation. The next step is risk control which engages risk reduction and acceptance. The output of the risk management process is then reviewed as the last procedural step of the risk management.

3.2 Structure of questionnaire

The general research methodology for this project comprised basically of a structured survey questionnaire of a closed-end format which was issued out to interviewers at various locations and centres by postage and emails. The purpose for embarking on this type of data collection was because it is less expensive and not too pervasive in comparison with the one-on-one interviews. Also most of the respondents are more familiar with this kind of questionnaire. According to Fowler, 1993 [8], Finn and Jacobson 2008 [9] and Gillham, 2008 [10], there is less of a biased situation introduced by the researcher when this kind of data collection is embarked upon. Another reason is ease at analysing the completed data made using this type of data collection.

3.3 Selection of risk factors

The 23 technical risk factors were categorised under the just explained reasons. These factors were selected and shortlisted as having a significant influence on construction projects in Africa. They were also based on pertinent previous studies on construction risk management, the various considerations and contributions of practitioners, local industry engineers, and professionals.

Consequently, a total number of 42 organisations or contractors were contacted for this project. All of these are Chinese firms which are predominant in most of the African construction enclave. During the third quarter of 2009, Ghana registered a total of 81 new companies with a combined value of

Table 1 Showing confidence level and critical values (z-value)

Confidence level, %	z-value
80	1.28
85	1.44
90	1.64
95	1.96
98	2.33
99	2.58

GH¢374.15 million in the third quarter compared to 83 new companies in the second quarter which were valued at GH¢156.34 million. These firms have gained grounds and have opened branches in neighbouring African countries of Ghana, though others are targeting the European and South American markets.

The displayed formula in (1) was adapted by Hogg *et al.*, 2009, for a statistically representative sample of population [11]:

$$n = \frac{m}{1 + \left((m-1/N)\right)} \qquad (1)$$

where n, m and N represent the sample size of the limited, unlimited and available population, respectively.

Critical values (z-values) are vital components of confidence intervals (the statistical technique for estimating population parameters). The z-value, which is displayed in the margin of error formula, calculates the number of standard errors to be added and subtracted to obtain your preferred confidence level (the percentage confidence you want). Table 1 shows common confidence levels and their corresponding z-values.

For the other variables, m is estimated by:

$$m = \frac{z^{2*}p^*\left(1-p\right)}{\varepsilon^2} \qquad (2)$$

where z stands for the statistic value for the confidence level used, i. e. 2.58, 1.96 and 1.64, represent 99, 95 and 90% confidence levels, respectively; p is the value of the population proportion which is being estimated; and ε is the sampling error of the point estimate. Since the precise value of p is not known, Sincich *et al.*, [12] 2002 suggest a conservative value of 0.50 to be used so that a sample size that is at least as large as required be obtained. Adopting a 95% confidence level, thus 5% significance level, the unlimited sample size of the population, m, is obtained by (2), as follows:

$$m = \frac{(1.96)^{2*}(0.50)^*1 - 0.50}{(0.05)^2} \qquad (3)$$

$$m = 385 \qquad (4)$$

Therefore, for the total number of 42 classified contractors, i.e. n, the representative sample size of the population required is determined by (1), as shown

$$n = \frac{385}{1 + \left((385 - 1/42)\right)} \qquad (5)$$

$$n = 37.96 \qquad (6)$$

Every factor used in the survey was ranked using the ordinal measurement scale ranking. An ascending order scale ranging from one to five was used for the research data collection to ensure credibility of the results obtained. The reason behind the usage of this range is because first, using a narrow range will undermine the reliability and validity of the results obtained. Second, using the wide range

may increase the biasness and subjectivity of the respondents' output which can greatly reduce the efficacy of the findings obtained. It is important however to note that the figures assigned to the scale is not an indication of absolute measures or equal intervals. It rather shows the level of importance of each factor used from the respondent's view.

Moreover, in order to find out the prevalent risk allocation response trend of the contractor for each factor investigated the respondents had to choose one of the three risk allocation alternatives namely: 'accept', 'mitigate' or 'transfer'. There was a pilot test conducted on a sample of the prospective respondents to primarily produce valid results and also test the reliability of the questionnaire. The aim of the test was: (i) to find out the efficiency with which the questionnaires are completed by the respondents; (ii) to establish the reliability of the range adequacy of the response choices; (iii) to determine the internal consistency of the data collection material or questionnaire; (iv) to make sure that the questionnaires are clear and understandable enough for the respondents and that all the interpretations are appropriate and does not create any form of insecurity for them.

