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Analysis of rework risk triggers in the Nigerian construction industry

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Abstract: The construction industry plays a significant role in the infrastructure development of many countries. Construction projects suffer from a lot of setbacks despite sophistication and advancement in technology and professionalism. This study, therefore, assessed the factors that triggered the emergence of rework and the benefits derived from eliminating such triggers in the Nigerian construction industry. The study adopted a quantitative survey approach in which a structured questionnaire was adopted as the research instrument. Factor analysis using principal component analysis was adopted to determine the factors that triggered the rework and the pattern of relationship that existed amongst the factors; relative importance index (RII) was used to assess the benefits of eliminating rework triggers. The study concluded that the factors that triggered the emergence of rework were omission and planning issues, change issues, funding and communication issues, and poor workers and resource control. Repeat patronage, higher productivity, and reduced delivery time reduced the rework and waste and improved the employee job satisfaction and morale; they were the benefits derived from eliminating rework triggers. It was recommended that there is a need for clarity, effectiveness, and timeliness of instruction and information dissemination amongst project participants and the participation of contractors, subcontractors, and other stakeholders at the design stages to avoid omissions and construction changes.

Keywords: construction industry, *construction* professionals, construction stakeholders, factor analysis, Nigeria, rework, risk triggers

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1 Introduction

The construction industry is the driving force behind the socio-economic development of many countries (Saidu and Shakantu 2016a). The industry is the means through which countries upgrade their national economies (Anil and Danielraj 2016). Construction industry involves a huge amount of money, time, and energy (Meshksar 2012). It is amongst the major industries that contribute to economic growth and civilization; as such, its importance is approved in all communities (Meshksar 2012). The activities of industries improve the quality of life by providing infrastructures such as buildings, roads, hospitals, and schools amongst other facilities (Saidu and Shakantu 2016b).

In spite of the significance of the construction industry, it is faced with the problems of poor financial performance, high cost of project delivery, poor quality and material waste, and failure to deliver value to clients on schedule (Abdul-Rahman et al. 2013; Saidu and Shakantu 2016b; Anil and Danielraj 2016). Consequently, the industry has been extensively criticized for poor performance and ineffective productivity (Simpeh 2012). The cost and schedule overrun often experienced in the construction project delivery are directly and significantly attributed to rework factors (Hwang et al. 2009; Anil and Danielraj 2016).

Rework is one of the major factors responsible for the setback experienced in the industry (Simpeh 2012; Anil and Danielraj 2016). Rework is the main contributor to time wastage and schedule overruns that ultimately impact on cost, resources, and quality (Love and Edwards 2004; Anil and Danielraj 2016). Love (2002) opined that rework would naturally increase total project costs by 12.6%. Similarly, Davis et al. (1989) reported that rework could cause additional cost to the construction of up to 12.4% of the total project cost.

Enshassi et al. (2017) carried out a study whose aim was to identify the factors that contribute to rework and their impact on construction project performance in Palestine. The study examined the views of contractors, consultants, and project owners using questionnaire survey and concluded that the contractor-related rework causes and human-related rework causes are the major categories which impact on project performance.

Mahamid (2016) analyzed the cost and causes of rework in residential building projects in West Bank, Palestine. The study revealed that construction projects are mostly affected by client- and contractor-related factors. Ajayi and Oyeyipo (2015) studied the effect of rework on project performance in a building project in Lagos State, Nigeria. The study adopted a questionnaire survey with 52 construction professionals and found out that rework impacts on project cost and project schedule. The most ranked causes of rework under client-, design-, and subcontractor-related causes were poor communication with design consultant, use of poor quality materials, poor workmanship, lack of experience and knowledge of design and construction process, and incomplete design at tender time.

Anil and Danielraj (2016) carried out a study whose aim was to determine the underlying causes of rework during construction and their impact on the overall project performance to develop effective prevention strategies in Indian construction industry. The study adopted a questionnaire survey amongst professionals and found out that poor communication between design consultants and clients, deviation from drawings, poor coordination of resources, setting out errors, and low-skilled labour employed by subcontractors are the major causes of rework and these causes are related to the activities of the client, consultants and contractors.

The foregoing studies failed to establish the underlying relationships amongst the factors that influenced rework occurrence. Furthermore, there is little or no research concerning rework triggers in the geographical area of the study. Therefore, this study assessed the factors that triggered the emergence of rework in the Nigerian construction industry. The aim of this study was to analyze the construction professionals' perception on the factors that triggered the rework occurrence in the Nigerian construction industry with a view to ascertain the benefits of eliminating such triggers from the project participants. The specific objectives of this study were as follows: to establish the predominant rework triggers that affected the project performance and to determine the benefits of eliminating rework.

Construction professionals recognize that rework has a considerable impact on project performance (Love and Edwards 2004). Improved quality requires an understanding of the root causes of rework (Love et al. 1999). Rework is a major problem that has befallen the construction industry of Nigeria, and a better understanding of the factors that trigger their emergence will assist the project managers and other participants to ascertain the most effective techniques to improve or eliminate rework. In addition, with the knowledge of the benefits of eliminating or avoiding rework emergence, construction stakeholders will better be prepared to eliminate or reduce their occurrence to take advantage of these benefits.

2 Rework risk triggers

An event or condition that causes a risk to occur is known as risk trigger. Risks have the potential to bring about negative occurrences (Spacey, 2016). According to Spacey (2016), a trigger is the root cause of an event. Based on this definition, rework risk triggers are factors that can cause rework to emerge in the construction work, and this could happen throughout all the phases of construction projects. These triggers are causes, factors, variables, events, or occurrences that could result in rework. Rework occurs when a product or service does not meet the requirements of the customer (Love et al. 1999). As a result, the product is distorted according to the requirements of the customers.

