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Cost impacts of variations on building construction projects

Abstract

Variation is the almost inevitable situation in construction projects. It is common in all types of construction projects and plays an important role in determining the closing cost and time of projects. The purpose of the paper seeks to establish the types of variations which normally occur on building projects and the impact of such variations. The study covered all projects initiated from the year 2000 and completed by 2014. Data was collected from contract documents, files and payment certificates, using tailored data collection table. The research approach was purely quantitative and the study population was three hundred and forty eight (348), representing project files. Findings show that the cost of multiple variations was higher than single variations and the projects with multiple variations had high percentage variation. Contract sum was significantly and positively correlated to duration of project and cost of variation. Further findings show that the duration of project was significantly and positively correlated to cost of variation and percentage variation, but cost of variation was insignificantly and negatively correlated to percentage variation. The regression model one reveals that 96.8% of the variation in cost of variation was explained by contract sum, duration of project, type of variation and number of types of variation. Clients should provide detail project briefs to design teams, to assist designers to arrive at conclusive designs. This is to ensure that designs are not frequently altered.

Keywords: cost impact, construction projects, variations, Ghana

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Introduction

The cost of a building construction project right from the inception to completion assumes greater importance in the building construction industry. One important problem in the building construction industry is managing variation orders.[1] Success in managing variation orders result in uninterrupted construction operations and agreed project costs as well as duration. Variation order contains a set of instructions which allow changes or modifications to be made to an earlier agreement in terms of volume or nature of task to be carried out.[2] These changes however, occur after the award of the initial contract or after work might have commenced at the construction sites. There are many reasons why variations occur. They may be due to extra work caused by subsurface conditions, errors in contract documents, additional quantities of works or materials, reduction on work, or lack of proper communication between parties. Needs of the owner may change in the course of design or construction, market conditions may impose changes to the parameters of the project, and technological developments may alter the design and the choice of the engineer. The architect's review of the design may bring about changes to improve or optimize the design and hence the operation of the project. All these factors and many others necessitate changes that are costly and generally unwelcomed by all parties.[3] However, to date, few studies have been carried out to investigate non value– adding activities associated with the changes or variations during the construction stage. While academic and practitioners concur that variation orders are common in the construction industry and their potential effect on project performance has been overlooked.[2] Arguably, variation orders may be seen as counter to the principle of waste reduction. The more variation orders on a project, the greater the likelihood that they become time consuming and costly elements in construction projects.[4] Construction contracts must make provisions for possible variations given the nature of building construction[5,6] because construction projects involve complex operations which cannot be accurately determined in advance.

A degree of change should be expected as it is difficult for clients to visualize the end product they procure.[7] Unforeseen condition may arise which require measures that have not been provided for in the contract.[5] Variation orders cannot be avoided completely.[4] Ssegawa added that it is hardly possible to complete a construction project without changes to the plans or the construction process itself due to the complexity of construction activities. Variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, discrepancies between contract documents.[8–10] Further, the human behavior of parties to the contract cannot be predicted. A variation order is work that is added to or deleted from the original scope of work of a contract, which alters the original contract amount and/or completion date. A variation order may fork a new project to handle significant changes to the current project.[9] Variation orders represent the mutual consensus between the parties on a change to the work, the price, the schedule, or some other terms of the contract. Variations represent mutual consensus, it is usually the best and least controversial way to make changes to an agreed contract.[4] Most variation orders received at the time of construction phase when multiple activities started impact on time and cost. Variation orders have become routine events in many building construction projects in Ghana, be it big or small because needs are not assessed, nor designed often times critically examined and queried at the right time.

Problem statement

Many building projects initiated by government and state institutions usually exceed their completion time and cost. Almost every project initiated sees one form of variation or the other. Though variations are likely to occur on construction projects, many are as a result of poor planning, bad designs, poor client brief, poor need identification and requirement and over dependence on incomplete designs. These factors put together have often resulted in extensive variations on many governments funded building projects which cost huge sums of Ghana Cedis. Projects which commence without any clear cut direction are bound to encounter different types of variations during the period of execution. Unfortunately, what is usually overlooked is the threat that variations poses to any construction project.