The 'Cronbach's alpha (α)' of the sets returned was used to test the internal consistency of the questionnaire. The alpha coefficient ranges in value from 0 to 1, and is used to show the reliability of factors obtained from the ordinal rating scale questionnaires. Cronbach's alpha (α) is calculated by (3), Howitt *et al.*, 2008 [13]:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum V_i}{V_{\text{test}}}\right) \qquad (7)$$

$$\alpha = \frac{23}{23-1}\left(1 - \frac{0.913}{3.379}\right) \qquad (8)$$

$$\alpha = \frac{23}{23-1}(0.7298) \qquad (9)$$

$$\alpha = 0.763 \qquad (10)$$

where n is the number of questions; V_i is the variance of scores on each question; and V_{test}, is the total variance of the overall scores.

The specific value of the alpha coefficient is very important when considering the generated scale. A high value of the alpha coefficient gives more credence and reliability to the generated scale. A value of 0.70 was indicated by Nunnally, 1978 as an acceptable reliable coefficient [14]. However, lower values or thresholds are commonly recorded in the literature. Using the Statistical Package for the Social Sciences (SPSS V20) software, Cronbach's alpha for the sample group of contractors was obtained, where a coefficient value of 0.763 was eventually derived. This shows an appropriate and accepted measure of the reliability of the questionnaire by the respondents. It indicates an acceptable measure of questionnaire reliability by all respondents. Therefore, a total of 42 randomly chosen contractors were approached to be the participants of the survey. This was followed up by phone calls, direct contacts through emails, WhatsApp, Viber and WeChat. In all, 130 questionnaires were administered with at least three respondents from each contractor. A total of 81 questionnaires were received after a period of 10 months, representing 62% for the required sample size. The respondents engaged in this survey were mainly technical directors, industrial and commercial managers, project managers and administrators with at least 7 years of experience in the African construction industry. This response rate suggests reasonable validity and reliability of the findings. Many of the respondents were busy with different projects and this accounted for the slow rate of response. This survey information can ultimately give a firm framework for area-focused and diverse studies of construction risk management.

Since the comparative ranks of the factors surveyed can be easily identified (Jarkas, 2013), the 'relative importance index' (RII)

technique, which has values ranging from 0 (not inclusive) to 1, was used [15]. This technique was used instead of the 'mean ranking' to analyse the data collected [16–18]. The RII for each risk factor explored was quantified by the formula displayed in:

$$\text{RII} = \frac{5(N5) + 4(N4) + 3(N3) + 2(N2) + N1}{5(N1 + N2 + N3 + N4 + N5)} \quad (11)$$

where $N1$–$N5$, denotes the number of respondents who selected: 1, for no importance; 2, for little importance; 3, for moderate importance; 4, for strong importance; and 5, for very strong importance, respectively.

The RII was used to determine the rank of each factor surveyed. A high RII value denotes a higher importance of the risk factor explored. Moreover, the risk allocation response associated with each of the factor investigated, namely, 'accept', 'mitigate' or 'transfer', were quantified and expressed as a percentage, according to the number of respondents who chose a particular option. This option was in connection to the total number of respondents, and consequently made it feasible to determine the overall outstanding pattern of the contractors' attitudes toward risk allocation in the survey. The four main groups were ranked by quantifying the average value of the relative importance indices for all risk factors. As specified by Sambasivan *et al.*, 2007, the higher the average value, the higher the importance of the related group [19]. It is vital to clarify that the current study was neither designed to investigate the adverse effects of the risk factors on the specific key performance indicators of projects, being 'time', 'cost' or 'quality', nor to find out about the relationship between these factors. The actual purpose was to explore the 'holistic' view of the relative importance of the risk factors on the overall project performance, and to ascertain the outstanding risk allocation procedures.

4 Results and discussion

23 different construction technical risk factors have been considered and their allocation response and importance have also been studied. The general allocation response, relative importance indices and ranks of the factors considered are discussed and presented. Some comparisons have relatively been made with previous studies and findings. Consequentially, the average of the relative importance indices of the main categories or groups were quantified, and influence levels compared.