Enshassi et al. (2017) categorized 57 rework factors such as construction process-related causes, material- and equipment supply-related causes, client-related causes, contractor-related causes, human resource capability-related causes, design-related causes, and external environment-related causes. The study carried out by Enshassi et al. (2017) revealed that contractor- and human resource capacity-related factors are the major factors that trigger rework and they have the highest impact on construction project performance. The root causes of construction rework are categorized into client-, design-, and contractor-related factors (Love and Edwards 2004).

Client-related factors identified by Palaneeswaran (2006) included the following: poorly prepared contract documentation, poor communication with design consultants, inadequate briefing, lack of client involvement in the project, lack of funding for site investigation, the inexperience and lack of knowledge of the design and construction processes. The inadequate briefing, lack of knowledge of construction process, and lack of funding allocated for site investigation are the principal causes of rework that impact on project performance which are related to the project owner (Enshassi et al. 2017). According to Dalty and Crawshaw (1973), poor flow of communication or deficits in the flow of communication among members of the client and design team could result to errors and omission being incorporated into contract documentation without being noticed by the parties. The design team must ensure that they communicate and work together amicably, for the projects to be delivered on time or ahead of schedule.

According to Simpeh (2012), lack of coordination and integration of design by the design team have resulted in deficiencies in design, and these have contributed greatly to rework. Design errors and omission, incomplete information for design, incomplete design, and lack of professionalism are the major causes of design-related rework (Enshassi et al. 2017). According to Love et al. (2010), the argument, therefore, is that design professionals lack the professionalism due to design fee reduction that has further resulted in the production of contract documents that are incomplete and inadequate. This, according to Simpeh (2012), leads to rework. The failure to plan work by most supervisors and adequately direct activities and communicate with workers has an impact on the volume and costs of rework (Simpeh 2012). Enshassi et al. (2017) revealed that the major contractor-related rework causes are as follows: attempt to fraud, competitive pressure/low contract value, unqualified technically, and poor quality system. The efficiency of the major contractor's construction planning efforts has an effect on the success of the projects of the site management team and subcontractors (Simpeh 2012). A project without a quality management system in place essentially increases the cost of the project by 10% due to rework (Cusack 1992).

For the subcontractors, specific rework factors found by Love and Smith (2003), Love et al. (1999), Josephson et al. (2002), Oyewobi and Ogunsemi (2010) and Rounce (1998) are as follows: damage to other trade works due to carelessness, inadequate supervision, poor choice of materials, poor managerial skills, and low skill level of construction artisans and labour; poor skill levels of the client's project manager, the design team, and subcontractors (Love et al. 2002). According to Wasfy (2010), the factors that lead to the rework of material and equipment supplies include non-compliance with specifications, untimely deliveries, Failure to prefabricate to project specifications, and non-availability of materials at right time and place when needed.

Environmental factors that cause rework are political situation (siege–conflicts), economy (inflation, exchange rates, market), and physical condition (Enshassi et al. 2017). Mahamid (2016) reported that weather and lack of safety are the major environmental causes of rework that affect project performance. The construction environments are confronted with problems related to production, design changes, general quality of materials and quality of work, and use of available capacity (Mahamid 2016). The majority of construction projects are faced with a lot of causes that lead to rework, such as omissions, alteration, failures, proper communication, and inadequate coordination and collaboration between stakeholders (Anil and Danielraj 2016). As such, rework has critically influenced productivity, performance, and the finance of a project (Anil and Danielraj 2016).

The summary of the identified rework triggers from the literature is provided in Table 1.

Tab. 1: Summary of rework risk triggers in building construction projects.

Sl. no.	Factors	Sources
Client-induced factors		
1	Poor communication with the architect and engineers (design consultants)	Dalty and Crawshaw (1973); Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
2	Lack of knowledge and inexperience in project design and development	Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
3	Lack of knowledge and inexperience of the construction process	Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
4	Inadequate time and money spent during project brief development	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
5	Insufficient fund allocated to site investigations	Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
6	Lack of adequate participation of the client in the project	Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
7	Low fee payment for preparing contract documents	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)

(Continued)

Tab. 1: Summary of rework risk triggers in building construction projects (*Continued*).

Sl. no.	Factors	Sources
Consultant-related factors		
8	Client-initiated changes	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
9	Design not completed at tender time	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
10	Items being omitted from the contract documents	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010); Enshassi et al. (2017)
11	Poor design coordination	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
12	Contractor-initiated changes during construction	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010); Palaneeswaran (2006)
13	Mistakes and errors discovered in the contract documents	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010); Enshassi et al. (2017)
14	Inadequate time devoted for preparing contract documents	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
15	Time boxing (i.e. fixed time for completing the task)	Simpeh (2012); Ajayi and Oyeyipo (2015)
16	Insufficient client brief for preparing detailed contract documents	Palaneeswaran (2006); Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
17	Deficiency of required skills for completing the task	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010); Love et al. (2010)
18	Poor workload planning	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
19	Changes initiated by the municipality/regulatory bodies	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
20	Ineffective use of quality management practices	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010); Enshassi et al. (2017)
21	Change in design due to economic changes	Love et al (2000); Mastenbroek (2010)
22	Design change is initiated due to social changes	Love et al (2000); Mastenbroek (2010)
23	Design change is initiated due to legal changes	Love et al (2000); Mastenbroek (2010)
24	Ineffective use of information technologies	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
Contractor-related factors		
25	Errors in setting out	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
26	Inadequate training and inexperience	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
27	Poor coordination of resources (e.g. subcontractors)	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
28	Constructability problems	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
29	Ineffective use of quality management practices	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010); Enshassi et al. (2017)
30	Poor planning of resources	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
31	Lack of protection of completed work	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
32	Lack of safety	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
33	Excessive overtime	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
34	Non-compliance with specification	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
35	Low labour skill level	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
36	Shortage of skilled labour	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
37	Staff turnover	Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
38	Shortage of skilled supervisors	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
39	Defective workmanship	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010); Josephson et al (2002)

(*Continued*)

Tab. 1: Summary of rework risk triggers in building construction projects (*Continued*).

