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The Causes And Effects Of Variations On Infrastructure Projects Delivery In Abuja. Nigeria

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***Abstract*— Nigeria infrastructure projects delivery have been faced with challenges of the variation orders during the course of construction projects especially road, bridges, railways, high rise building, flyovers, and airport construction. The paper aimed at establishing the causes and effects of variations on infrastructure projects delivery. A total of 100 numbers of questionnaires were distributed to Engineers, Quantity surveyors, Project Managers, Construction Managers, Contractors, Consultant and Clients in the construction industry in Abuja. Only 82% of the questionnaire distributed were filled correctly and returned which was used for the analysis. The descriptive analysis was used to analyzed the data obtained from the survey. The result obtained from the analysis show that the design related factors, client related factors and consultant related factors are the majors causes of the variations on infrastructure projects delivery. The design related factors was further evaluated and the result ranked discrepancies, inadequate working drawing, error and omission in design very high as factors that causes the variation on infrastructure project delivery. Furthermore, the followings delays in construction, increase in projects cost, slow project progress and construction rework were ranked high as effects of variations on infrastructure projects delivery. Therefore, the paper recommended that adequate site feasibility study should be conducted before the brief stage in order to avoid the following problems: change of scope and design, site condition problems, change of specifications that lead to the delay, slow progress of work and cost overrun.**

***Keywords*— Changes order, Fluctuations, Infrastructure Projects, Project Delivery and Variations**

1. Introduction

According to Chan and Yeong (1995) variation is a change that occurs in the master plan of the project different from the agreed or signed contract. O'Brien (1998) added that variation is a combination of any or all of the followings: addition, omission or substitution of any work and the alteration of the kind or standard of materials or goods. Variation can be removal from site of work, material or goods that were formerly in accordance with the contract but now been changed and change in the circumstances in which the work is carried out for examples: access and use of site; limitation of working space; limitation of working hours and changes made to the sequencing of work (Zhao *et al.*, 2009 and Tiware & Kulkarni 2013). However, Ssegawa *et al.* (2002) described variation as any causes that trigger alteration and modification in the construction project whether as modest as change of mind by the clients, the consultant and uncertainty during the course of construction. These changes in a construction projects have a detrimental effect on the initial budget plan of the construction projects cost and time (Newton, 2015). This sometime resulted in time and cost overruns and additional works which affected the developmental plan and sometimes abandonment of projects. It has been observed globally that, variation orders are the main causes of cost and time overrun in construction contracts (Doloi, 2013). Various studies on variations attribute 6-17% cost overrun in construction projects to variations (Hsieh *et al.* 2004; Mohamed, 2001; Randa *et al.* 2009) even as time overrun due to variation orders are in the magnitude of 10-50% (Kumaraswamy *et al*, 1998). Ndihokubwayo and Haupt (2009) observed that construction projects have a prevalence of variation orders of 85% of the total site instructions with clients being the origin of 49%, consultants 47% and contractors 4% of the variation. Shresta *et al.,* (2013) affirmed that 63% of site instructions culminated in additional works and suggested that more attention should be devoted to the design stage such that issue of variation order can be minimized. However, Nigeria infrastructure projects development have been faced with challenges of the variations orders during the course of construction projects especially road, bridges, railways, high rise building, flyover constructions and thereby affect the cost, time and quality of projects. The study focused mainly on the causes of variation and effects of variation in the infrastructure projects delivery. Although previous studies in Nigeria focused on causes and impact of variation on building projects, without considering the infrastructure projects that were abandoned every in the country as a result of variations. Therefore, this paper aimed at establishing the causes and effects of variations on infrastructure project delivery. This have added to the body of knowledge by identifies the causes and effects of variations on infrastructure projects delivery in Abuja.