Shown in Table 2 are the relative importance indices, ranks achieved and allocation response rates, for each technical risk factor. From the investigation made it can be observed that the main technical risk factors are: Industrial disputes; shortage in power supply; shortage in supply of water; problems due to partner's and client different practice; Shortage of skilful workers; shortage in supply of fuel; accidents on site; theft of materials at site; equipment failure and unknown site physical conditions.

As can be seen from Table 3, industrial dispute with an RII of 0.886 is seen as the most vital technical risk factor. This is not surprising considering that mere language difference can cause a dispute about so many issues during construction. According to Hinshaw and Yap 2013 [20], there have been several disputes between Chinese workers and Ghanaians, including other countries such as Gabon, Tanzania, Uganda and Botswana that has led to serious legal implications and injuries. Projects such as the China-Pakistan economic corridor and Baltic Pearl Project along the coast of the Gulf of Finland have been affected by these issues according to the construction reports on site. 89% of the respondents normally transfer the repercussions of this situation to the district or regional head and sometimes the embassy for resolution.

Industrial disputes occur mainly among the locals and some Chinese workers due to misunderstanding even though the

Table 2 Factors of the construction technical risks considered by general contractors in Ghana

No. 1	Technical risk factor	Related group
1	accidents on site	contractor
2	design changes by client	client
3	equipment failure	contractor
4	errors in design drawings	consultant
5	high degree of difficulty in construction	contractor
6	stiff environmental regulations	exogenous
7	incompetence of transportation facilities	exogenous
8	industrial disputes	exogenous
9	materials shortage	exogenous
10	obsoleteness of building equipment	exogenous
11	poor quality of procured materials	contractor
12	problems due to partner's and client different practice	client
13	shortage in supply of water	exogenous
14	shortage in supply fuel	exogenous
15	shortage in Power Supply	exogenous
16	unknown site physical conditions	exogenous
17	following government standards and codes	exogenous
18	wastage of materials by workers	exogenous
19	theft of materials at site	exogenous
20	site distance from urban area	exogenous
21	surplus materials handling	contractor
22	architect vs. structural engineer dispute	consultant
23	shortage of skilful workers	exogenous

Chinese and Ghanaians are generally peaceful people. Disputes arising with miscommunication about technical details must be taken seriously because the least error caused by either party can lead to fatal consequences especially if it is a building construction. There was an incidence in Kumasi, in the Ashanti Region of Ghana where a technical error on the part of one of the engineers led to the total collapse of a story building with many casualties. Disputes also arise among top managers when duties and functions are not well defined. Other issues that cause disputes are the differences of specific standards and codes for construction.

To address industrial disputes which happen to be a high risk factor, a temporal dispute settling committee could be set up within the firm. Their sole responsibilities would be to settle any industrial disputes developing within the confines of the firm. This way, executives and managers can concentrate on other areas of the project whiles this dispute committee deals with all arising altercating concerns.

With an RII of 0.871, 'shortage in power supply' ranks second among the factors explored. In the past few years power supply has been one of the main problems of Ghana and this has even led to the decline of foreign investment in the country. Many companies have resorted to the use of fuel powered generators, 'Genset' and solar-powered gadgets for various projects. 'Dumsor' a local term for the constant power-outage is now a growing term even among foreign nationals.

Shortage in supply of water with an RII of 0.853 ranks third as the next technical risk factor related directly and indirectly to the construction work on site. Many of the firms have resorted to digging their own bore holes to supply water for construction even though it requires a lot of time and resources. Firms that do not have machines to adequately detect the location of springing deposits of water waste time looking for suitable places to get water for construction. Others also buy water from companies like Taysec but at expensive rates increasing the cost of production. Since water in nearby streams are somehow polluted they cannot be used as it affects the chemical properties and thereby the binding strength of the cement being used in the construction work.