Sl. no.	Factors	Sources
40	Inadequate supervisor/foreman/tradesmen ratios	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
41	Damages to work due to carelessness	Simpeh (2012); Ajayi and Oyeyipo (2015); Mahamid (2016); Oyewobi and Ogunsemi (2010)
42	Unclear instruction to workers	Simpeh (2012); Ajayi and Oyeyipo (2015); Oyewobi and Ogunsemi (2010)
43	Change in construction methods caused by site conditions	Love and Sohal (2003); Mastenbroek (2010); Oyewobi and Ogunsemi (2010)
44	Incomplete and inaccurate information	Oyewobi and Ogunsemi (2010)
45	Machine breakdown or defects	Josephson et al (2002); Mastenbroek (2010)
46	Damage due to weather conditions	Love and Sohal (2003); Oyewobi and Ogunsemi (2010)
47	Damage due to natural disasters	Love et al (2000); Oyewobi and Ogunsemi (2010)

3 Effects of eliminating rework

There is a consensus on the potential benefits of the varied quality management techniques as reported in different studies, and these quality management techniques have successfully been applied in non-construction industries and could be of great benefits in the construction industry (Chindo and Adogbo 2011).

Peter et al. (2010) reported that there are 13 potential areas of benefits of quality improvement activities in the construction industry, and these are as follows: higher productivity, reduced rework, improved safety, more repeat customers, enhanced employee job satisfaction, enhanced architects/engineers, improved chances in bidding process at pre-qualification, improved subcontractor relationships, reduced change orders, improvement in schedule performance, reduced employee turnover, reduction in claims, and better project cost performance. Peter et al. (2010) confirmed that contractors are positively affected by quality improvement in the construction industry. They observed that improved job satisfaction, more repeat customers, and rework reduction are considered the most important effects (benefits) of rework reduction and quality improvement.

Harrington et al. (2012) reported that the positive effects of total quality management in the Australian construction firms are as follows: reduced cycle time, better measurement of performance, reduced damaged goods, better customer satisfaction, the process starting from design to delivery is being more controlled, and reduced delivery time. In addition, according to Love et al. (2004), the benefits of implementing total quality management are as follows: client satisfaction, successful bidding, reduction in rework, better measurement of performance, better staff morale.

According to Cheng and Liu (2007), there is a creation of competitive advantage in companies who applied proper quality management techniques in their activities, and these provide a sustainable environment for the competitiveness of the companies against powerful global competitors through the continuous improvement in every aspect of the companies.

The summary of the effects of eliminating rework is provided in Table 2.

Tab. 2: Effects of eliminating rework in construction.

Sl. no.	Variables	Sources
1	Higher productivity and reduced delivery time	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011); Peter et al. (2010)
2	Reduced rework and waste	Peter et al. (2010); Love et al. (2004)
3	Improved safety	Peter et al. (2010)
4	More repeat customers	Peter et al. (2010); Harrington et al. (2012); Love et al. (2004)
5	Improved employee job satisfaction and morale	Peter et al. (2010)
6	Improved relationships with architects/engineers	Peter et al. (2010)
7	Better chances in bidding process with pre-qualification	Peter et al. (2010); Love et al. (2004); Cheng and Liu (2007)
8	Improved relationships with subcontractors	Peter et al. (2010)

(*Continued*)

Tab. 2: Effects of eliminating rework in construction (*Continued*).

Sl. no.	Variables	Sources
9	Reduced change orders	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011); Peter et al. (2010)
10	Improved schedule performance	Peter et al. (2010)
11	Lower employee turnover	Peter et al. (2010)
12	Reduced claims	Peter et al. (2010)
13	Better project cost performance	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
14	Creation of a harmonious team spirit	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
15	Increased revenues	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
16	Reduction in quality costs	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
17	Better customer satisfaction	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
18	Improved customer service and market competitiveness	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
19	Encourage holistic resolution of Problems	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
20	Enhanced professionalism and skills in all spheres of the construction sector	Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
21	Better coordination of activities	Harrington et al. (2012); Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
22	Better control over the construction process	Harrington et al. (2012)
23	Helps to achieve the desired project objectives and inherent benefits	Harrington et al. (2012); Low and Teo (2004); Khan (2003); Low and Peh (1996); Chindo and Adogbo (2011)
24	Reduced cycle time	Harrington et al. (2012)
25	Better measurement of performance	Harrington et al. (2012); Love et al. (2004)
26	Better control of design to delivery process	Harrington et al. (2012)

4 Methodology

A quantitative research approach was adopted for data collection, and well-structured questionnaires were used to collect the data on the perception of various professionals regarding the factors that triggered the emergence of construction rework. The questionnaire was self administered by the authors and through the help of trained field assistants who were properly briefed about the research topic and given the necessary information on how to administer the questionnaire.

The appropriateness of the questionnaire to meet the study objectives was carried out through a pilot survey. Fellows and Liu (2008) opined that research instrument (questionnaire) should be initially piloted to verify whether the questions are intelligible, unambiguous, and easy to answer, providing an opportunity to improve the questionnaire and determining the time required in completing the exercise. A total of 20 of the draft questionnaires were randomly distributed to the selected construction professionals, and the final draft was adjusted based on their feedback.

The populations of the study were registered professionals such as builders, quantity surveyors, architects, and engineers practicing within Abuja, Nigeria. The total population of this study was 6,899 (404 builders, 845 quantity surveyors, 400 architects, and 5,250 engineers). This number was obtained from the register of Abuja chapter of various professional bodies, namely Nigerian Institute of Building (NIOB) for builders, Nigerian Institute of Architects (NIAs) for the architects, Nigerian Institute of Quantity Surveyors (NIQSs) for quantity surveyors, and Nigerian Society of Engineer (NSE) for engineers. Abuja was selected for this study, because it is the administrative headquarter of Nigeria, and it is one of the metropolitan cities in Nigeria with the highest population of construction professionals practicing in either constructing or consulting firms within the built environment (Saidu and Shakantu 2016a,b).