2. Variation Orders

The variation order comprises of the instruction that enable modification and alteration of the original master plan of the construction project. Usually this alteration and modification happen after the contract have been awarded to the contractor and have started work on the construction site. Sometime, this alteration and modification may be as a result of different reasons for instance the issues concerning the scope, materials and labour schedules, cost, as well as the method of construction. In Nigeria, majority of the contractor does not meet up with stipulated time for completion of the projects due to alteration and modification of the master design (Amu *et al.*, 2005; Kasimu *et al*., 2013; Pourrostam and Ismail, 2011). In addition, there are other factors that influence the alteration and modification of the design such as funding, design aesthetic, geographical location, weather condition of the environment, statutory law and client wishes (Hanna *et al.*, 2002). Researchers and scholars have conducted many studies in different part of the world in relation to the variation problems in construction projects. For example, Hsieh *et al.* (2004) discovered that 10-17% ratio of the cost of alteration and modification in relation to the total cost of the projects. Similarly, Duaij *et al.* (2007) conducted a study and discovered that 63% of the site order ended in additional works. Moreover, 14% of the variations are accompanied by wastages particularly in the areas of those that involve in modification to the part already completed (Duaij *et al.* 2007 and Shehu *et al.,* 2014). Table 1 summarized the causes of variations in construction projects.

Table 1: The causes of variation order on construction projects delivery

S/No	Consultant related	Client related	Contractors related
1	Inadequate working drawing details	Modification of plans or scope by the clients	Change the site conditions
2	Design discrepancies	The obstacle of making prompt decision	Lack of enough skilled workers
3	Conflicts on contract documents	Lack of enough project objectives	Contractors desired profitability
4	Inadequate scope of the work	Change of materials, alteration and modification of the specification by client	Contractor's financial challenges
5	Errors and omission in design	Change of schedule by clients	Lack of required data
6	Lack of proper coordination	Clients financial impediment	Lack of proper communication
7	Lack of judgement and experiences		Lack of judgement and experiences
8	In adequate knowledge of available materials and equipment		Defective workmanship

Source: Kasimu, (2016); Alaryans *et al.,* (2014) and Memon *et al.,* (2014)

2.1 The influence of variation orders on construction project performance

The significance influence of the variation orders in construction project performance is mainly where the appropriate schedule of work is prepared for a certain project to adhere to and the schedule was altered as a result of change order that might affected the project performance. Thomas *et al.* (2002) alleged that variability generally impedes project performance in terms of delivery within the stipulated time and cost with high quality. In addition, variation orders have marvelous effects on project performance as well as it affects the productivity and cost (Olateju *et al.,* 2011 and De-Miguel *et al.,* 2015). Arain and Phen (2005) stressed that variation orders are undesirable but predictable reality of any construction project. Hanna*, et al.* (2002) argued that construction project wedged by means of variation order causes the contractor to accomplish a lower output level than planned.

2.2 The Factors responsible for Variation Orders

The enormity of the various factors causing variations identified over the years by Wambeke *et al,* (2011) show that variation has come to stay as part of the construction projects and it cut across all contracting parties. Kazaz *et al.* (2012) highlighted that changes made in response to legislative or policy changes, changes in response to complaints of civilians and geological conditions were significant causes of variation order in highway construction projects in Taiwan. Arain & Pheng (2006) revealed that errors and omission in design, change in specification by client, design discrepancies, change in specifications by consultant, and non-compliance design with governmental regulation were considered as the most significant causes of variation order on institutional buildings in Singapore. Amiruddin *et al.* (2012) disclosed that change of plans or scope by the client, errors and omissions, differing site conditions, contractor's financial difficulties, weather condition, conflict in the project site, client's financial problems, value engineering and quality improvement are the top ten most important causes of variation order on construction projects delivery in Iran. Memon *et al.,* (2014) highlighted the followings as causes of variation orders: unavailability of equipment, poor workmanship and design complexity.

2.3 The Potential Effects of Variation

Variations are inevitable in any construction project (Ibbs *et al*., 2001). The needs of the client may change during the course of design or construction. Market conditions and technological developments may impose changes to the parameters of the project and also alter the design and the choice of the engineer (Ibbs *et al*., 2001 & Oloo *et al.,* 2014)). The Architect review of the design may bring about changes to improve or optimize the design and hence

the operations of the projects. Furthermore, errors and omissions in engineering or construction may force a change. All these factors and many others necessitate changes that are costly and generally unwelcomed by all parties. The construction process can be influenced by highly changing variables and unpredictable factors that could result from different sources. These sources include the performance of construction parties, availability of resources, environmental conditions, involvement of other parties and contractual relation. The consequence of these sources, the construction projects may face variations that could cause delay in project completion time (Clough and Sears, 1994). Memon *et al.,* (2014) outlined the effects of variations as increase in projects cost, delay in completion and logistic delay and causes disputes among the client and contractors.