Table 3 Showing the technical risk factors with the relative importance index

Technical risk factor	RII	Rank	Risk allocation response rates			Related group
			Transfer, %	Mitigate, %	Retain, %	
industrial disputes	0.886	1	89	7	4	exogenous
shortage in power supply	0.871	2	78	15	7	exogenous
shortage in supply of water	0.853	3	67	10	23	exogenous
problems due to partner's and client different practice	0.814	4	75	5	20	client
shortage of skilful workers	0.801	5	15	60	25	exogenous
shortage in supply of fuel	0.791	6	76	14	10	exogenous
accidents on site	0.786	7	20	65	15	contractor
theft of materials at site	0.775	8	93	5	2	exogenous
equipment failure	0.742	9	51	35	14	contractor
unknown site physical conditions	0.743	10	45	35	20	exogenous
errors in design drawings	0.731	11	10	83	7	consultant
obsoleteness of building equipment	0.723	12	30	55	15	exogenous
architect vs. structural engineer dispute	0.711	13	40	20	40	consultant
following government standards and codes	0.701	14	78	15	7	exogenous
poor quality of procured materials	0.697	15	30	46	24	contractor
surplus materials handling	0.685	16	15	73	12	contractor
stiff environmental regulations	0.674	17	90	4	6	exogenous
site distance from urban area	0.663	18	13	76	11	exogenous
materials shortage	0.651	19	20	69	11	exogenous
incompetence of transportation facilities	0.642	20	30	64	6	exogenous
high degree of difficulty in construction	0.632	21	10	77	13	contractor
wastage of materials by workers	0.627	22	15	82	3	exogenous
design changes by client	0.615	23	90	5	5	client

Problems due to partner's and client different practice, shortage of skilful workers, shortage in supply of fuel, accidents on site, theft of materials at site with indices 0.814, 0.801, 0.791, 0.786, 0.775 were ranked fourth, fifth, sixth, seventh, and eighth, respectively. Problems due to partner's and client different practice has a transfer rate of 75% due to the fact that the Chinese have a different code of practice and other technical variations in construction, so most of the sensitive technical discrepancies in terms of practice are reported to the client or government if it was not indicated previously during the bidding process for final decision to be taken. A local skilled engineer on site working along with the Chinese may be helpful to resolve some of these differences.

Shortage of skilful workers with a mitigation response of 60% sometimes draws controversy among officials and workers as a whole. Many of the Chinese contractors tend to bring in their own skilled workers from China because they perceive the local workers as unskilled sometimes due to the fact that they cannot communicate effectively with them on vital technical issues. They also feel that the Chinese workers are well versed with their code of practice and are able to work in all kinds of working conditions with fewer complaints.

Shortage in supply of fuel has been a major setback for many stakeholders embarking on various projects in Africa. With an RII of 0.791 and ranked 6th, this has been one of the main issues that the firms seek immediate help from the client or government if they have to work within the scheduled time. During shortage of fuel supply like gasoline and petrol, the overall construction cost is high because of the national increased cost of fuel purchase. The Ghana government has been on different projects to help resolve this issue.

Errors in design drawings ranked 11th with an RII of 0.731 had 83% of mitigation as viewed by the respondents. Sophisticated and complex design work requires constant attention data clarifications and requests for details. If these are not adhered to they can pose as a threat to construction work. Some of these threats can be unclear and incomplete drawings; omissions and errors in design drawings; technical terms and stipulations; inept design disciplines; misinterpretation of codes and measurements.

Apart from these examples, there may be important revisions and alterations in the design drawings and documents which can extensively lead to delay in the work and response to general request for information. These may even lead to complete cessation of construction activities, reworks and disruption of the construction schedules. Many of these reasons warrant for mitigation measures by the consultant instead of transferring the pertinent technicalities to be resolved. These situations have led to late delivery of materials in many cases. This is in agreement with the findings of Al-Momani (2000) [21] and Frimpong et al. (2003), [22] whose research have depicted the influence of this factor on the progress of the construction work in Ghana and Jordan. The recognised setbacks of such technical risk factors on the construction may be as a result of:

• The lack of some designers in providing quality work and competent proficient services.
• Shortfall of the designers in applying basic and fundamental principles in construction which may be due to their lack of knowledge in addressing these construction basics.
• Imposition of unreasonable schedules and durations leading to incomplete and erroneous tender documents.

Table 4 shows the risk-related group average relative importance indices, risk allocation average response rates and group ranks obtained. According to the results, the risk factors related to the 'Exogenous' group was the most significant with an average RII of 0.743, followed by the 'consultant', 'client' and 'contractor', with average RII of 0.721, 0.715 and 0.708, respectively. This means that there is a lot of impact from external units and other construction related institutions during projects and technical procedures. This situation is different from the findings in Asia and other parts of the world reported by Adulaziz et al. (2015), Zou et al. (2007), Al-Dubaisi (2000), Jawad et al. (2009), Alnuaimi et al. (2010) and Haseeb et al. (2011) [23–28]. The contractors surveyed perceived the 'Client' as most significant risk factors, followed by 'consultant', 'contractor' and 'exogenous', respectively.