The sample size of this study was 364, and this was derived by applying the formula by Krejcie and Morgan (1970) to the population using a 95% confidence interval.

$$s = X^2 NP(1-P) \div d^2(N-1) + X^2P(1-P) \quad (1)$$

where s is the sample size from finite population, X is based on confidence level 1.96 for 95% confidence interval, which is used for this study, d is the precision desired, expressed as a decimal (i.e. 0.05 for 5% used for this study), P is the estimated variance in population as a decimal (i.e. 0.5 for this study), and N is the total number of population, 6,899.

$$s = \frac{1.96^2 \times 6899 \times 0.5 \times (1-0.5)}{\left(0.05^2 \times (6899-1) + 1.96^2 \times 0.5 \times (1-0.5)\right)}$$

$$= \frac{6625.7996}{(17.2450 + 0.9604)}$$

$$= \frac{6625.7996}{18.2054}$$

where s = 363.9469. Therefore, s = 364.

A total of 195 questionnaires were retrieved out of the 364 distributed. Out of the 195 responses received, seven were invalid because of incomplete response and 188 were properly filled and considered a valid response; this represented a response rate of 51.64%. The 188 valid responses consisted of 32 builders, 61 quantity surveyors, 44 architects, and 51 civil engineers. According to Alreck and Settle (1985), this response rate was considered suitable for a study whose focus was to gain responses from professionals and practitioners within the construction industry.

The questionnaire was based on a 5-point Likert scale and ranged from 1 to 5, with 5 being the highest. The analysis of the data collected was carried out using percentages, factor analysis, and relative importance index (RII). Tables were also used to present the analyzed data. Percentage was used to analyze the respondents' demographic information. Factor analysis was used to analyze the responses on rework triggers and group them into more manageable and significant sizes. Therefore, factor analysis is a general term to refer to the general family of techniques. The principal component analysis (PCA), which is one of the techniques of factor analysis, was used to determine whether there exist relationships amongst the variables (i.e. factor extraction). PCA technique was adopted, because it was psychometrically sound and mathematically simpler as suggested by Pallant (2007). RII was used to analyze the effects of eliminating rework triggers from building construction projects. These analyses were performed using statistical package for social science (*SPSS 20, IBM*, Armonk, NY, United States of America).

A total of 47 rework triggers were initially identified from an extensive literature review; following the initial suitability test and factor analysis, the factors were reduced to 26. A total of 21 variables were eliminated from further analysis after obtaining a communality figure of 0.4 and below, and this was in line with the suggestion of Costello and Jason (2005). In addition, Zhao (2008) suggested a communality value of 0.6 and above, as being suitable regardless of the sample size adopted. The authors considered items with communality figure of 0.5 and above, this was to ensure that items with high communalities are used for the analysis and that only items that fit well with other items in the components are considered.

5 Results and discussion

5.1 Demographic information

As summarized in Table 3, the analysis of the respondents' information revealed that 51.60% of the works with contractor's organization, 20.74% and 25.0% of the works with consultants and client's organization, respectively, and only 2.66% of the works in organizations were into consulting and contracting. Regarding their years of experience, 48.40% of them had worked for about 1–10 years, 39.90% had work in the construction industry for 11–20 years, 9.04% and 2.66% had worked for 21–30 years and 31–40 years, respectively, and none (00.0%) of them had worked for 41 years and above. This implied that they were experienced enough to give reliable information that would aid the study. In addition, 29.80% of the respondents had diploma degree, 46.30% had BSc/BTech degree, 21.80% of them were Master's degree holders, and only 2.10% of them had Doctorate degree. This implied that they were academically qualified to take an active part in this study.

Regarding the profession and professional qualification of the respondents, 17.02% of them were builders, 32.45% were quantity surveyors, and 23.40% and 27.13% were architects and engineers, respectively. In addition, 54 of the respondents were probationer members of the professional bodies representing 28.72% of the respondents, 130 were corporate members representing 69.15% of the respondents, and four were fellow members representing 2.13% of the respondents. Regarding their designation, 30.30% of the respondents were project managers, 18.60% were contract managers/administrators, 11.20% were quality and safety engineers, and the majority were project team members with a percentage frequency of 38.30%. It, therefore, implied that the respondents were professionally qualified to give valid information regarding the subject of this study. Furthermore, the high

Tab. 3: Demographic characteristics of respondents.

Category	Classification	Freq.	%
Organizational type	Consultants	39	20.74
	Clients	47	25.00
	Contractors	97	51.60
	Consultant/contracting	5	2.66
	Total	188	100.00
Years of experience	1–10 years	91	48.40
	11–20 years	75	39.90
	21–30 years	17	9.04
	31–40 years	5	2.66
	41 years and above	0	0.00
	Total	188	100.00
Academic qualification	Diploma degree	56	29.80
	BSc/BTech	87	46.30
	Master degree	41	21.80
	Doctorate degree	4	2.10
	Total	188	100.00
Professional affiliation	Building	32	17.02
	Quantity surveying	61	32.45
	Architecture	44	23.40
	Engineering	51	27.13
	Total	188	100.00
Professional qualification	Probationer member	54	28.72
	Corporate member	130	69.15
	Fellow	4	2.13
	Total	188	100.00
Designation in the organization/project	Project manager	57	30.30
	Contract manager/ administrator	35	18.60
	Quality and safety manager	21	11.20
	Project director	3	1.60
	Project team member	72	38.30
	Total	188	100.00

Freq, Frequency of distribution of responses.

proportion of quantity surveyors implied that they were involved in cost-associated matters such as rework in the construction industry.

