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Profiling Causes and Effects of Variation Order on the Performance of Civil Engineering Projects

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ABSTRACT
One of the most significant challenges bedevilling the construction industry is variations. They occur in almost every construction and their magnitudes are not the same as they vary significantly from project to project. The main objective of this paper is to examine the causes of variation in civil engineering projects, explore its effect and establish the strategies that could be employed to reduce their occurrences on construction projects. The study focused on completed civil engineering construction projects awarded by the Federal Government of Nigeria over the past ten years. To achieve the stated objective of this paper, a quantitative research was employed using a questionnaire survey self-administered to construction professionals; the Engineers, Quantity Surveyors and Contractors. A total of 120 questionnaires was administered using snowball sampling technique. The results indicated that the major causes of variation are bad contractual procedure and lack of understanding and correct interpretation of client's requirement. Chief amongst the effects of variation on projects are cost and time overrun as shown by the analysed results. However, the study suggested that the best strategy to reduce variation is that no design engineer should be allowed to practice without having a professional license and that registration of the construction companies should be reviewed regularly to reflect their technical capabilities. It was concluded that a better understanding of the causes of variation would be of help for construction professionals in assessing variation and this would be helpful in taking pre-emptive measures for reducing variation orders in construction projects.

Keywords: *Civil Engineering, Construction Project, Strategies and Variation*

1 INTRODUCTION

The construction is a very risk prone sector of the economy due to the multifaceted and unstable project environments which often give rise to uncertainties and risks (Mulholland and Christian, 1999). The construction industry plays a significant part in nation's building and in the achievement of societal objectives (Mahamid, 2017). However, Enshassi *et al.* (2010) asserted that the business agreement within a construction contract allows for variation in the scope of work. This underscores the observation of Ndihokubwayo and Haupt (2008) who reiterated that the clauses in the contract relating to changes permits parties to the contract to easily initiate variation within the remit of the scope of the work without altering the original contract. However, the cost of a construction project is one of the most vital factors in the construction industry most especially in Nigeria where the poor performance of the construction industry is at the highest level. For instance, Nnabugwu (2015) revealed that 60% of construction projects in Nigeria fail to meet its intended objectives. This is because many projects do not measure up to the expectation of the clients regarding quality, time or cost eventually with many projects being abandoned (Ubani and Ononuju, 2013). The failure of projects from this perspective has become a worrisome trend in the Nigerian construction industry, where variation in the total cost of a project can considerably vary from the initial estimated cost (Halwatura and Ranasinghe, 2013). The causes for the variation could be as a result of changes in scope of work, specifications, or any other contract documents.

Although, Msallam *et al.* (2015) viewed variation as one of the uncommon tools that the project manager contractually has to accommodate any unforeseen occurrences when project is being executed, but it is essential for managers of project to understand the reasons behind such unforeseen variations in a project by acting accordingly in order to ensure that the goals of the project can be successfully achieved. Some of these variations are beneficial while some negatively affect project performance. However, there is lack of knowledge within the construction industry to identify a non-value adding costs which ultimately leads to variation in construction project. This non-value adding costs often affect construction clients greatly and the impact is underestimated. Few of previous researches have examined the causes of variation or change orders and their effects on construction projects (e.g. Alnuaimi *et al.*, 2010; Enshasis *et al.*, 2010; Oyewobi *et al.*, 2016). However, little or no research has been conducted to address the impact of variation on civil engineering construction projects which are most prone to variation in Nigeria. The lack of literature on similar studies conducted in Nigeria suggests that little attention has been paid to this area of study. Therefore, this study intends to bridge the gap in literature. The current study attempts to establish the strategies that can be used to reduce the menace of variation in civil engineering construction projects

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3 RESEARCH METHODOLOGY

This study adopted quantitative approach to research in achieving the objectives stated in this paper. Twenty-four factors that might cause variation in civil engineering projects and 11 factors that might impact on their performance were identified through extensive review of literature relating to civil engineering work in the construction industry. The factors were used in developing questionnaire that was administered to explore the perception of stakeholders majorly; the engineers, quantity surveyors and contractors to determine the extent of the significance of the identified factors. The study also examined whether agreement exists between the ranking of the extent of significance of the identified factors between contractors and consultants. The questionnaire is divided into three sections: the first part obtained the background information of the respondents; the second part elicited data on the causes of variation, and the third section explored the effects of variation on projects considered. The respondents were requested to rate the degree of importance of each factors causing variation on a five-point scale: very high (5), high (4), moderate (3), little (2) and very little (1). On the effect of variation on projects, the respondents were asked to use the same five-point scale to rank the identified causes according to their degree of importance using the rating: very severe (5), severe (4), moderately severe (3), not severe (2) not very severe (1). The questionnaire was piloted amongst 4 professionals who have experience on civil engineering works to ascertain the level of clarity of the questions and to also determine the level of its comprehensiveness in dealing with objective of the study. Adjustments and corrections were made based on the feedback received from pilot study basically on the structure of questions to encourage high response rate.

