

Volume 9 | No. 2 | 2017

ISSN: 2006 - 8167

JOURNAL OF ENVIRONMENTAL DESIGN AND MANAGEMENT



**Faculty of Environmental Design and Management,
Obafemi Awolowo University,
Ile-Ife, Nigeria**

Evaluation of Risk Factors Impacting Cost and Time Performance of Mechanical and Electrical Services Installation in North Central Nigeria

Yusuf Ganiyu AMUDA , Ranti Taibat ADEBIYI, Theophilus Oluwarotimi Olatunde OLOWA, Ibrahim Babatunde OLADAPO, Lukman Olarewaju OLORUNOJE and Soliu IDRIS

Department of Quantity Surveying, Faculty of Environmental Sciences, University of Ilorin.

Corresponding author's e-mail: amuda.g@unilorin.edu.ng

Abstract

Mechanical and Electrical (M&E) services project are complex in nature and a number of risk arises at the design and installation stages resulting into poor cost and time performance. This paper identified and ranked the risk factors affecting cost and time performance of M&E services projects. Thirty risk factors identified from preliminary investigations were adopted as basis for a questionnaire survey to architects, engineers, quantity surveyors and project managers in North Central Nigeria. Initial statistical analysis produced 23 risks factors that would affect cost and time performance of M&E services projects and analysis of variance results show that no significant difference exists among the opinions of the professionals surveyed on the 7 risk factors. Factor analysis was adopted to classify the risk factors into five principal components namely, pre-contract risks, post contract risks, clients' related risks, procurement and external risks. The risk identification and ranking are good tools for assessment of risks related to M&E services projects. In addition, the classification of the risk factors can be used to establish important risk factors that require the attention of project participants. This will allow the client and contractor to understand the high-risk areas in M&E services projects and assign responsibility for those risks to the party or parties best situated to control them.

Keywords: Cost and time performance; mechanical and electrical services; Nigeria practitioners; risk.

Introduction

M&E services are considered to be among the riskiest aspects of a building project for several reasons. First, the value and complexity of M&E project in modern buildings is increasing and a typical M&E service cost could represent between 35-70% of the total cost of a building (Aibinu, Dassanayake, Chan and Thangaraj, 2015). As buildings grow in size and complexity, M&E services also tend to be more sophisticated and difficult to manage from design to installations. Consequently, huge cost overruns and significant delays resulting from frequent design changes occur (Mok, Tummala and Leung, 1997; Lam,

2006). Secondly, M&E services are complex and dependent upon the completion of other critical elements of buildings such as building fabrics and finishes (Barton, 1983; Gura, 1984; Churcher, 2009). Thirdly, the complexity of M&E services requires division of roles and responsibilities among the client, design team, specialist designer, contractors and specialist subcontractors (Lam, Gibb and Sher, 1997; Lam, 2006). These project participants enter the M&E project life cycle at different stages with different roles, responsibilities, risk management capabilities, and risk bearing capacities with conflicting interests, therefore, leading to significant interface risks

Some aspects of this paper were part of the Proceedings of the Environmental Designs and Management (EDM) Interantional Conference organized by Faculty of EDM (Advances in Built Environment Research) held between 22nd - 24th May, 2017 at the conference Centre, Obafemi Awolowo University, Ile-Ife, Nigeria.

among the project team which materializes throughout the lifecycle of the project (Hanna, Bodai and El Asmar, 2013). Lastly, in developing countries such as Nigeria, M&E services project is characterized by high foreign materials content (i.e. imported materials) (Akinpelu, 2009), making equipment cost susceptible to import duties and change in exchange rate, exposing clients to limited choice of specified equipment which may be obsolete at the time of delivery as well as unpredictable lead time.

More importantly, project participants often fail to see that the risk generated in one stage of the project can have a significant knock-on impact throughout its later stages. In particular, poor risk assessment and risk allocation through contract and late involvement of project participants in the design phase could lead to higher risks occurring (Smith, Merna and Joblin, 2006). Poorly designed project delivery approach can lead to delays, higher costs, and ultimately unhappy clients (Boussabaine and Kirkham, 2003; Babalola, 2012). Good risk management in the construction industry requires more than purely common sense and instinct (Ashworth, Hogg and Higgs, 2013). If risk is not properly managed, it becomes a threat to project objectives and consequently detrimental to cost, time and quality (Mok, Tummala and Leung, 1997; Boussabaine and Kirkham, 2003; Smith *et al.* 2006). This paper reports findings on risk factors affecting cost and time performance of M&E services projects in Nigeria. The study is important because a review of previous studies reveals that though much has been done on cost and time performance of construction projects and focus has been on general civil and building projects (Bowen and Edwards, 1996; Abinu and Jagboro, 2002; Del Pico, 2012; Akanni, *et al.*, 2015), there is dearth of research on the effects of risk factors on M&E services projects. Therefore, this study aims to: identify and evaluate risk factors in M&E services projects with a view to assessing the relative importance of the risk factors affecting cost and time performance of M&E services projects. Since project objectives are subject to risk and uncertainties, the first objective identifies the

potential risks to M&E services projects. This will assist practitioners to assess and allocate risk to parties in a manner which is likely to optimize project performance. The second objective will help to determine the principal risk factors that could lead to variations and provide clients with better information upon which to make value for money decisions.