5.2 Factor analysis of rework triggers

Factor analysis was used to analyze and group the rework triggers into more significant and manageable portion. The suitability of the data gathered for factor analysis was determined first by considering the sample size and number of variables under consideration. There exists the abundance of studies concerning factor analysis carried out using smaller sample size. Although Pallant (2007) confirmed the existence of little agreement amongst authors concerning the size of a sample for factor analysis, he suggested the use of a larger sample. Tabachnick and Fidell (2007) suggested that for factor analysis to be considered, the sample size of the study should be from 150 to 300. Similarly, Mundfrom et al. (2005) suggested that the minimum sample size for factor analysis should be from 3 to 20 times the number of variables, and a range of 100 to more than 1,000 is absolute.

Concerning the number of variables, Hair et al. (1998) proposed that factor analysis is suitable for 20–50 variables, as the extraction of common factors becomes inaccurate if the number of variables exceeds this range. However, studies have shown that less number of variables can be used when the sample size is large enough (Ahadzie et al. 2008). Researchers and reviewers should not be overly concerned about small sample size, because as long as the communalities are high, the number of expected factors is relatively small and model error is low (Preacher and MacCallum 2002). Zhao (2008) suggested a communality value of 0.6 and above, as being suitable regardless of the sample size adopted. The study considered items with communalities of 0.5 and above and recorded an average communality of 0.781.

Therefore, the data gathered in this study can arguably be said to be suitable and adequate for factor analysis, considering the sample size of 188 which were quite within the range proposed by Tabachnick and Fidell (2007); 26 variables were within the range proposed by Hair et al (1998), and the average communality value of 0.781 was recorded. Table 4 summarizes that 92.31% of the variables have their communality figure of 0.6 and above.

The second way of establishing the suitability of the data gathered for factor analysis and to determine the existence of a patterned relationship amongst the variables was carried out by testing the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity.

The variables are said to have a patterned relationship when the significant level of p (Sig.) < 0.05. In addition, the cut-off for adequacy of the variables is that the KMO measure of sampling adequacy should be above 0.50 (Yong and Pearce 2013). Yong and Pearce (2013) recommend 0.5 (value for KMO) as a minimum (barely Acceptable), values between 0.7 and 0.8 acceptable, and values above 0.9 are superb. As summarized in Table 5, Bartlett's test of sphericity for the rework triggers was <0.05, meaning that there was a relationship between the variables. In the same vein, KMO measure of sampling adequacy for the triggers of rework was greater than the cut-off point of 0.50, meaning that the variables were adequate and suitable for factor analysis. In addition, the value 0.734 obtained from the reliability test carried out through the use of Cronbach's α test was

Tab. 4: Communalities of rework risk triggers.

Sl. no.	Rework triggers	Initial	Extraction
1	Poor communication with the architects and engineers (design consultants)	1	0.797
2	Lack of knowledge and inexperience of the construction process	1	0.772
3	Inadequate time and money spent during project brief development	1	0.817
4	Insufficient fund allocated to site investigations	1	0.849
5	Lack of adequate participation of the client in the project	1	0.587
6	Low fee payment for preparing contract documents	1	0.833
7	Items being omitted from the contract documents	1	0.854
8	Poor design coordination	1	0.575
9	Contractor-initiated changes during construction	1	0.912
10	Mistakes and errors discovered in the contract documents	1	0.735
11	Insufficient client brief for preparing detailed contract documents	1	0.6
12	Deficiency of required skills for completing the task	1	0.761
13	Poor workload planning	1	0.789
14	Changes initiated by the municipality/regulatory bodies	1	0.886
15	Change in design due to economic changes	1	0.861
16	Design change initiated due to social changes	1	0.705
17	Inadequate training and inexperience	1	0.714
18	Poor coordination of resources (e.g. subcontractors)	1	0.872
19	Ineffective use of quality management practices	1	0.726
20	Poor planning of resources	1	0.753
21	Non-compliance with specification	1	0.79
22	Low skill level of labour	1	0.736
23	Shortage of skilled labour	1	0.824
24	Lack of skilled supervisors	1	0.823
25	Unclear instruction to workers	1	0.932
26	Damage due to weather conditions	1	0.804

Tab. 5: KMO and Bartlett's test

KMO measure of sampling adequacy		0.793
Bartlett's test of sphericity	Approximately Chi-square	5,424.571
	df	325
	Sig.	0

Sig, P value or significant level/value.

a confirmation that the use of factor analysis for the data gathered was appropriate. Binyam et al. (2016) posited that when the computed values of Cronbach's α are >0.5, there is a consistency and the data are reliable.

Having determined the suitability of the data, factor analysis was conducted using PCA with varimax rotation as the extraction method. As summarized in Table 6, it can be seen that six components with eigenvalue of >1 were extracted using the factor loading of 0.50 as the cut-off point as suggested by Spector (1992). According to Pallant (2007), SPSS uses the Kaiser criterion, which would normally retain all components with an eigenvalue of >1. Similarly, Spector (1992) posited that a clear component structure is present when a variable has significant factor loading (loading > 0.50) on one component only. Hence, only elements with 0.5 and above are considered under each component. The total variance explained by each component extracted was as follows: component 1 (24.55%), component 2 (21.35%), component 3 (16.69%), component 4 (10.24%), component 5 (4.61%), and component 6 (3.93%). Thus, the final statistics of the PCA and the components extracted accounted for approximately 81.37% of the total cumulative variance.

However, six components retained were too much, and these were the reasons for the wider criticisms of the Kaiser's criterion (Pallant 2007). Pallant (2007) further suggested a critical examination of the scree plot and component matrix in order to determine the number of components (factors) to extract/retain. In analyzing the scree plot, a change (or elbow) in the shape of the plot was identified and only components above this point were retained. The point at which the break occurred should not be included (Costello and Jason 2005). Fig. 1 shows the break occurred at the fifth component. Thus, only the four points above this break were considered, and only these four components were suitable for extraction. It, therefore, means that components 1–4 explain or capture much more of the variance than the remaining components.