Variations also increase the possibility of contractual disputes and unnecessary claims (Babatunde *et al.,* 2012 & O'Brien, 1998). Typically, variations present problems to all the parties involved in the construction process. Variations can be originated from numerous factors pertinent to the construction projects. Variations in construction projects will have effects in all the parties involved in construction sector. Effects of variation order were observed by previous researchers (Kolawole *et al.,* 2015; Clough and Sears, 1994; Ibbs *et al*., 1998) as delay in construction projects, loss of productivity, additional fund for contractor, slow project progress, and causes of non-value adding activities etc. Amiruddin *et al.* (2012) further added that variations have effects in construction projects delivery in the followings area: delay in construction schedule, increase in project cost, disputes between client and contractor, additional revenue for contractor and decrease in quality of work.

3. Research Method

This study adopted quantitative research approach via survey questionnaire to sample individuals from a population with a view towards making statistical inference about the population using the sample (Groves *et al.*, 2009). And also to pull out public opinion, such as beliefs, perception, ideas, views and thought about the causes and effects of variations on infrastructure projects delivery. In order to obtain the require population for this study, the stratified random sampling technique was adopted for the selection of the construction firms that participated in this study. This selection was in line with concept of Creswell and Tashakkori (2007) that respondents are arranged in strata for the convinienency in questionnaire distribution and assessment. In addition, the simple random sampling was adopted in each of the construction firms for the selection of construction players from the strata.

The questionnaire that was used to record the responses of each respondent contained mainly closed ended questions using a five- point Likert scale ranged from none, low, moderate, high and very high. The scores of the respondents were computed based on the variables used in the questionnaire. However, the questionnaires were distributed to the following professionals in the construction industry in Abuja. These are Quantity Surveyors, Architects, Engineers, Project Manager, Construction Manager, Contractors, Consultants and Client. A total number of 100 questionnaires were distributed and only 82 questionnaires were filled correctly and returned, which represent 82% of the Questionnaires used for the analysis.

The inference statistic was adopted to summarize the sample, rather than use the data to learn about the population and sample. In this paper, inference statistic was used to present means score, standard deviation and frequency counts. The mean value was used to rank the respondents' opinions or responses obtained and percentages was used to established the level of awareness on lean construction principles by construction firms in the Nigerian Construction Industry.

4. Findings and Discussion of Results

Table 2. A. Demographic profile of the respondents

S/N	ITEMS	NUMBER	PERCENTAGE (%)
1	**ACADEMIC QUALIFICATION**		
	HND	**32**	39.02
	BSC	**26**	31.71
	MSC	**20**	24.39
	Ph.D	**4**	4.88
	Total	**82**	**100%**
2	**PROFESSIONS**		
	Quantity Surveyors	18	21.95
	Builders	13	15.85
	Architects	14	17.07
	Engineers	12	14.63
	Project Managers	10	12.20
	Construction Managers	15	18.30
	Total	**82**	**100%**
3	**RESPONDENTS EXPERIENCES**		
	0-5 Years	15	18.29
	6-10 Years	12	14.63
	11- 15 Years	18	21.95
	16 -20 Years	10	12.02
	21- 25 Years	14	17.07
	25 Years and Above	13	15.85
	Total	**82**	**100%**
4	**SERVICES OF RESPONDENTS**		
	Pre Contract	18	21.95
	Construction	24	29.27
	Operation	17	20.73
	Maintenance	14	17.07
	Others	14	10.98
	Total	**82**	**100%**

Source: Field Survey (2018)

Table 2 show 39% of respondents that partake in this study have HND certificate and 31.7% with BSc

degree. However, 24.3% have Msc certificate and 4.88% with Ph.d certificate. This imply that the respondents that participated in this study have the full knowledge of the subject matter.