Conceptualization of construction project performance and risk

Project performance is derived from project objectives which are derived from the objectives and success measures of the organisational level (Vandeveld, Dierdonck and Debackere, 2002). Fundamentally, clients (organisational) project objectives focus on three factors critical to project success, namely: quality, time and cost (Walker, 2007). Time is described as the time from the present until the completion of the project, the point when the project ends and is absorbed back into the core client business (Winch, 2010). According to Walker (2007), time can be assessed on a continuum from time is "of the essence" to time is "at large"; of the essence - where the project is delivered one day late then it would be of no value. While cost includes all costs associated with the capital costs of the project, measured on a continuum between rigidity in budgeting and flexibility in budgeting (Kelly and Male, 2002). Quality is subdivided into technical, functional and aesthetic aspects of the project. However, project cost and time performance are the most common measures in project management literature (Walker, 2007). Risk is generally considered as the impact of the uncertainty on the achievement of project objectives (Jaafari, 2006; Winch, 2010). Risk is defined as uncertainty of outcome, whether positive opportunity or negative impact. It is an exposure to loss/gain or the probability of occurrence of loss/gain multiplied by its respective magnitude (Smith, Mema and Joblin 2006).

Events are said to be certain if the probability of their occurrence is 100% or totally uncertain if the probability of occurrence is 0% (Jaafari, 2006).

Mechanical and electrical services project delivery and risk factors

M&E services installations are crucial to the smooth running of construction projects (Aibinu, Dassanayake, Chan and Thangaraj, 2015). According to Hall and Greeno (2009), M&E services are specialist work, discrete and complex in nature. The complex nature of this important element of building was further outlined by Akinpelu (2009) in terms of its design, technical capability, excessive reliance on foreign materials, long gestation period for project completion, initial capital involved, contract documentation and administration. However, the complexity of M&E services are too often ignored at the inception of building projects. For instance, building process is generally divided into; a design function, a construction function, and a coordinating function (Churcher, 2009). Within the design team, the design coordination function is usually coordinated by the architect while the construction function is co-ordinated by the main contractor (Lam, Gibb and Sher 1997). Perhaps, the architects think in terms of aesthetics, the structural engineers think in terms of loads and stresses, the QS in terms of costs, the service engineer in terms of internal environmental consideration and the service subcontractors in terms of production methods (Barton, 1983;Gura, 1984). This practice follows that, the architect and the structural engineer produce pictorial and dimensional drawings in the form of plans, sections and elevations. The service engineers communicate by means of diagrammatic presentations since working drawings are not part of his normal services (Lam *et al.*, 1997).

Consequently, most M&E services in buildings often failed to meet clients requirements because of faults in pre-design and design phase; defects in installation stages and malfunction during testing and commissioning (Heimonen, Immonen, Kauppinen, Nyman and Junnonen, 2000). Gura (1984) maintained that the traditional method of sequential design development delays project completion because contractors' areas of specialisation are not taken into consideration

during design. Gura (1984) explained that M&E engineers require specialist advice at this stage of design development, but specialist designers are not usually involved because of the sequential way of design development. Pavitt and Gibb (2003) considered that non-involvement of specialist contractors always causes serious problems during construction, especially at the interface between the M&E design team and contractors. Marsh (2003) observed that this normally occurs because of the following reasons: communication gap between designers often caused by poor coordination of the various design inputs; lack of management at interfaces and blurred divisions of responsibility", and procurement of specialist contractors' design – (specialist contractors are not contractually recognised as a member of the team). The resulting problems were identified as design related problems and coordination problems.

Design related problems

According to Mathews and Howell (2005), M&E services and other related trades were generally brought into the design process by the main contractor at the tender stage. Then the specialist services contractors receive information from the main contractor, process client requirements at their individual organisation level without input from the client and even designers (Marsh, 2003). M&E design activities may be undertaken by different types of organization, such as consultants who only do the systems design; manufacturers who design and manufacture; and installers who design and install (Churcher, 2009). In essence, the final design comes from specialist designers/contractors/manufacturer and they are not usually involved in the design development. In most cases, good ideas are held back by specialist contractors in order to gain a competitive advantage during the tender (Buys and Mathew, 2005) and this makes it difficult for design consultants to optimise design solutions (Churcher, 2009). Rawlinson and Dedman (2010) stated that most M&E works involve an element of design by specialist designers who are not involved early in the project. These specialist design engineers (i.e. HVAC, IT, Security

and Communications, Plumbing, and Fire Fighting) have based their art on different backgrounds, training and development, leading to lack of appreciation of each other's problems (Michie, 1981). Moreso, in most cases these specialist engineers are not usually reflected in the conditions of engagement, forms of contract and actual management of M&E projects (Pavitt and Gibb 2003).

Coordination problems

According to Barton (1983) the probable areas of conflict resulting from lack of coordination are as follows: services conflicting with the structural frame; discrepancies in dimensioning as stated on different drawings; improper reservation of holes; conflicts between two or more services; differences between the dimensions of the actual equipment and those in the detailed design; differences in the location of equipment; improper arrangement of the sequence of works; difficulties in the identification of access points and services; difficulties in the support and fixing of services; insufficient space for the completion of adjacent finishing works and difficulty in inspection, commissioning and maintenance.

According to Marsh (2003), none of the standard forms of contract fully respect the complex interrelationship required for a successful installation of M&E services project in buildings. The major drawbacks of these standard forms of contract when dealing with services include: lack of interconnectivity between the various contracted parties; lack of defined design responsibility; lack of provision for commissioning and/or testing; lack of provision for contractor's design portion; lack of provision for detailed costing other than capital cost; lack of provision for maintenance or system operation. Marsh (2003) further explained that, this lack of standardization, together with the dominance of imposed conditions set by the main contractor creates a chain of liability that does not allow a direct contractual relationship between client and subcontractor.