Tab. 6: Initial and rotated matrix of rework triggers.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cum. %	Total	% of variance	Cum. %	Total	% of variance	Cum. %
1	6.382	24.547	24.547	6.382	24.547	24.547	6.288	24.18	24.184
2	5.552	21.354	45.901	5.552	21.354	45.901	5.126	19.72	43.901
3	4.34	16.692	62.593	4.34	16.692	62.593	4.724	18.17	62.069
4	2.662	10.24	72.833	2.662	10.24	72.833	2.665	10.25	72.32
5	1.197	4.606	77.438	1.197	4.606	77.438	1.208	4.648	76.968
6	1.021	3.928	81.366	1.021	3.928	81.366	1.144	4.399	81.366

Cum, Cumulative.

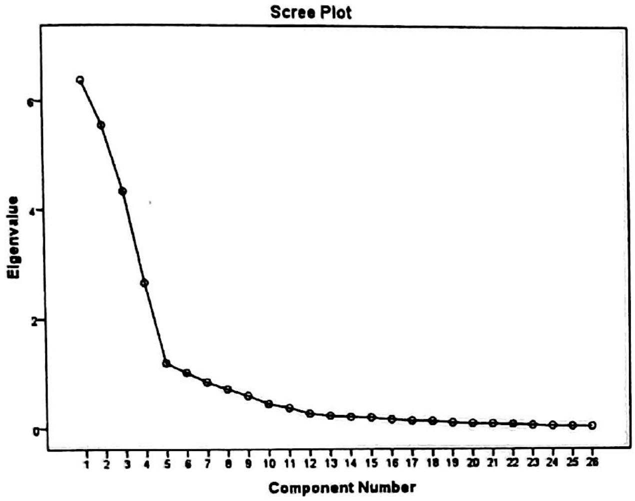

Fig. 1: Scree plot.

Since there is no any hard and fast statistical rule regarding the consideration of the remaining components, according to Pallant (2007), this study considered only the first four components. This decision was further supported by the items loading shown in the "component matrix" (Table 7). Items loading on each of the first four components are three and above. This decision holds as opined by Pallant (2007) that the ideal number of items loading required of a component should be from three and above. A factor with fewer than three items is generally weak and unstable; 5 or more strongly loading items (0.50 or better) are desirable and indicate a solid factor (Costello and Jason 2005). Components 5 and 6 have one item loading each, therefore, cannot be retained.

Based on the abovementioned considerations, varimax rotation was conducted with the number of components to be extracted set at 4. The result of the new total variance explained showed component 1 (24.55%), component 2 (21.35%), component 3 (16.69%), and component 4 (10.24%) as summarized in Table 8. Thus, the final statistics of the "PCA" and the components extracted accounted for approximately 72.83% of the total cumulative variance. This, therefore, fulfilled the criterion of factors explaining at least 50% of the variance as stated by Costello and Jason (2005) and Pallant (2007).

Table 9 summarizes the factor loading on each of the four extracted components. According to Spector (1992), a clear component structure is present when a variable has significant factor loading (loading > 0.50) on one component only. Hence, only elements with 0.5 and above are considered under each component.

5.3 Discussion of extracted factors

5.3.1 Omission and planning triggers

The first principal component had the highest factor loading of nine factors, and it accounted for about 25% of the total variance explained. A closer look at these factors showed that they were related to the omission and inefficiencies of both the design and construction teams; hence, this component was named as "omission and planning triggers". Oyewobi and Ogunsemi (2010) made a deposition which implies that right conception of the project would result in a well-finished project. For omission during design, construction, and fabrication to be avoided, the consultants must ensure that client requirement is well understood and implemented. Proper planning by both the design team and construction team is critical to the success of a well-conceived project as well as in reducing rework incidence. Thus, there must be synergy between the participants to ensure that every party is satisfied at the end of the project. Hence, there should be proper design and construction integration (Oyewobi and Ogunsemi 2010). Approved change requests have been identified to significantly contribute to construction rework (Josephson et al. 2002). Hwang et al (2009) confirmed that insufficient pre-project planning is a causative factor to

Tab. 7: Component matrix[a] result.

S/Nr		Component 1	2	3	4	5	6
1	Items being omitted from the contract documents	0.917					
2	Poor workload planning	0.88					
3	Deficiency of required skills for completing the task	0.862					
4	Mistakes and errors discovered in the contract documents	0.855					
5	Ineffective use of quality management practices	0.845					
6	Design change initiated due to social changes	0.814					
7	Insufficient client brief for preparing detailed contract documents	0.761					
8	Lack of adequate participation of the client in the project	0.753					
9	Poor design coordination	0.751					
10	Contractor-initiated changes during construction		0.834				
11	Shortage of skilled labour		0.812				
12	Changes initiated by the municipality/regulatory bodies		0.782	−0.517			
13	Change in design due to economic changes		0.776				
14	Lack of skilled supervisors		0.768				
15	Low fee payment for preparing contract documents		0.767				
16	Insufficient fund allocated to site investigations		0.574	0.719			
17	Poor communication with the architects and engineers (design consultants)		0.524	0.715			
18	Inadequate time and money spent during project brief development		0.552	0.707			
19	Non-compliance with specification			0.705			
20	Lack of knowledge and inexperience of the construction process		0.519	0.691			
21	Low skill level of labours		0.591	0.606			
22	Unclear instruction to workers				0.944		
23	Poor coordination of resources (e.g. subcontractors)				0.912		
24	Damage due to weather conditions				0.869		
25	Inadequate training and inexperience					0.707	
26	Poor planning of resources						0.692

[a] signifies the number of components extracted (in this case is 6 components).