The target population for the study are construction professionals as well as contractors who had worked or still executing contract with federal ministry of works in Abuja from year 2000 to 2016 with valid address. However, the study could not determine the size of the population because a comprehensive of these category of respondents was made available, instead a snowball sampling technique was used. The technique is a non-probability sampling method that allows the sample elements to be identified through the referral networks and by friends. This technique is appropriate when it is difficult to get response from sample population selected at random (Sekaran, 2000) and this has been used in a similar study conducted in Gaza Strip by Enshasis *et al.* (2010). One hundred and twenty questionnaires were administered to the potential respondents identified through the process described and 100 valid responses were obtained.

4 DATA ANALYSIS

The questionnaires were analysed using Spearman's correlation and the factors were ranked according to the weighted arithmetic means (mean) as used by Mahamid (2017).

4.1 VALIDITY AND RELIABILITY TEST

In order to ensure that the data obtained from the questionnaires administered were valid and reliable, three statistical tests were conducted. The first test is to determine the Cronbach's Alpha values of the constructs as shown in Table 1, the values were above the required threshold value of 0.7 as stated by Sekaran (2005). This implies that the data were reliable. The study also conducted a Criterion-related validity test using Spearman rank correlation test as suggested by Enshassi *et al.* (2010) which examines the correlation coefficient between each item in one Group and the whole Group. In testing criterion related validity test as stated, the correlation coefficient for each item of the group factors and the total of the field is achieved. The p-values depicting the level of significance are less than 0.01 for all results (Table 1), the correlation coefficients of each group are significant at $\alpha = 0.01$, hence the study conclude that the paragraphs of each group are consistent and valid to measure what it was set for. The last test focuses on the structure validity test (Spearman test) that was employed to examine the validity of the questionnaire structure by exploring the validity of each group and the validity of the whole questionnaire. It measures the correlation coefficient between one group and all the groups of the questionnaire that have the same level of similar scale. Therefore, values of the Spearman's rank correlation coefficients of values which is above 0.60 as postulated by Dancey and Reidy's (2011) show a good agreement between contractors and consultants in ranking of the importance of factors affecting causes of variation and effects.

TABLE 1: CONSTRUCTS PEARSON'S RANK CORRELATION COEFFICIENT

S/No	Constructs	1	2	3	4	5	6	7	Cronbach's Alpha (α)
1	Lack of understanding and correct interpretation of Client's requiremer	1							.816
2	Bad Contractual Procedure	.128	1						.748
3	Consultants' Initiated Changes	.926**	.023	1					.926
4	Contractor-initiated Changes	.825**	.069	.800**	1				.904
5	Technological Changes	.818**	.016	.790**	.986**	1			.893
6	Effects of Variation	.689**	.278**	.698**	.854**	.865**	1		.788
7	Strategy for reducing variation	-.759**	-.064	-.710**	.926**	-.908**	-.840**	1	.944

** Correlation is significant at the 0.01 level (2tailed). * Correlation is significant at the 0.05 level (2 tailed).

Source: Researcher's Analysis (2017)

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4.2 CAUSES OF VARIATION

Table 2 shows the causes of variation in civil engineering works and causes were categorized under five main sub-headings. As illustrated in Table 2, the first category was named lack of understanding and correct interpretation of client's requirement. However, the respondents unanimously agreed that inadequate project objectives are the most severe cause of variation on aggregate with overall mean of 4.681, followed by change of scope or plans with overall mean of 2.512. With respect to second category labelled 'bad contractual procedure', inconsistent government policy with mean of 4.869 was the most severe origin of variation, followed by lack of attention to differing site conditions with mean of 4.661. Although, there were differing opinions amongst the respondents, Engineers, Quantity surveyors and Contractors themselves recognise that inconsistent government policy and lack of attention to differing site conditions are the major causes of variations. The most severe consultants' initiated changes as cause of variation on aggregate is change in specifications with mean of 2.417, followed by change in design by the consultant with mean of 1.962. This is also the opinions of Engineer, Quantity surveyor and Contractor who collectively identified change in specification as the major cause of variation. Under contractor initiated changes, lack of contractor's involvement in design was the most severe cause of variation with overall mean of 2.715. this resonate the perceptions of the respondents' who agreed late or lack of involvement of contractor at early stage often lead to variation with respect to buildability of the designs on site. Lastly, poor information use has an overall mean score of 3.423 and this is in tandem with perceptions of both the Engineers and the Quantity Surveyors who considered it as the most severe cause of variation under technological changes. However, the contractors involved viewed this on contrary by considering sub-standard products and services as the main technological cause of variation.