In addition, 21.9% of the respondents are quantity surveyors and 18.3% are construction managers. 17.07% are Architects and engineers are 14.63% with only 12.20% of project managers. This reflect that the respondents are professionals that are in charge of construction projects with different background of knowledge of construction projects.

The result shows that 21.95% of respondents have 11-15 years of working experiences, 18.29% are within 0-5 years of working experiences, 17.07% are within 21-25 years of working experience, 15.85% are within 25 and above years of working experience, 14.63% are within 6-10 years of working experience and 12.02% are within 16-20 years of working experience. This signifies that the respondents have the years of working experience in infrastructure projects.

The result further shows that 29.27% of respondents are mostly involved in construction activities and 21.95% of the respondents are involved in pre-contract activities. 20.73% of the respondents are involved in operation of construction projects and 17.07% are involved in maintenance activities. This implies that the respondents are involved in the production, maintenance and management of construction projects.

A. The results of the causes and effects of variations on infrastructure projects delivery were summarized in Tables 4-9

Table 3: Causes of Variation**s** on Infrastructure projects

S/No	Factors	MEAN	RANK
1	Design related factors	4.11	1st
2	Client related factors	4.05	2nd
3	Consultant related factors	3.32	3rd
4	Contractor related factors	3.32	3th
5	Other causes of variation	2.72	5th

Source: Field Survey (2018)

Table 3 shows that designed related changes and client related changes were ranked 1st, &2nd with mean scores of 4.11 &4.05 respectively. This implies that design related changes and client related factors were the main causes of variation on infrastructure projects delivery. Furthermore, consultant related factors and contractors related factors were ranked 3rd with mean score of 3.22 each respectively. This signifies that consultant related factors and contractors related factors were also considered as causes of variation on infrastructure projects delivery. Others related factors was ranked 5th with mean score of 2.72. This indicates that others related factors was considered least factors that causes variation on infrastructure projects delivery. These results were in line with the outcome of Hsieh *et al.,* (2004) that client and professionals involved in the construction projects contributes immensely to the causes of variation on construction projects. Halwatura and Ranasinghe (2013) also conducted a similar study in Sri Lanka and established the followings as factors that causes variation on construction projects: This includes; unforeseen site condition, political pressure during construction stage and poor investigation.

Table 4: Design Related Factors

S/No	Factors	MEAN	RANK
1	Design discrepancies	3.79	1st
2	Inadequate working drawing details	3.74	2nd
3	Errors and omissions in design	3.61	3rd
4	Lack of coordination from designs	3.26	4th
5	Architect lack of judgment and experience	2.61	5th

Source: Field Survey (2018)

Table 4 shows that design discrepancies, inadequate working drawing details, error and omission in design were ranked 1st,2nd, &3rd with mean scores of 3.79, 3.74 and 3.6 respectively. This reflects that design discrepancies, inadequate working drawing details, error and omission are the main causes of variations on infrastructure projects delivery. However, lack of coordination from design was ranked 4th with the mean score of 3.26. This indicates that lack of coordination from design causes variation on infrastructure projects delivery. In addition, Architect lack of judgement and experiences was ranked 5th with the mean score of 2.61. This shows that Architect lack of judgement and experiences was considered least factors that causes variation on infrastructure projects delivery. This result was in agreement with findings of Hanna *et al*., (2002) that lack of working drawing details, errors and lack of coordination from design are causes of variations on construction projects.