Tab. 8: Initial and rotated matrix of rework triggers.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cum. %	Total	% of variance	Cum. %	Total	% of variance	Cum. %
1	6.382	24.547	24.547	6.382	24.547	24.547	6.364	24.475	24.475
2	5.552	21.354	45.901	5.552	21.354	45.901	5.132	19.74	44.215
3	4.34	16.692	62.593	4.34	16.692	62.593	4.75	18.268	62.483
4	2.662	10.24	72.833	2.662	10.24	72.833	2.691	10.35	72.833

rework. Josephson et al. (2002) opined that changes due to improper planning can have a high impact of 34% on rework cost and wrong information and bad planning method can have 15% impact each on rework cost. Therefore, it is imperative that when issues such as those contained under component 1 are allowed, rework is inevitable, and consequently, cost and time overrun.

5.3.2 Change issues

The second principal component had factor loading of six factors, and it accounted for about 21.4% of the total variance explained. These factors were as follows: contractor-initiated changes during construction, changes initiated by the municipality/regulatory bodies, change in design due to economic changes, low fee payment for preparing contract documents, lack of skilled supervisors, shortage of skilled labour. This component was named as "change issues", because a critical analysis of the items showed that they were related to construction changes. According to Mastenbroek (2010), changes mean the action of altering requirements that are still current. Contractor-initiated changes are those alterations introduced by the action or inaction of the contractor during construction. Therefore, such changes when discovered may lead

Tab. 9: Structure of varimax rotation of rework triggers.

S/Nr		Component			
		1	2	3	4
1	Items being omitted from the contract documents	0.921			
2	Poor workload planning	0.884			
3	Deficiency of required skills for completing the task	0.858			
4	Mistakes and errors discovered in the contract documents	0.855			
5	Ineffective use of quality management practices	0.844			
6	Design change initiated due to social changes	0.823			
7	Insufficient client brief for preparing detailed contract documents	0.766			
8	Lack of adequate participation of the client in the project	0.757			
9	Poor design coordination	0.757			
10	Poor planning of resources				
11	Contractor-initiated changes during construction		0.949		
12	Changes initiated by the municipality/regulatory bodies		0.94		
13	Change in design due to economic changes		0.923		
14	Low fee payment for preparing contract documents		0.909		
15	Lack of skilled supervisors		0.905		
16	Shortage of skilled labour		0.879		
17	Inadequate training and inexperience				
18	Insufficient fund allocated to site investigations			0.917	
19	Inadequate time and money spent during project brief development			0.899	
20	Poor communication with the architects and engineers (design consultants)			0.892	
21	Non-compliance with specification			0.875	
22	Lack of knowledge and inexperience of the construction process			0.872	
23	Low skill level of labour			0.846	
24	Unclear instruction to workers				0.957
25	Poor coordination of resources (e.g. subcontractors)				0.927
26	Damage due to weather conditions				0.875

to rework, waste, and claims (Mahamid 2016). Contractors have been reported to be responsible for 46% of rework costs (Meshksar 2012). Those changes that influence design and construction activities and even management decision in complying with Government regulation, taxes, interest rates, and/or the regulatory agency of government are called regulatory body changes (Mastenbroek 2010). Regulatory body is external to the project and complying with certain regulations of the body may require that already executed task may need to be redone, thereby resulting to rework. In addition, a change in the level of income of a client may trigger a modification of a completed design at the construction phase.

5.3.3 Funding and communication issues

The third principal component had factor loading of six factors, and the factors under this component were as follows: insufficient fund allocated to site investigations, inadequate time and money spent during project brief development, poor communication with the architects and engineers (design consultants), non-compliance with specification, lack of knowledge and inexperience of the construction process, low skill level of labour. These variables accounted for 17% of the variance explained. After examining critically the latent characteristics of these triggers, the factor was named as "funding and communication issues". Poor communication amongst project participants has been identified as the critical factor responsible for rework incidences on construction work. Poor exchanges of information amongst the client, design consultants, and contractors are the most factors responsible for rework (Mahamid 2016). The combination of weak communication, improper coordination, and poor integration between project participants at design phase is responsible for increased rework experienced on construction projects (Ajayi and Oyeyipo 2015). Poor communication results from the fact that clients are most times far from matters concerning the project. Failure to be consistent in attending project meetings by the client or his/her representative or poor management decisions, varied specification, and changes in scope and materials of the projects leads to rework (Mahamid 2016). Poor communication between parties may also lead to conflicts and claims, misinterpretation of requirements; these have a negative impact on work flow (Mahamid 2016). Mahamid (2016) emphasized the necessity of ensuring that there is awareness amongst project parties for the creation of an environment where team work and working climate subsist which meets every party desires.

Unclear work specifications may result in rework, because they are written guidelines that contain statements regarding all project requirements such as manufacturing, materials, and operational characteristics (Clough et al. 2005; Wasfy 2010). Poor information generates uncertainty which is a major cause of rework (Koskela 1992). Therefore, incomplete and inaccurate design information undiscovered at the design stage will result in rework at the construction stage when discovered.

5.3.4 Poor workers and resource control

The fourth principal component accounted for 10.2% of the variance explained. It composed of triggers, such as unclear instruction to workers, poor coordination of resources (e.g. subcontractors), and damage due to weather conditions. These triggers were subsequently named as "poor workers and resource control". The PCA reveals that lack of clarity of instruction given to workers and inappropriate organization of construction resources can cause rework. Therefore, there is a need for both the consultant and contractor team to ensure that instruction given to workers is clear and understood by them before they proceed with any work. This can be achieved through the implementation of feedback systems on site (or asking them to repeat what was said in the case of phone conversation). Oyewobi and Ogunsemi (2010) made an assertion which implies that buildings can be constructed free of rework when there is adequate and non-conflicting information. Proper resource coordination amongst the construction stakeholders (participants) is a critical factor for a construction free of rework (Adejimi 2005). Construction activities are carried out in sequence (Oyewobi and Ogunsemi 2010), and as such, there is a need for efficient and effective resource organization in both the design and construction phases. Natural causes of rework are natural, and they emanate from the environment, as such they are classified as environmental causes (Mahamid 2016). Mahamid (2016) observed that natural disaster such as weather damage affected the environment the most and accounted for 57.56% of rework due to a natural disaster.