Literature review

Variations are almost inevitable elements and have become so prevalent that a project cannot be completed without altering design drawings or the construction process.[11] Fisk[12] posited that contract provisions seem to support variation orders on construction projects. In practice, variation seems to be a misunderstood concept by stakeholders both on its application and limit. Variation is an unwanted event in a project which has stand– by defense within the terms and conditions of contract. It has now become a common phenomenon in all types of construction projects.[12–14] Mohamed[4] affirmed that variation orders cannot be avoided completely in construction projects. Ssegawa et al. further added that the presence of variation clauses in contracts amounts to admitting that no project can be completed without changes. This means that carefully planned projects are even likely to see changes occurring to their scope as the work progresses.[9] Hanna et al.,[15] indicated that variations which occur on given projects are unique and can be linked to the extent of time and money made available for planning. Hanna et al.,[15] said increase in scope and changes in work condition have great impact on productivity. Moselhi et al.,[16] added that they can result in labour efficiency decline. Hegazy et al.,[17] defined change as any modification to the contractual guidance provided to the contractor by the owner, owner's agent or design engineer. Bin Ali[18] on the other hand defined variation order as the alteration or modification of the design, quality of works, as shown upon the contract drawings, bill of quantities, and/or specifications and includes the addition omission, or substitution of any works. However, Hanna et al.,[15] said change order is any event that results in a modification of the original scope, execution time, or cost of work. Changes in construction projects are likely to arise from different sources, by various causes, at any stage of a project. No matter where they come from, they have substantial negative consequence on time and cost.[19] Many researchers such as[14, 20–22] have studied this subject, its causes and the approaches used to manage it in construction projects, but decisively dealing with variation especially in government projects seems to be a mirage.

Predominance of variation orders

Building construction contract is a business agreement that is subject to variability. Contractual clauses relating to changes allow parties involved in the contract to freely initiate variation orders within the scope of the works without alteration of the original contract. Variation orders involve additions, omissions, alterations and substitutions in terms of quality, quantity and schedule of works. Without contractual clauses, the building contractor would have to agree to erect the building shown on the drawings and represented in the bills for a contract sum. Any minor change that the client or his/her architect wished to make later would mean that the contract had to be cancelled and a new one drawn up.[6] Once a contract has been concluded, its terms cannot be changed unless the contract itself contains some provisions for variation and then the only permitted variations are those that fall clearly within the contractual terms. Uff indicated that a clause permitting variation of works is an essential feature of any construction contract because without it the contractor is not bound to carry out additional work or to make changes. Moreover, the contractor could not refuse to carry out the varied obligation with the only remedy being an adjustment of price to be paid for the performance and in appropriate circumstances, an extension of time in which to execute such performance.

Universality of variation orders

Unfortunately, since building construction projects involve complex operations which cannot be accurately determined in advance, variation are bound to occur. Arain et al.[1] & Oladapo[23] posited that variation orders are common to all types of projects. Several researchers [9,10] have argued that variation orders occur due to a number of reasons ranging from finance, design, aesthetic, geological, weather conditions to feasibility of construction, statutory changes, product improvement, discrepancies between contract documents. It has been stated that human behavior of parties to a contract cannot be predicted, as such, changes arise from the minds of parties involved in the contract.[9] Unforeseen conditions may arise which require measures that have not been provided for in the contract.[5] This requires provisions for most contracts for possible variations, given the nature of building construction. [5, 6] The disadvantage of the variation clause is that architects tend not to crystallize their intentions on paper before the contract is signed because they know the variation clause will permit them to finalize their intentions during the term of the contract.[6] Ashworth[24] added that the advantage of the variation clause is that it allows the architect or other designers to delay making some decisions almost until the last possible moment. An unfortunate aspect of the variation clause is that it tends to encourage clients to change their minds and embark on building projects without having properly gone through their project requirements.[5]

Beneficial variation orders

A beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project.[1] It is a variation order initiated for value analysis purposes to realize a balance between the cost, functionality and durability aspects of a project to the satisfaction of clients. Value analysis aims at identifying and eliminating unnecessary costs which are defined as costs which provide neither use, nor life, nor quality, nor appearance, nor customer features.[25] It describes a project that is already built or designed and analyses the product to see if it can be improved.[26] Therefore, a beneficial variation order seeks to enhance client's value. Among others, the client's value system elements include time, capital cost, operating cost, environment, exchange or resale, aesthetic/esteem and fitness for purpose.[27] A beneficial variation eliminates unnecessary costs from a project. Zimmerman et al.,[26] revealed that all designs have unnecessary cost regardless of how excellent the design team may be. They said a beneficial variation order is the one that seeks to optimize the client's benefits against the resource input by eliminating unnecessary costs. Impliedly, a beneficial variation is initiated in the spirit of adding value to the project.