Table 4 Showing the risk-related group average relative importance indices, risk allocation average response rates and group ranks obtained

Related group	No. of risk factors surveyed	Average relative importance index (RII)	Risk allocation response rates			Group rank
			Transfer, %	Mitigate, %	Retain, %	
exogenous	14	0.743	53	37	11	1
consultant	2	0.721	25	52	24	2
client	2	0.715	83	5	13	3
contractor	5	0.708	25	59	16	4

Table 4 also shows the measured average RII and risk allocation response rate for the different four major groups, for which the risk factors studied were categorised. The findings, moreover, show that the 'Mitigate (59%), option is the contractors' dominant response to risk factor whereas the 'Transfer' discretion is the predominant trend associated with 'Client' (83%) and 'Exogenous' (57%) group-related factors. This is due to the fact that many of the contractors try to resolve the issues they encounter instead of transferring them so as to facilitate and expedite work procedures. The most prevalent risk allocation response for the consultant was the 'Mitigate' (52%) response rate. Many consultants also resort to the same measure as contractors and many times do not engage the auspices of governmental units in resolving matters to avoid the time-consuming bureaucracy. Compared to the previous, Martin *et al.*, (2013) [29], studies which suggested critical risk factors and a need to promote the application and awareness of various analytical techniques for risk management, these new findings give a more vital index to identify technical risk, show the risk related group, facilitate risk allocation and identify risk group ranks.

5 Conclusion

This study considered international construction engagements and the technical risk factors which affects construction globally. Chinese companies which have major top on-going projects like the West Texas wind farm and Algeria's East-West Highway project were studied in Ghana and 23 technical risk factors were ranked using the RII. These factors were selected and shortlisted as having a significant influence on construction projects. They were also based on pertinent previous studies on construction risk management, the various considerations and contributions of practitioners, local industry engineers, and professionals. A high RII value denoted a higher importance of the risk factor explored. Industrial disputes, shortage in power supply, shortage in supply of water, problems due to partner's and client different practice, with RII values 0.886, 0.871, 0.853, and 0.814 respectively were some of the significant technical risk factors.

To address industrial disputes which happened to be a high risk factor, a temporal dispute settling committee could be set up within the firm. Their sole responsibilities would be to resolve any disputes developing within the confines of the firm and educate the firm about the culture and practices of each country. This creates a mutual understanding and respect of each working group and offers executives and managers relief to concentrate on other areas of the project whiles this dispute committee deals with all arising issues. Other high risk factors included shortage of skilful workers, shortage in supply of fuel, accidents on site, theft of materials at site, equipment failure and unknown site physical conditions.

Also, the risk allocation response associated with each of the factors were investigated, namely, 'accept', 'mitigate' or 'transfer'. They were quantified and expressed as a percentage, according to the number of respondents who chose a particular option. This option was in connection to the total number of respondents, and eventually made it easy to locate the overall outstanding pattern of the contractors' attitudes toward risk allocation in the survey.

The four main groups were ranked by quantifying the average value of the relative importance indices for all risk factors. According to the results, the risk factors related to the 'Exogenous' group was the most significant with an average RII of 0.743, followed by the 'consultant', 'client' and 'contractor', with average RII of 0.721, 0.715 and 0.708, respectively. It reflected that there is much influence from external units and other construction related institutions during projects and technical procedures. This situation is different from the findings in Asia and other parts of the world. The findings from the study can serve as a prerequisite guide for international firms engaging in developmental projects in in any terrain using the observations from the Chinese companies. Its limitation is that the technical risks identified may not be applicable in countries with totally different and unstable economic tide as this is not a holistic risk assessment study of construction as a whole. The various technical risk factors investigated in this paper can be a useful data information bank and resource to help reduce certain latent and neglected risk factors in the construction industry and aid to facilitate national economic development as a whole. Project managers can use it as an immediate start-up guide to managing projects and advance the overall well-being of construction engagements.

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