Design related problems and coordination problems are considered risky because the smaller the level of information available at the early design stage of a construction project, the higher the level of risks and uncertainties (Odeyinka, Weatherup, Cunningham, Mckane and Larkin, 2010). For instance, the risk allowance at project inception stage can be a significant percentage of the total estimated cost, whereas after completion, the requirements for risk allowance will be zero (RICS, 2012). Therefore, inadequate design information is considered a potential source of risks that could negate the achievement of M&E services project objectives. The complex nature of M&E services makes risks inevitable in the design of M&E and the amount of risk considered acceptable is the challenge faced by designers (Mok, Tummala and Leung 1997). According to Lam *et al.*, (1997) all M&E projects are risk prone and one of the major difficulties for the designer is to manage and eliminate that risk. Risk management is about quantifying the outcome of alternative decisions, ensuring the decisions being made today will provide a satisfactory basis for decisions tomorrow (Marsh, 2003).

RICS (2000) pointed out that failure in the coordination of M&E services design could affect installation time, installation costs, delay of other trades, cooperation between parties and standard of workmanship. Meanwhile, design coordination problem which is not recognised during the design process may become evident during installation of the works (Churcher, 2009). For instance, a clash of ductwork with structural beam will require time for design solution which could lead to preparation of revised calculations; preparation of revised drawings; approval by others of the re-design; re-ordering of materials; re-installation of the ductwork and re-programming. During installations, however, remedying a design coordination problem can lead to additional costs, including those arising from drawing time, incidental item (e.g retaining scaffolds for a longer time) and cost associated with variation (Michie, 1981).

Table 1: Summary of risk factors affecting cost and time performance of M&E services projects

S/No	Risk factors	Authors and Year
1	Late involvement of M&E services engineers.	(Heimonen, <i>et al.</i> , 2000); (Marsh, 2003); (Smith, <i>et al.</i> , 2006)
2	Non-involvement of specialist designers	(Mathew & Howell, 2005); (Gura, 1984); (Pavit & Gibb, 2003)
3	Poor specification	(Mathew & Howell, 2005); (RICS, 2012)
4	Poorly prepared tender document	(Babalola & Adesanya, 2008)
5	Inappropriate procurement path for Mechanical and Electrical.	(Marsh, 2003); (Akinpelu, 2009); (Aibinu, <i>et al.</i> , 2015)
6	High cost of co-ordination.	(Lam, <i>et al.</i> , 1997); (Lam, 2006)
7	Clients' reluctance to pay for the services of specialist	(Mathew & Howell, 2005); (Marsh, 2003);
8	Incomplete consideration of clients' requirements	(Churcher, 2009); (Rawlinson & Dedman, 2010)
9	Poor coordination of design inputs	(Mok, <i>et al.</i> , 1997); (Lam, <i>et al.</i> , 1997); (Lam, 2006)
10	Lack of effective communication and co-ordination between the key parties.	(Michie, 1981); (Marsh, 2003)
11	Blurred division of responsibility	(RICS, 2000); (Gura, 1984)
12	Lack of contractual recognition for specialist designers	(Mok, <i>et al.</i> , 1997); (Mathew & Howell, 2005)
13	High foreign materials content.	(Akinpelu, 2009)
14	Difficulty in managing many specialist contractors by the main contractors	(Lam, <i>et al.</i> , 1997); (Marsh, 2003)
15	Differences in the location of equipment as designed & as installed	(Barton, 1983); (Pavit & Gibb, 2003); (Marsh, 2003)
16	Discrepancies in dimensioning as stated on different drawings	(Gura, 1984); (Marsh, 2003); (Churcher, 2009)
17	Difficulty in inspection, commissioning and maintenance.	(Marsh, 2003); (Churcher, 2009)
18	Improper reservation of holes	(Barton, 1983); (Gura, 1984)
19	Difficulty in the identification of access points and services	(Barton, 1983); (Hanna, <i>et al.</i> , 2013)
20	Services conflicting with the structural frame	(Barton, 1983); (Hanna, <i>et al.</i> , 2013)
21	Desire to comply with emerging technologies	(Churcher, 2009); (Rawlinson & .A., 2010)
22	Separation of design from construction and maintenance.	(Marsh, 2003); (Churcher, 2009)
23	The need to maintain competitive advantage by specialist	(Marsh, 2003); (Mathew A., & Howell, 2005)
24	Need for energy efficient M&E service components	(Lam, 2006); (Rawlinson & . 2010)
25	Fast-tracking pressures on design and construction	(Marsh, 2003); (Churcher, 2009)
26	Improper arrangement of the sequence of works	(Marsh, 2003); (Churcher, 2009)
27	Inexperience specialist contractors	(Mathew & Howell, 2005); (Churcher, 2009)
28	Increasing client sophistication	(Lam, 2006); (Rawlinson & .A., 2010)
29	Compliance with statutory requirements.	(Michie, 1981); (Dandy & Warner, 1989)
30	Government policy change	(Akinpelu, 2009); (Hanna, <i>et al.</i> , 2013); (Aibinu, <i>et al.</i> , 2015)

The time needed to resolve coordination issues might cause a critical delay to trades or activities (Michie, 1981; Churcher, 2009). Owing to the adversarial nature of the construction industry, none of the parties to the project will want to accept liability for poorly-defined design duties resulting from gaps in the design, since the consequence is not known (Lam, 2006; Rawlinson and Dedman, 2010).