Detrimental variation orders

Detrimental variation order is one that has a negative impact on client's value or project performance.[1] A detrimental variation order therefore compromises the client's value system. A client who is experiencing financial problems may require the substitution of quality standard expensive materials to substandard cheap materials. This may have a negative effect on the total performance of the project which will lead to increase in the running cost of the facility.

Methodology

The research study approach was purely quantitative involving the use of descriptive and regression analyses. The population of the study comprised of all contract documents and associated contract management files for all building projects spanning for the fourteen (14) year period that is from 2000 to 2014. The total population for the study was three hundred and forty– eight (348) contract documents and their related files. In all a total of eighty– four (84) contract documents with their associated files were purposively sampled for the research study. The study considered only projects which fell within this period. Projects were sampled for inclusion if their contract documents and related contract administration files proved that there was issuance of a variation order. Data was collected from project contract documents, files and payment certificates using a tailored table. The information collected using the table was the contract sums, contingency sums, start dates, completion dates, and projects' duration, the types of variations and their frequencies of occurrence. Data collected was analyzed using descriptive and regression analysis which led to the determination of the impact of variation types on contract sum, cost of variation, percentage variation and duration of projects. The analysis led to the establishment of the correlation between contract sum and other variables, the impact of the number of types of variations and duration of projects on percentage variation. The development of regression models helped to establish to what extent the cost of variation can be explained by contract sum, duration of project, types of variation and the number of types of variation.

Results and discussions

Table 1 shows that the cost of variation for all the 84 projects studied amounted to GH¢18,705,393.37 which is equivalent to USD$3,963,007.0699 or €3,425,896.2216 using an exchange rate of USD$1 to GH¢4.72 or €1 to GH¢5.46. On the average, the cost of variation per project over the period of study was recorded as GH¢2,515,692.92, USD$532,985.78814 or €460,749.61905. However, the total cost of variation for the 25 projects which had substitution was recorded as GH¢2,954,004.85. The mean cost of variation for projects with substitution was GH¢118,160.19 per project. The maximum and minimum cost of variation for projects with substitution was GH 914.246.00 and GH 90.00. There were 46 projects with additional works and the cost of variation over the period of study was GH¢12,095,700.84. The mean cost of variation per project for projects with additional works was GH¢262,950.02. The maximum and minimum cost of variation per project for projects with additional works was GH 7,887,787.24 and GH 808.28. There were also eight projects with both substitution and additional works associated cost of variation of GH¢2,429,461.22. The mean cost of variation for projects with both substitution and additional works was recorded as GH¢303,682.65 per project. The maximum and minimum cost of variation for projects with both substitution and additional works was GH 922,031.16 and GH 16,678.01 per project. It was revealed that the cost of variation of projects with substitution, additional works and omission of works was generally higher than the others. This was followed by projects with substitution and additional works. However, projects with substitution, additional works and change in design had the lowest average cost of variation as compared to the others.

Table 1 Type of variation by cost of variation

	Count	Sum	Mean	Standard deviation	Minimum	Maximum
Substitution	25	2,954,004.85	118,160.19	203,046.41	90.00	914,246.00
Additional Works	46	12,095,700.84	262,950.02	1,160,093.34	808.28	7,887,787.24
Change in Design/ Specification	1	32,891.78	32,891.78		32,891.78	32,891.78
Omission of Works	1	220,636.40	220,636.40		220,636.40	220,636.40
Subs and Add	8	2,429,461.22	303,682.65	391,368.97	16,678.01	922,031.16
Sub/Add/Spec	1	16,678.01	16,678.01		16,678.01	16,678.01
Sub/Spec	1	122,066.64	122,066.64		122,066.64	122,066.64
Sub/Add/Omission	1	833,953.63	833,953.63		833,953.63	833,953.63
Total	84	18,705,393.37	222,683.25	874,579.68	90.00	7,887,787.24

Works with and without variation and cost of variation

Table 2 shows that the average cost of variation for projects with substitution of works was GH¢176,560.12 per project whiles projects without substitution of works recorded a cost of variation of GH¢257,275.60 per project. Comparatively, the cost of variation for projects with substitution of works was generally lower than those without substitution of works. Also, cost of variation for projects with change in design and specification was generally lower than those without change in design and specification and omission of works. On the other hand, cost of variation for projects with additional works and omission of works was higher than those without additional works and omission of works respectively.

Single and multiple types of variations against cost of variation

The average cost of projects with only one type of variation was recorded as GH¢209,633.34 per project as shown in Table 3. Projects with more than one type of variation recorded a cost of variation of GH¢309,287.23 per project. Comparatively, the cost of variation for projects with only one type of variation was generally lower than those with more than one type of variations.