Table 5: Client Related Factors

S/No	Factors	MEAN	RANK
1	Change of plan and scope by client	4.26	1st
2	Change in specification by client	4.03	2nd
3	Clients financial problems	3.97	3rd
4	Change of schedule by client	3.54	4th
5	Replacement of materials or procedures	3.54	4th
6	Impediment in prompt decision making process	3.47	6th
7	Inadequate project objectives	3.27	7th

Source: Field Survey (2018)

Table 5 shows that change of plan & scope by client and change in specification by client were ranked 1st &2nd with the mean scores of 4.26 and 4.03 respectively. This signifies that change of plan & scope by client and changes in specification by client were the main causes of variation on infrastructure projects delivery. However, client's financial problems, change of schedule by client, replacement of materials or procedures were ranked 3rd &4th with the mean scores of 3.97 and 3.54 respectively. This reflects that client's financial problems, change of schedule by client, replacement of materials or procedures are causes of variations on infrastructure projects delivery. In addition, impediment in prompt decision making process and inadequate project objectives were ranked 6th, &7th with the mean scores of 3,47 and 3.27 respectively. This shows that impediment in prompt decision making process and inadequate project objectives were considered least factors that causes variation on infrastructure projects delivery. Amiruddin *et al,* (2012) conducted a similar study and outlined that contractor financial difficulties, lack of judgement and experiences of both professionals and contractors are the causes of variations on construction projects. Mohammad *et al.,* (2010) argued that major factors necessitating variation order is attributing to preference or taste for enhanced finished product different from the initially agreed quality by the client in a particular contractual agreement.

Table 6: Consultant related Factors

Factors	MEAN	RANK
Conflict between contract documents	4.47	1st
Consultants lack of required data	4.32	2nd
Inadequate working drawing	4.09	3rd
Design discrepancies	3,97	4th
Error and omission in design	3.50	5th
Consultants lack of judgement and experience	3.32	6th
Lack of coordination	2.89	7th
Lack of consultants knowledge of available materials and equipment	2.51	8th

Source: Field Survey (2018)

Table 6 shows that conflict between contract documents, consultants lack of required data, inadequate working drawing, design discrepancies and error & omission in design were ranked 1st,2nd,3rd,4th &5th with the mean scores of 4.47,4.32,4.09,3.97, &3.50 respectively. This displays that conflict between contract documents, consultants lack of required data, inadequate working drawing, design discrepancies and error & omission are the main causes of variation on infrastructure projects delivery. Furthermore, consultants lack of judge and experience, lack of coordination and lack of consultant knowledge of available materials and equipment were ranked 6th,7th, & 8th with the mean scores of 3.32,2.89,2.51 respectively. This indicates that consultants lack of judge and experience, lack of coordination and lack of consultant knowledge of available materials and equipment are the least factors that causes variation on infrastructure projects delivery. Amiruddin *et al*. (2012) conducted a similar study on factors causes variation order and their effects in road construction project in Kebangsaan in Malaysia and established the followings as main causes of variation consultant lack of required data, conflict between the contract document, design errors, and lack of coordination among the key players. Moreover, Halwatura and Ranasinghe (2013) emphasized that variations occur in every construction projects and the magnitude of these variations varies considerably from project to project.

Table 7: Contractor Related Factors

S/No	Factors	MEAN	RANK
1	Differing site conditions	4.54	1st
2	Defectives workmanship	4,23	2nd
3	Contractor's lack of judgment and experience	3.85	3rd
4	Contractor's lack of required data	3.64	4th
5	Contractor's financial difficulties	3.59	5th
6	Shortage of skilled manpower	3.41	6th
7	Contractor's desired profitability	3.23	7th

Source: Field Survey (2018)

Table 7 shows that differing site conditions and defectives workmanship were ranked 1st &2nd with the mean scores of 4.54 and 4.23 respectively. This implies that differing site conditions and defectives workmanship are the main causes of variation on infrastructure projects delivery. In addition, contractors lack of judgement and experience, contractors lack of required data and contractor's financial difficulties were ranked 3rd,4th, &5th with the mean scores of 3.85, 3.64 and 3.59 respectively. This signifies that contractors lack of judgement and experience, contractors lack of required data and contractor's financial difficulties are the causes of variation on infrastructure projects delivery. Furthermore, shortage of skilled manpower & contractors desired profitability were ranked 6th&7th with the mean scores of 3.41 & 3.23 respectively. This indicates that shortage of skilled manpower & contractors desired profitability were considered least factors that causes variation on infrastructure projects delivery. Wambeke *et al.,* (2011) conducted a similar study and established that contractor lack of experience and financial difficulties; site condition and desired profitability are the major causes of variations on construction projects.