According to Lam, Gibb and Sher (1997) once specialist contractors experience a problem resulting from design coordination, the solution can necessitate a compromise of the quality of the installations. The summary of risk factors affecting M&E services project delivery as identified from literature review are presented in Table 1.

Research methodology

The main objectives of this study was to identify risk factors affecting cost and time performance of M&E services projects. Based on the literature review (Barton, 1983; Gura, 1984; Lam, Gibb and Sher, 1997; Churcher, 2009), a preliminary list of factors was prepared in order to explore and evaluate the risk factors influencing cost and time performance of M&E services projects. Lam, (2006) considered that a simple approach to risk management is to perform risk analysis at project inception by developing a table showing the type of risk to M&E project, its possible causes, its potential consequences (low L, medium M, and high H) the severity/impact of the risk (L, M, H) and finally what would be the typical safeguards. Boussabaine and Kirkham, (2003) called this a risk matrix, whereby for each of the identified risks, a score is assigned for the probability and severity facets of the risk. Boussabaine and Kirkham (2003) opined that there are two dimensions to a risk matrix, first, it looks at how severe and likely an unwanted event is and that, the combination of this probability and severity will give any event a place on a risk matrix.

In order to ensure validity of survey instrument, the initial risk factors identified were further reviewed and verified by 4 industry practitioners,

these practitioners have good experience of M&E services project. The practitioners were asked if they consider the risk factors identified as contributing to poor cost and time performance of M&E services project. Validity of survey instrument is the extent to which it provides adequate coverage for the construct domain (Kumar 2011), and since the establishment of content validity is not numerical but subjective and judgmental (Paulraj and Chen, 2004), the process is considered adequate for this study. Based on the refined questionnaire, data were obtained using a structured questionnaire on the 30 risk factors identified from preliminary investigations. The questionnaire was based on a 7 point Likert scale grade ranging from 1 = "extremely low", 2 = "very low", 3 = "low", 4 = "moderate", 5 = "high", 6 = "very high", 7 = "extremely high". Although, a 5 or 7 point scales will produce similar results useful for analytical tools (Zumbo, Gadermann and Zeisser, 2007). However, a 7 point scale is adopted for this study because 5-point scale will produce only two options for positive response while a 7-point scale produces three options for positive response with a higher comparative variance (Dawes, 2002). Moreover, a 7-point rating system has the advantage of reducing leniency and central tendency problems that characterize ordinal scales (Dawes, 2007). Therefore a 7-point scale is considered more appropriate for the assessment of probability of occurrence and severity of the risk factors on M&E services projects.

Online questionnaire survey using "Google Forms" was administered purposively on professionals involved in the construction industry in the North Central Nigeria. A total of 145 professionals were contacted via email to seek their participation in the online survey. A total of 78 replied the email request showing interest to participate out of which only 53 completed the survey questionnaire. SPSS version 20 was used for the statistical analysis. Mean response analysis was performed to rank the relative importance of the risk factors, while analysis of variance (ANOVA) was used to investigate differences of opinions between respondents' groupings. The arithmetic

mean response analysis was used to establish the relative significance of the risk factors relating to their probability and severity. The approach is used because it represents the central tendency and is widely used in construction management studies (Ameyaw and Chan, 2015). The summary of the probability and severity of the risk factors as perceived by the industry practitioners in the construction industry is presented in Table 3. The impact of the risk factors according to Ameyaw & Chan (2015) can be derived by taking the squareroot of the product of probability and severity as shown in equation No. 1

$$RI = \sqrt{(P \times S)} \text{-----Equation 1.}$$

This approach to measurement of risk impact is well-established in decision theory domain (Odeyinka, et al., 2012; Ameyaw and Chan, 2015).

Reliability test

Prior to the commencement of data analysis, reliability analysis was carried out to statistically check the consistency of the 30 risk factors and reliability of survey instrument. The internal consistency of the dataset was tested using Cronbach's alpha model (Ameyaw and Chan, 2015). It has coefficient between 0 and 1, and MacKenzie, Podsakoff and Podsakoff (2011) recommended α value of 0.7 or higher as indication of reliable factors in the survey instrument. The Cronbach's alpha value of 0.894 and 0.896 was derived from the construct on 30 risk factors, suggesting a high internal reliability and consistency of the datasets.

Data analysis and results

Demographic information about respondents is presented in this section. Figure 1 illustrates information on respondents' discipline and Figure 2 presents information about respondents' years of working experience in the industry. In terms of education, 11.3% are PhD holders, 37.7% have Masters' degree, 28.3% have Bachelors' degree, 16.6% HND and 6% with other qualifications. Majority (77.4%) are Associate members, while 12.5% are Fellows and 10.1% other professional qualifications. Majority (94.4%) of the respondents are from consulting (49.1%) and contracting (45.3%) firms while very few (5.7%) are from the academia.

The ranking of the risk factors were then based on the respective impact value. As illustrated in Table 3, the mean probability values for the 30 risk factors ranged between 3.05 (low) and 5.75 (very high), the severity scores ranged from 2.47 (very low) to 5.45 (high) and the mean impact values ranged between 2.94 (low) and 5.56 (very high). What this suggests is that overall risks ranged from 'low' to 'very high'. Looking further into the trend it can be observed that 7 risk factors (HR_1- HR_7), based on the magnitude of their impact are considered by the respondents as having high impact on M&E services projects. These identified risk factors are: (i) high foreign material content (ii) poorly prepared tender document (iii) late involvement of M&E services engineers (iv) non-involvement of specialist designers (v) Government policy change (vi) poor specification and (vii) poor coordination of design inputs. These 7 risk factors have risk impact scores >5.