Type of variation against percentage variation

Table 4 shows that the average percentage variation of a project was 84.30%. Projects with substitution recorded average percentage variation of 80.98%. Also, the average percentage variation of projects

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with additional works was 76.67%. On the other hand, the average percentage variation of projects with both substitution and additional works was 107.54%. It can be seen from that, the percentage variation of projects with change in design was generally higher than the others. Moreover, projects with substitution, additional works and change in specification inclusively had the lowest percentage variation as compared to the others.

Table 2 Comparison between the types of variation by cost of variation

	Count	Sum	Mean	Standard deviation	Minimum	Maximum
None Substitution	48	12,349,229.02	257,275.60	1,135,640.38	808.28	7,887,787.24
Substitution	36	6,356,164.35	176,560.12	279,637.46	90.00	922,031.16
None Additional Works	28	3,329,599.67	118,914.27	193,145.47	90.00	914,246.00
Additional Works	56	15,375,793.70	274,567.74	1,061,956.53	808.28	7,887,787.24
None Change in Design/ Specification	81	18,533,756.94	228,811.81	890,184.06	90.00	7,887,787.24
Change in Design/ Specification	3	171,636.43	57,212.14	56,747.70	16,678.01	122,066.64
None Omission of Works	81	17,403,249.07	214,854.93	888,162.43	90.00	7,887,787.24
Omission of Works	3	1,302,144.30	434,048.10	346,589.77	220,636.40	833,953.63
Total	84	18,705,393.37	222,683.25	874,579.68	90.00	7,887,787.24

Table 3 Number of types of variation by cost of variation

	Count	Sum	Mean	Standard deviation	Minimum	Maximum
One	73	15,303,233.87	209,633.34	927,380.70	90.00	7,887,787.24
More than One	11	3,402,159.50	309,287.23	383,195.19	16,678.01	922,031.16
Total	84	18,705,393.37	222,683.25	874,579.68	90.00	7,887,787.24

Table 4 Type of variation by percentage variation

	Count	Mean	Standard deviation	Minimum	Maximum
Substitution	25	80.98	100.2	2.09	427.85
Additional Works	46	76.67	91.96	0.37	515.96
Change in Design/Specification	1	274.24		274.24	274.24
Omission of Works	1	87.33		87.33	87.33
Subs and Add	8	107.54	49.17	33.89	186.21
Sub/Add/Spec	1	33.89		33.89	33.89
Sub/Spec	1	86.33		86.33	86.33
Sub/Add/Omission	1	187.59		187.59	187.59
Total	84	84.3	91.51	0.37	515.96

Regression analysis on the variation of contract

A correlation matrix of the variables for the sample units was discussed to examine the strength and relationships among variables under study. From Table 5, comparing the between contract sum, duration of project, variations and percentage variation, a relationship between the dependent and independent variables can easily be established. As shown in Table 5, contract sum is insignificantly and negatively correlated with percentage variation, whereas it is significantly and positively correlated to duration of project and cost of variation. The duration of project however, is significantly and positively correlated to cost of variation and percentage variation, but cost of variation is insignificantly and negatively correlated to percentage variation. By controlling the type of variation, it can be observed that similar result was generated as explained earlier, but with improved correlation values.

Regression coefficient for variables

Table 6 shows that the negative coefficients of substitution of works, additional works and change in design in the models one and two show that the type of variation has negative impact on cost of variation and percentage variation. On the other hand, the contract sum, duration of contract and number of variation had positive coefficients in model one meaning as they increase the cost of variation also increases. In model two, the contract sum turns to have a negative relationship with percentage variation, since its coefficient was negative. On the other hand, the number of types of variation and duration of projects has positive coefficients in model two showing a positive impact on percentage variation. In other to determine the significance of the predictor, a test was performed. From model one of Table 6, there is overwhelming evidence to infer that a linear relationship between contract sum and cost of variation exist. This is because the value of the test statistics is t = 42.79, with a significant value of 0.00 less than 0.05 level of significance. Also, there is an evidence of linear relationship between duration of project and cost of project, since the t = 6.38 had a highly significant result of 0.000. No linear relationships exist between type of variation and cost of variation, and number of types of variations and cost of variation. This is because the significant values are greater than 0.05. For model two, there is evidence of linear relationship between duration of project and percentage variation. This is because the value of the test statistics is t = 3.033, with a significant value of 0.003 less than 0.05 level of significance. There are no linear relationships between contract sum and percentage variation, type of variation and percentage variation, and number of types of variation and percentage variation.