TABLE 2: CAUSES OF VARIATION

Causes of Variation	Engr		QS		Builder		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Lack of understanding and correct interpretation of Client's requirement								
Client's financial problems	2.117	4	1.000	5	1.571	3	1.563	5
Delay in land acquisition/compensation	2.200	3	1.818	4	1.571	3	1.863	4
Inadequate project objectives	4.217	1	4.970	1	4.857	1	4.681	1
Change of schedule	1.950	5	2.636	3	1.143	5	1.910	3
Change of scope or plans	2.717	2	2.818	2	2.000	2	2.512	2
Bad Contractual Procedure								
Inconsistent government policy	4.667	2	4.939	1	5.000	1	4.869	1
Fraudulent practices	3.900	3	4.000	3	4.000	3	3.967	3
Bad contractual management	3.350	5	3.818	4	3.000	5	3.389	5
Lack of co-ordination among project participants	3.883	4	3.182	5	4.000	3	3.688	4
Lack of attention to differing site conditions	4.800	1	4.182	2	5.000	1	4.661	2
Consultants' Initiated Changes								
Errors and omissions in design	1.950	3	2.636	2	1.000	2	1.862	3
Change in design by the consultant	2.250	2	2.636	2	1.000	2	1.962	2
Change in specifications	2.433	1	2.818	1	2.000	1	2.417	1
Inadequate scope of work for contractor	1.733	5	1.030	4	1.000	2	1.255	4
Conflicts between contract documents	1.800	4	1.000	5	0.857	5	1.219	5
Contractor Initiated Changes								
Lack of contractor's involvement in design	2.933	1	2.212	1	3.000	1	2.715	1
Lack of strategic planning	1.417	4	0.000	4	0.429	4	0.615	4
Inadequate site reconnaissance by the contractor	1.383	5	0.000	4	0.000	5	0.461	5
Inadequate shop drawing details	2.550	2	0.364	3	1.714	2	1.543	2
Defective workmanship	1.729	3	1.000	2	1.143	3	1.291	3
Technological Changes								
Incomplete documentation at the time of award	1.350	6	2.455		3 0.000	5	1.268	5
Lack of proper monitoring and evaluation	1.450	5	0.909		6 0.000	5	0.786	6
Unavailability of equipment	2.800	3	3.545		2 2.000	4	2.782	3
Poor technology application	2.800	3	1.364		5 2.857	3	2.340	4
Poor information use	3.450	1	3.818		1 3.000	2	3.423	1
Sub-standard products and services	3.417	2	1.545		4 4.000	1	2.987	2

Source: Researcher's Analysis (2017)

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4.3 EFFECT OF VARIATION ON PROJECT

As shown in Table 3, the results indicated that the most significant effects of variation are time overrun and cost overrun with overall mean of 4.886 and 4.886 respectively. Furthermore, Engineer, Quantity surveyor and Builder mutually recognised that these two effects are the main effect of variation. While degradation of quality standards and additional specialist personnel were the least ranked with overall mean of 1.300 and 1.178 respectively.

TABLE 3: RANKING OF EFFECTS OF VARIATION

S/No	Effects of Variation	Engr		QS		Builder		Overall	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Time Overrun	4.750	1	4.909	1	5.000	1	4.886	1
2	Cost Overrun	4.750	1	4.909	1	5.000	1	4.886	1
3	Delay in payment	3.767	4	3.303	4	4.000	4	3.690	4
4	Disputes between parties to the contra	4.533	3	3.394	3	5.000	1	4.309	3
5	Complaints of one or more of the parti to the contract	3.317	5	2.182	6	3.000	5	2.833	5
6	Professional reputations of one or mor parties adversely affected	2.383	7	1.182	8	2.000	6	1.855	8
7	Additional specialist equipment	2.517	6	2.879	5	2.000	6	2.465	6
8	Additional health & safety equipment/measure	2.333	8	1.242	7	2.000	6	1.859	7
9	Degradation of health & safety	1.817	10	1.000	9	1.143	9	1.320	9
10	Degradation of quality standards	1.900	9	1.000	9	1.000	10	1.300	10
11	Additional specialist personnel	1.533	11	1.000	9	1.000	10	1.178	11

Source: Researcher's Analysis (2017)

4.4 GROUP ANALYSIS

This section presents the mean and ranks for each group of causes of variation orders as shown in the Table 4.