Table 2: Instrument reliability test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.894	.896	30

Table 3: Results of the Questionnaire Survey

Code	Risk factor	Risk probability	Risk severity	Risk impact	Rank
HR_1	High foreign materials content	5.67	5.45	5.56	1
HR_2	Poorly prepared tender document	5.54	5.37	5.46	2
HR_3	Late involvement of M&E services engineers.	5.49	5.30	5.39	3
HR_4	Non-involvement of specialist designers	5.49	5.26	5.37	4
HR_5	Government policy change	5.30	5.26	5.28	5
HR_6	Poor specification	5.75	4.79	5.25	6
HR_7	Poor coordination of design inputs	5.29	4.97	5.12	7
MR_1	Incomplete consideration of clients' requirements	4.56	4.91	4.68	8
MR_2	Services conflicting with the structural frame	4.58	4.64	4.61	9
MR_3	Lack of effective communication and co-ordination between the key parties.	4.64	4.47	4.55	10
MR_4	Lack of contractual recognition for specialist designers	4.35	4.35	4.35	11
MR_5	Difficulty in managing many specialist contractors by the main contractors	4.50	4.11	4.30	12
MR_6	Inappropriate procurement path for Mechanical and Electrical.	4.09	4.50	4.29	13
MR_7	The need to maintain competitive advantage by specialist	4.13	4.24	4.18	14
MR_8	Clients' reluctance to pay for the services of specialist	4.13	4.15	4.14	15
MR_9	Desire to comply with emerging technologies	4.24	3.86	4.05	16
MR_10	Inexperience Specialist contractors	4.30	3.69	3.98	17
MR_11	Differences in the location of equipment as designed & as installed	3.77	4.01	3.89	18
MR_12	Fast-tracking pressures on design and construction	4.05	3.66	3.85	19
MR_13	Need for energy efficient M&E services components	4.18	3.50	3.83	20
MR_14	Increasing client sophistication	3.75	3.81	3.78	21
MR_15	Blurred division of responsibility	3.56	3.90	3.73	22
MR_16	High cost of co-ordination.	3.84	3.24	3.53	23
LR_1	Compliance with Statutory requirements.	3.52	3.45	3.49	24
LR_2	Improper arrangement for the sequence of works	3.18	3.81	3.48	25
LR_3	Discrepancies in dimensioning as stated on different drawings	3.33	3.50	3.42	26
LR_4	Difficulty in inspection, commissioning and maintenance.	3.22	3.11	3.16	27
LR_5	Separation of design from construction and maintenance.	3.16	3.03	3.10	28
LR_6	Difficulties in the identification of access points and services	3.05	2.90	2.98	29
LR_7	Improper reservation of holes	3.50	2.47	2.94	30

High Risk =HR; Moderate Risk (MR); Low Risk (LR)

On the other hand, results revealed that 16 risk factors (MR-1 –MR-16) are perceived by respondents as medium risk with risk impact value > 3.5. Based on their risk impact scores, 7 risks factors (LR-1 – LR-7) were identified as having low impact on M&E services project. The 3 risk factors with lowest impact score on M&E services are: (i) separation of design from construction and

maintenance (ii) difficulties in the identification of access points and services (iii) improper reservation of holes. What this suggests in essence is that respondents don't perceive these risk factors as major risks in the industry. Some of the major risks factors (those with high impact on M&E services project) identified in the study were high foreign material content and poorly prepared

tender document.

This is the bane of the construction industry in Nigeria over the years. Majority of the components of M&E services in buildings are imported, hence the local environmental factors have not been taken into consideration by manufacturers or producers of some of these products.

The ANOVA results (Table 4) show that no significance difference exist in the mean score among the respondents on each of the 7 risk factors identified as having high probability of occurrence (HR_1 $F=1.646, p>0.05$, HR_2 $F=1.023, p>0.05$, HR_3 $F=1.445, p>0.05$, HR_4 $F=2.128, p>0.05$, HR_5 $F=.584, p>0.05$, HR_6 $F=2.883, p>0.05$, and HR_7 $F=1.174, p>0.05$). The results, in essence, show that the respondents are unanimous in their scoring of these risk factors. However, for those risk factors that respondents perceived as having medium chances of occurrence, their ANOVA results revealed that no statistical significant differences were recorded except for MR_10 ($F=11.769, p<0.05$), MR_11 ($F=4.434, p<0.05$), MR_13 ($F=3.922$), MR_14 ($F=17.592, p<0.05$) and MR_16 ($F=12.667, p<0.05$). What this suggests is that respondents varied in their perception on the need to maintain competitive advantage by specialists, inappropriate procurement path for M&E services projects, need for energy efficient M&E services components, increasing client sophistication and high cost of coordination as risk factors in M&E services project. For those risk factors perceived as having low probability of occurrence, ANOVA results show that

respondents unanimously agreed in their scoring (i.e. no statistical significance difference exist for each of the factors). except for LR_1 ($F=3.922, p<0.05$), LR_2 ($F=17.592, p<0.05$), and LR_4 ($F=12.667, p<0.05$).