5.4 Effects of eliminating rework triggers

Table 10 summarizes the ranking of the analyzed benefits derived from eliminating rework triggers on construction projects. The analysis revealed that the top five effects of eliminating rework triggers were as follows: repeat patronage, higher productivity and reduced delivery time, reduced rework and waste, improved employee job satisfaction and morale, and help to achieve the intended project objectives and benefits. This finding corroborated what Peter et al. (2010) and McIntyre and Kirschenman (2000) reported on the potential areas of benefits of improving quality and reducing rework on construction projects. Peter et al. (2010) found that improved job satisfaction, more repeat customers, and reduced rework are considered the most important benefits of rework reduction and quality improvement. Judicious implementation of quality management programmes will enable companies to improve long-term relationships and product and process improvement and create a harmonious team spirit, increased revenues, reduction in quality costs, decreasing waste and rework, employee job satisfaction, more customer focused, and improved customer service and market competitiveness. Others are; Encourage holistic resolution of Problems, improved safety, better coordination of activities, subcontractors with proper quality management system, better control over the construction process, and closer relationships with subcontractors and suppliers and help to achieve the intended project objectives and benefits (Low and Teo 2004; Chindo and Adogbo 2011).

Tab. 10: Effects of eliminating rework triggers.

Sl. no.	Factors	RII	Rank
1	Repeat patronage (more repeat customers)	0.88	1st
2	Higher productivity and reduced delivery time	0.871	2nd
3	Reduced rework and waste	0.871	2nd
4	Improved employee job satisfaction and morale	0.852	4th
5	Help to achieve the intended project objectives and benefits	0.846	5th
6	Reduced cycle time	0.837	6th
7	Improved relationships with architects/engineers	0.833	7th
8	Reduced change orders	0.829	8th
9	Lower employee turnover	0.823	9th
10	Reduced claims	0.821	10th
11	Improved safety	0.819	11th
12	Improved schedule performance	0.815	12th
13	Improved relationships with subcontractors	0.811	13th
14	Better chances in bidding process with pre-qualification	0.809	14th
15	Increased revenues	0.809	14th
16	Improved customer service and market competitiveness	0.809	14th
17	Better project cost performance	0.804	17th
18	Creation of harmonious team spirit	0.794	18th
19	Reduction in quality costs	0.794	18th
20	Enhanced professionalism and skills in all spheres of the construction sector	0.743	20th
21	More customer focused	0.736	21st
22	Better control of design to delivery process	0.729	22nd
23	Better control over the construction process	0.726	23rd
24	Encourage holistic resolution of Problems	0.721	24th
25	Better measurement of performance	0.69	25th
26	Better coordination of activities	0.661	26th

The least five effects reported in this study are as follows: better control of design to delivery process, better control over the construction process, encouraging open addressing of problems, better measurement of performance, and better coordination of activities. These variables of benefits derivable from rework reduction activities have a high level of importance. This implies that they are beneficial to the project and its participants and other stakeholders who might be directly or indirectly affected by the existence of the project. These variables may have been reported to be least important in this study but a good number of companies see benefits in these areas (Peter et al. 2010; Harrington et al. 2012). Harrington et al. (2012) reported that the benefits of total quality management in the Australian construction firms are as follows: reduced cycle time, better measurement of performance, reduced goods damaged, better customer satisfaction, the process starting from design to delivery is being more controlled, and reduced delivery time. In addition, according to Love et al. (2004), the benefits of implementing total quality management are client satisfaction, successful bidding, reduction in rework, better measurement of performance, and better staff morale.

The RII of the analyzed responses from the respondents ranged from 0.880 (88.0%) to 0.661 (66.1%) with an overall average of RII = 0.797 or 79.7%. It is obvious that all the variables of benefits derivable from rework reduction activities have a high level of importance. This implies that they are all beneficial to the projects, the parties to the contract, and other stakeholders who may be directly or indirectly affected by the existence of the project.

6 Conclusion and recommendations

Rework causes undesirable and unnecessary loss of efforts; it threatens the performance of construction projects' cost and time. It is triggered by several factors that create non-value-added scenarios. This study, therefore, examined the perception of construction professionals regarding variables that triggered the emergence of rework in the Nigerian construction industry.

Based on the findings, it was concluded that the factors that triggered the emergence of rework were omission and planning issues, change issues, funding and communication issues, and poor workers and resource control. Furthermore, it was concluded that repeat patronage, higher productivity and reduced delivery time, reduced rework and waste, and improved employee job satisfaction and morale were the benefits derived from eliminating rework triggers.

Based on the conclusion, the study, therefore, recommends the need for clarity, effectiveness, and timeliness of instruction and information amongst project participants. Adequate funding should be provided at every stage of construction to ensure that works are carried out to the fullest. The participation of Contractors, subcontractors, and other stakeholders at the inception of the project. This will ensure that design and other contract documents are complete prior to award and construction. By such participation, the majority of rework triggers at the design stage is eliminated, and construction can proceed with very little changes and omissions. In addition, the use of skilled and experienced professionals, skilled supervisors, and proper implementation of quality management practices by both the design consultant and contractor throughout the project's phases is necessary if rework-free construction is to be achieved. The implementation of these recommendations will improve planning and resource control, which could result in savings in project time and cost caused by rework.

6.1 Further research directions

A similar study should be carried out on construction and developmental projects within the petroleum industries, especially at the south–south areas of Nigeria. In addition, a further study should be undertaken to examine the perception of construction professionals regarding rework risk triggers and minimization measures in civil engineering construction projects in Nigeria.

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