Ranking of the causes of variation in civil engineering projects indicated that the chief amongst these causes is bad contractual procedure. The factors listed under bad procedure includes; client's financial problems; delay in land acquisition/compensation; inadequate project objectives; change of schedule; change of scope or plans. The second most important cause of variation as shown by the overall ranking is lack of understanding and correct interpretation of Client's requirement. Contractor initiated changes was ranked least. This is not unexpected as contractor only implement changes made by the client and instructed by the consultants to execute.

TABLE 4: MEAN AND RANKS OF THE GROUP OF CAUSES OF VARIATION

S/No	CAUSES OF VARIATION	Engr		QS		Builder		Overall	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Lack of understanding and correc interpretation of Client's requirement	2.6	2	2.648	2	2.229	2	2.506	2
2	Bad Contractual Procedure	4.12	1	4.024	1	4.2	1	4.115	1
3	Consultants' Initiated Changes	2.033	4	2.024	4	1.171	5	1.743	4
4	Contractor-initiated Changes	2.002	5	0.715	5	1.257	4	1.325	5
5	Technological Changes	2.544	3	2.273	3	1.976	3	2.264	3

Source: Researcher's Analysis (2017)

4.5 DISCUSSION OF RESULTS

The constructs were first subjected to correlation to establish the relationship between them and also examine if multicollinearaity exists between the constructs. Afterwards further analyses were performed to make more meanings out of the data solicited from the professionals. The most significant

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cause of variation is bad contractual procedure. The factors under this heading includes: client's financial problems; delay in land acquisition/compensation; inadequate project objectives; change of schedule; change of scope or plans. This finding is similar to the assertion of Msallam et al. (2015) who listed among other factors change of plan or scope, conflict between contract documents, lack of coordination, and client financial problem among others factors as the most significant causes of variation order. The assertion also underscores the findings of Alnuaimi *et al.* (2010). Lack of understanding and correct interpretation of client's requirement was ranked second while contractor initiated change was ranked least. These findings are in consonance with the position of Alaryan et al. (2014) where change orders were associated to project owners. Whereas Awad (2001) and Ndihokubwayo and Haupt (2008) underpinned the results of the study that contractor initiated changes was ranked least among the factors. They argued that the initiative of any variation is directly related to the approval of client.

The two most significant effects of variation on projects are cost overrun and time overrun respectively. These findings underpinned the conclusion of Osman *et al.* (2009), who inferred that the most common effects of change orders on construction projects are: cost overrun, additional payment for the contractor, increase in overhead expenses, delay, rework and demolition. In fact, Homaid *et al.* (2011) argued that increase in total cost of construction projects due to change orders may be up to about 11.3 per cent. However, Alaryan *et al.* (2014) opined that the most important effects of change orders on the project were found to be delays, cost overrun and disputes. The conclusion of Alaryan *et al.* (2014) is similar to that of Oyewobi et al. (2016) and Alnuaimi *et al.* (2010) where increase in cost and change schedule were seen as the most significant effects of variation on projects.

CONCLUSION

The research concluded that the bad contractual procedure was the most predominant cause of variation in civil engineering works, this is followed by lack of understanding and correct interpretation of client's requirement by the professionals. Contractor-initiated Changes is most insignificant cause of variation. This implies that contractor had lesser influences on the occurrence of variation orders. This is because the initiation of any variation is directly related to the authorization of client which is chiefly caused by changes required by the owner or problems in the design documents. The study also draws conclusion that the major effects of variation in civil engineering projects are cost and time overruns. However, the study suggested that the best strategy to reduce variation is that no design engineer should be allowed to practice without having a professional license and that registration of the construction companies should be reviewed regularly to reflect their technical capabilities. It was concluded that a better understanding of the causes of variation would be of help for construction professionals in assessing variation and this would be helpful in taking pre-emptive measures for reducing variation orders in construction projects.

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