Factor analysis

Factor analysis is usually adopted to statistically reduce the number of factors on which the variables under investigation have high loadings (Proverbs, Holt, & Olomolaiye, 1999). The Kaiser-Meyer-Olkin (KMO) and Bartlett's test result is used to measure the sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis to continue. The KMO statistics ranges from 0 to 1. A value of 0 infers that the sum of partial correlations is large relative to the sum of correlations, therefore factor analysis will not be appropriate, on the other hand, a value close to 1 implies that patterns of correlations are relatively compact and factor analysis would yield distinct and reliable individual factors (Gravetter & Wallnau, 2007). In this survey, the Bartlett's test of sphericity was significant ($p<0.05$) (Table 5), and the value of the KMO index was 0.837 (above 0.6) (Table 5). The results of these tests confirmed that the data were appropriate for factor analysis. As can be seen in Table 5, the Bartlett's test of sphericity is significant at 939.38 compared with associated significance level, and the associated probability is less than 0.05 ($p\text{-value} = 0.000$), meaning that the correlation matrix is not an identity matrix.

Table 4: Risk factors with high probability of occurrence

Code	Risk factor	Risk probability	F-Stat	P-Value
HR_1	High foreign materials content	5.67	1.646	.533
HR_2	Poorly prepared tender document	5.54	1.023	.367
HR_3	Late involvement of M&E services engineers.	5.49	1.445	.245
HR_4	Non-involvement of specialist designers	5.49	2.128	.149
HR_5	Government policy change	5.30	.584	.562
HR_6	Poor specification	5.75	2.883	.065
HR_7	Poor coordination of design inputs	5.29	1.174	.421

Table 5: Bartlett's test for the risk factors and KMO

Approx. Chi-square	939.38
Df	
Sig	0.000
Kaiser -Meyer -Olkin Measure of Samplin adequacy	0.837

Table 6: Results of factor analysis

	Rotated Component Matrix ^a				
	1	2	3	4	5
Late involvement of M&E services engineers.			.927		
Non-involvement of specialist designers			.632		
Poor specification			.591		
Poorly prepared tender document			.803		
Inappropriate procurement path for Mechanical and Electrical.				.911	
High cost of co-ordination.	.853				
Clients' reluctance to pay for the services of specialist	.903				
Incomplete consideration of clients' requirements			.838		
Poor coordination of design inputs		.825			
Lack of effective communication and co-ordination between the key parties.				.672	
Blurred division of responsibility				.715	
Lack of contractual recognition for specialist designers	.646				
High foreign materials content		.827			
Difficulty in managing many specialist contractors by the main contractors				.660	
Differences in the location of equipment as designed & as installed		.657			
Discrepancies in dimensioning as stated on different drawings	.865				
Difficulty in inspection, commissioning and maintenance.		.860			
Improper reservation of holes		.674			
Difficulties in the identification of access points and services		.854			
Services conflicting with the structural frame		.896			
Desire to comply with emerging technologies					.623
Separation of design from construction and maintenance.	.901				
The need to maintain competitive advantage by specialist	.847				
Need for energy efficient M&E services components					-.635
Fast-tracking pressures on design and construction				.934	
Improper arrangement for the sequence of works					.664
Inexperience Specialist contractors				.731	
Increasing client sophistication					.885
Compliance with Statutory requirements.					.642
Government policy change					.922
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. ^a					
Rotation converged in 8 iterations.					

The risk factors affecting cost and time performance of M&E services projects were grouped into 5 components through factor analysis (Table 6). These 5 factor groupings with eigen values greater than 1.000 explain 88.42% of the variance (i.e components 1- 34.35, components 2 – 21.84; component 3 – 14.30%; component 4- 11.96% and component 5 – 5.96%). Each of the risk factors belonged to only one of the groupings, with the value of factor loading exceeding 0.50.

Since this is an exploratory factor analysis, naming of the factors is based on the researcher's underlying knowledge of the phenomenon under study. Thus, the risk factors are classified and named as follows: Component 1 - pre-contract risk; component 2 - post-contract risk; components 3 - client related risk; component 4 - procurement related risks and component 5 - external risk factors. This is further explained in the ensuing section.

Component 1: Pre-contract risks.

This component which accounted for 34.35% of the total variance explains between risk factors. This factor was considered relatively more important than the other 4 factors. It indicates that respondents (architects engineers, quantity surveyors and project managers) consider that pre-contract risk factors have more effect on cost and time performance of M&E services projects. The results show that 6 items loaded under this component. The 6 factors are: high cost of co-ordination; clients' reluctance to pay for the services of specialist; lack of contractual recognition for specialist designers; discrepancies in dimensioning as stated on different drawings; separation of design from construction and maintenance and the need to maintain competitive advantage by specialist.

Component 2 – Post contract risks

Among the five components, this component ranked second and accounts for 21.85% of the total variance explained. It produced 7 items which includes: poor coordination of design inputs; high

foreign materials content; differences in the location of equipment as designed & as installed; difficulty in inspection; commissioning and maintenance; improper reservation of holes; difficulties in the identification of access points and services and services conflicting with the structural frame.

Component 3: Client related risks

The 5 items that loaded under the third component include late involvement of M&E services engineers, non-involvement of specialist designers, poor specification, poorly prepared tender document and incomplete consideration of clients' requirements.

Component 4: Procurement related risks

The *fourth factor* has 6 items which include inappropriate procurement path for M&E services, lack of effective communication and co-ordination between the key parties, blurred division of responsibility, difficulty in managing many specialist contractors by the main contractors, fast-tracking pressures on design and construction, and inexperience specialist contractors.