Table 8: Other Causes of Variations

S/No	Factors	MEAN	RANK
1	Change in economic conditions	3.97	1st
2	Unforeseen problems	3.85	2nd
3	Change in government regulations	3.47	3rd

Source: Field Survey (2018)

Table 8 show that changes in economic conditions and unforeseen problems were ranked 1st & 2nd with the mean scores of 3.97 & 3,85 respectively. This reveal that changes in economic conditions and unforeseen problems are the main causes of variation on infrastructure projects delivery. In addition, change in government relations was ranked 3rd with the mean score of 3.47. This signify that government relation was considered least factors that causes variation on infrastructure projects delivery.

Table 9: Effects of Variations in infrastructure project delivery

S/No	Effects	MEAN	RANK
1	Delays in construction	4.34	1st
2	Increase in project cost	4,26	2nd
3	Slow project progress	4.13	3rd
4	Construction rework	3.50	4th
5	Causes non value adding activities	3.39	5th
6	Unnecessary procurement	3.32	6th
7	Loss of productivity	3.29	7th
8	Decrease quality of project	3.27	8th
9	Addition fund for contractor	3.26	9th

Source: Field Survey (2018)

Table 9 shows that delay in construction projects, increase in project cost, slow project progress and construction rework were ranked 1st,2nd, 3rd & 4th with the mean scores of 4.34, 4.26, 4.13 and 3.50 respectively. This implies that delay in construction projects, increase in project cost, slow project progress and construction rework are main effects of variation on infrastructure projects delivery. In addition, cause non value adding activities, unnecessary procurement, loss of productivity, decrease quality of project and addition fund for contractor were ranked 5th,6th,7th,8th & 9th with mean scores of 3.39,3.32, 3.29, 3.27 & 3.26 respectively. This reflects that cause non value adding activities, unnecessary procurement, loss of productivity, decrease quality of project and addition fund for contractor are considered least effects of variation on infrastructure projects delivery. These results were in agreement with the findings of Alaryan *et al.,* (2014) that increase the cost of the projects, increase in duration of individual activities, delay in completion schedule and delay in payments are the major effects of variation on construction projects. Arain and Pheng (2005) agreed with the findings that unnecessary procurement, slow project progress, delay in construction projects and decrease in quality of

projects are the effects of variation on construction project delivery.

5. Conclusion

The paper concluded by summarized the findings that client related factors and consultant related factors are the main factors that causes variations on infrastructure projects delivery. Moreover, design related factors was further evaluated and it was established that discrepancies, inadequate working drawing, error and omission in design are the main factors that causes variation on infrastructure project delivery. Likewise, client related factor was further analyzed and it was established that change of plan and scope, change of specification, financial problems, change of schedules and replacement of materials or procedure are the main factors that causes variation on infrastructure projects delivery. Furthermore, consultant related factors was also evaluated and it was established that conflict between contract documents, consultants lack of required data, inadequate working drawing, design discrepancies and error & omission in design are the main factors that causes variations on infrastructure project delivery. Moreover, the result obtained in contractor related factors show that different site conditions, defective workmanship, contractors lack of judgement and experience, lack of required data and financial difficulties are the main factors that causes variations on infrastructure projects delivery.

However, the effects of variations on infrastructure projects delivery were analyzed and followings were established: delays in construction projects, increase in project cost, slow project progress and construction rework were considered as main effects of variations on infrastructure projects delivery. Therefore, the paper recommended that adequate information should be provided to the design team during the brief stage in order to avoid design error, omission, and discrepancies in the working drawing. In addition, adequate site feasibility study should be conducted before the brief stage in order to avoid the following problems: change of scope and design, site condition problems, change of specifications that lead to the delay of construction projects, slow progress of work and cost overrun. Both the consultants and contractors should adhere to the rules of engagement in order to avoid conflict in the contract document and discrepancies in design that would lead to variations. Further research should also be conducted on the mitigating measures to `overcome the challenges of variation on infrastructure projects delivery.

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