Component 5: External risk factors

Lastly, 6 items loaded under the fifth component. The items include desire to comply with emerging technologies, need for energy efficient M&E services components, improper arrangement for the sequence of works, increasing client sophistication, compliance with statutory requirements and government policy change. These factors are considered as external factors because they are mostly outside the control of project participants and could influence the final outcome of services projects.

Conclusion

A typical M&E services project is complex and has many participants, those who carry some share of the risks. Some risks are carried by the construction

contractor, some by clients or the design team. This study has identified and ranked risk factors impacting cost and time performance of M&E services project. A total of 30 risk factors identified from previous studies provided the basis for the questionnaire administered to industry practitioners. Mean response analysis of the probability and severity was used in determining the scores of risk factors, and the risk impact score used to rank the significance of the factors. In general, it can be concluded that 7 risk factors were identified as having high impact on M&E services project. They include: high foreign materials content, poorly prepared tender documents, late involvement of M&E engineers, non-involvement of specialist designers, government policy changes, poor specification and poor coordination of design inputs. Analysis of variance revealed that no significant difference exists in the mean score among respondents on each of the 7 risk factors identified as having high impact. The risk factors were further classified into five principal components using factor analysis. The components are pre-contract risks, post contract risks, clients' related risks, procurement and external risks.

It should be noted by practitioners and researchers that the risk factors adopted for this study were identified from previous studies on M&E services projects and refined based on the opinion of experienced industry experts in North Central Nigeria. However, there is likely to be some zonal

specific risk factors that are not identified. In addition, the remaining seven (7) risk factors considered less important in this study may be significant in another context. The identification and ranking of the risk factors has practical implication on M&E services projects. First, risk identification serves as an initial screening of risk factors in M&E services projects, thereby, offering project participants which risks they are exposed to at the early stage of a project. The evaluation of probability of risk occurrence and severity allows project participants to determine whether the impact of the risks is substantial on cost and time of M&E services projects. This will allow the client and contractor to understand the high risk areas in M&E services projects and, where applicable, assign responsibility for those risks to the party or parties best situated to control them. In addition, this could be used as part of invitation to tender for M&E services projects where each tenderer will be required to indicate how they intend to solve the problems during the construction phase of a building project. This will enable the various parties in M&E services project to evaluate their capacity to manage these risks at the outset of the project. Future research works include modelling the cost of M&E services project using the risk factors established in this paper. In addition, future research needs to cross compare the risk factors established on selected M&E services case study projects.

References

- Aibinu, A. A., Dassanayaka, D., Chan, T.-K. and Thangaraj, R. (2015). Cost estimation for electric light and power elements during building design: a neural network approach. *Engineering, Construction and Architectural Management*, 22(2), 190-213.
- Akanni, P., Oke, A. and Akpomiemie, O., (2015). Impact of environmental factors on building project performance in Delta State, Nigeria. *Housing and Building National Research Center HBRC Journal*, 11, 91-97.
- Akinpelu, A. (2009). A step by step approach to the delivery of International projects: conditions of contract/ legal framework, procurement tendering and evaluation. *Two days Seminar on Procurement of International Projects Organized by NIQS*. Lagos: NIQS Lagos State Chapter.
- Ameyaw, E. and Chan, A. (2015). Evaluation and ranking of risk factors in public-private partnership water supply projects in developing countries using fuzzy synthetic evaluation approach. *Expert Systems with Applications*, 42, 5102-5116.
- Ashworth, A., Hogg, K. and Higgs, C. (2013). *Willis's*

- Practice and Procedure for the Quantity Surveyor* (13th ed.). Chichester: Willey-Blackwell.
- balola, O. (2012). An evaluation of the level of satisfaction of clients on mechanical engineering services cost estimates. *Journal of the Nigerian Institute of Quantity Surveyors*, 1(1), 5-8.
- abalola, O. and Adesanya, D. A. (2008). An appraisal of the factors affecting production of cost estimates for electrical services in Nigeria. *Journal of Financial Management of Property and Construction*, 13(32), 200-208.
- Barton, P. K. (1983). *Building Services Intergration*. London: E.&N.Spon.
- Boussabaine, A. and Kirkham, R. (2003). *Whole Life – Cycle Costing: Risk Responses*. Oxford UK: Blackwell.
- Bowen, P. A. and Edwards, P. J., (1996). Interpersonal communication in cost planning during the building design phase. *Construction management and economics*, 14 (5) 395 - 404.
- Buys, J. and Mathew, E., 2005. Investigation into capital costs of HVAC systems. *Building and Environment*, 40, 1153-1163.
- Churcher, D. (2009). *A Design framework for building services: Design activities and drawings definitions* (2nd ed.). London: BSRIA.
- Dawes, J. (2002). Five point vs. eleven point scales: Does it make a difference to data characteristics? *Australasian Journal of Market Research*, 10(1), 1-17.
- Dawes, J. (2007). Do data characteristics change according to the number of scale points used? *International Journal of Market Research*, 50(1), 61-77.
- Del Pico, W., 2012. *Estimating Building Costs for the residential and Light Commercial Construction Professional*. New Jersey: John Willey& Sons.
- Gravetter, F. and Wallnau, L., 2007. *Statistics for the behavioral sciences*. Seventh Edition ed. Belmont: Thomson Wadsworth.
- Gura, J. (1984). Role of the Building Services Engineering Consultants. *IEEE proceedings, physical science, measurement and instrumentation, management and education – Reviews* 131(6) 413-419.
- Hall, F. and Greeno, R. (2009). *Building services Handbook* (5th ed.). London: Butterworth Heinemann.
- Hanna, A., Bodai, F., & El Asmar, M. (2013). State of practice of building information modeling in mechanical and electrical construction industries. *Journal Construction Engineering and Management*, 139(10), 1-10.
- Harvard, T. (2008). *Contemporary property development*, (2nd ed.). London UK: RIBA Publishing.
- Heimonen, I., Immonen, I., Kauppinen, T., Nyman, M. and Junnonen, J. (2000). *Risk management for planning and use of building service system*. Finland: Technical Research Centre. Retrieved from Heimonen, I., Immonen, I., Kauppinen, T., Nyman, M., and Junnonen, J.M. (2000). Risk management for planning and use of building service system. Finland: Technical Research Centre.
- Jaafari, A. (2006). Management of risks, uncertainties and opportunities on projects: Time for a fundamental shift. *International Journal of Project Management*, 19(2), 89-101
- Kelly, J. and Male, S., (2002). Value Management. In: J. Kelly, R. Morledge and S. Wilkinson, eds. *Best Value in Construction*. Oxford: Blackwell Publishing and RICS Research Foundation, 77-99.
- Kumar, R. (2011). *Research methodology : a step-by-step guide for beginners* (3rd ed.). London: Sage.
- Lam, K. C. (2006). Managing building services maintenance risk with prediction theories. *Health Estate Journal*, 41, 27-32.
- Lam, K. C., Gibb, A. and Sher, W. (1997). An analysis of building procurement factors affecting coordination of building services. In P. Stephen (Ed.), *13th Annual ARCOM Conference*, 15-17. 1, 83-92. Cambridge: Association of Researchers in Construction Management,.
- MacKenzie, S. B., Podsakoff, P. M. and Podsakoff, N. P. (2011). Construct measurement and validation procedures in mis and behavioral research: Integrating new and existing techniques. *MIS Quarterly*, 35(2), 293 - 334.
- Marsh, C. (2003). *Building services procurement*. London: Spons Press.
- Mathew, O. and Howell, G. (2005). Integrated project delivery: An example of relational contracting.

Lean Construction Journal, 2(1), 46-61.

McCaffrey, J. (2011). What is an M&E QS. *Royal Institution of Chartered Surveyors Students Construction Journal*, 22-23.

Michie, A. (1981). Integration and co-ordination of building services and its relationship with project management. *Building Services Engineering Research and Technology*, 2, 15-26

Mok, C., Tummala, V. and Leung, H. (1997). Practices, barriers and benefits of risk management process in building services cost estimating. *Construction Management and Economics*, 15 (2), 161-75.

NIQS. (2015). *Building and Engineering Standard Method of Measurement: NIQS BESMM4* (4th ed.). Abuja: The Nigerian Institute of Quantity Surveyors.

Odeyinka, H., Larkin, K., Weatherrup, R. C. and Bogle, G. (2012). *Modelling risk impacts on the variability between contract sum and final account*, London: Royal Institution of Chartered Surveyors, 1-19

Odeyinka, H., Weatherup, R., Cunningham, G., Mckane, M. and Larkin, K. (2010). Assessing risk impacts on the variability between tender sum and final account. The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors (COBRA), held at Dauphine Université, Paris, 2-3 September 2010 Dauphine University, Paris, 8-23

 Iraj, A. and Chen, I. J. (2004). Towards a theory of supply chain management: The constructs and measurements. *Journal of Operations Management*, 22, 115-150.

Pavit, T. and Gibb, A. (2003). Interface management within construction: In particular building facade, *Journal of Construction Engineering and Management*, 129(1), 8-15.

Proverbs, D., Holt, G. and Olomolaiye, P. (1999). Factor influencing the choice of concrete supply methods. *Building Research and Information*, 25(3), 176-184.

Rawlinson, S. and Dedman, A., D. (2010). *Specialist Costs: M&E Services*. Davis Langdon Building Magazine. 2010; available at <http://www.davislangdon.com/>. Retrieved August 25, 2011, from /EME/Research/ResearchFinder/Specialist-Costs/Specialist-Costs---ME-services-2010/;

RICS. (2000). *The Surveyors' Construction handbook- Part three, Section2:Building Services Procurement*. London: RICS.

RICS. (2012). *RICS New Rules of measurement - NRM 1: order of cost estimating and cost planning for capital building works* (Second Edition ed.). London: Royal Institution of Chartered Surveyors.

Smith, N., Merna, T. and Joblin, P. (2006). *Managing Risk in Construction Projects*. Oxford UK: Blackwell Publishing.

Vandeveld, A., Dierdonck, R. and Debackere, K. (2002). Practitioners View on Project Performance: A Three-Polar Construct. In R. L. Fellows, *Research Methods for Construction* (pp. 3-34). Blackwell Publishing.

 ker, A. (2007). *Project management in construction* (5th ed.). Oxford: Blackwell.

Winch, G. M. (2010). *Managing construction projects: An information processing approach* (2nd ed.). Chichester: Wiley-Blackwell.

Zumbo, B., Gadermann, A. M. and Zeisser, C. (2007). Ordinal versions of coefficients alpha and theta for likert rating scales. *Journal of Modern Applied Statistical Methods*, 6(1), 21-29.