Table 5 Correlation between contract sum, duration of project, variations and percentage variation

Control variables	Actual variables	Contract sum (GH)	Duration of contract (days)	Variations (GH)	% variation
–none–	Contract sum (GH)	1.000			
	Duration of contract (days)	.273 (.012)	1.000		
	Variations (GH)	.969	.418	1.000	
		(0.000)	(0.000)		
	% variation	–.097	.289	–.010	1.000
		(.381)	(.008)	(.927)	
Substitution & Additional Works & Change in Design/Specification & Omission of Works & No. of Variation	Contract sum (GH)				
	Duration of contract (days)	.308 (.006)	1.000		
	Variations (GH)	.975	.426	1.000	
		0.000	(0.000)		
	% variation	–.091	.283	–.013	1.000
		.423	(.011)	(.912)	

Note 1.Significant values are in bracket; 2. Correlation coefficients are without bracket

Table 6 Regression coefficient for individual variables

Model	Variables	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	–154664	67432.541		–2.294	.025
	Contract sum (GH)	.037	.001	.931	42.793	.000
	Duration of contract (days)	657.435	103.099	.150	6.377	.000
	Substitution	–82767.1	147955.618	–.047	–0.559	.578
	Additional Works	–101955	147270.111	–.055	–0.692	.491
	Change in Design/Specification	–188343	144988.824	–.040	–1.299	.198
	Omission of Works	32578.03	116143.628	.007	0.280	.780
	No. of Variation	209279.6	166439.355	.081	1.257	.212
2	(Constant)	50.824	36.430		1.395	.167
	Contract sum (GH)	–8.20E–07	.000	–.195	–1.740	.086
	Duration of contract (days)	.169	.056	.369	3.033	.003
	Substitution	–78.494	79.932	–.427	–0.982	.329
	Additional Works	–79.52	79.562	–.412	–0.999	.321
	Change in Design/Specification	1.525	78.330	.003	.019	.985
	Omission of Works	–29.352	62.746	–0.06	–.468	.641
	No. of Variation	73.53	89.918	0.273	.818	.416

1. Dependent variable: variations (GH)

2. Dependent Variable: % variation

Regression results

In Table 7, it was found that R– squared for model one is equal to 0.968. This statistics explain that 96.8% of the variation in cost of variation is explained by contract sum, duration of project, type of variation and number of types of variation (the remaining 3.2% is unexplained, but may be due to other factors). In addition, since the p– value of 0.000 is greater than 0.05 significant level, models one is a very good model. In model two, which was generally not a good model (since p– value is 0.105 greater 0.05 significant level), the R– squared of 0.14 explain that 1.4% of the variation in percentage variation is explained by contract sum, duration of project, type of variation and number of types of variation. These results indicate that contract sum, duration of project, type of variation and number of types of variation can be explained by the cost of variation but not percentage variation.

Table 7 Summary of regression result

Model	R	R square	Adjusted R square	Std. error of the estimate	F	P–value
1	.984[a]	.968	.965	164118.8258	325.858	.000
2	.375[a]	.140	.061	88.66441	1.772	.105

1. Dependent variable: Variations (GH); Predictors: (Constant), No. of Variation, Contract sum (GH), Omission of Works, Additional Works, Change in Design/Specification, Duration of contract (days), Substitution

2. Dependent variable: % Variations; Predictors: (Constant), No. of Variation, Contract sum (GH), Omission of Works, Additional Works, Change in Design/Specification, Duration of contract (days), Substitution

Conclusion

The paper concludes that: The cost of variation for all the 84 projects studied is GH¢18,705,393.37 which is equivalent to USD$3,963,007.0699 or €3,425,896.2216. The average cost of variation per project over the period of study is GH¢2,515,692.92 which is equal to USD$532,985.78814 or €460,749.61905. The types of variations identified over the fourteen year period are: substitutions, omissions, additional works, change in design and change in specification. The cost of variation for projects with additional works and omission of works are higher than those with only additional works or omissions. The cost of multiple variations is higher than single variations. There is insignificant and negative correlation between contract sum and percentage variation. However, contract sum is significantly and positively correlated to duration of project and cost of variation. The duration of project on the other hand, is significantly and positively correlated to cost of variation and percentage variation, but cost of variation is insignificantly and negatively correlated to percentage variation. The negative coefficients of substitution of works, additional works and change in design in models one and two show that the type of variation has negative impact on cost of variation and percentage variation. Contract sum, duration of contract and number of variation have positive coefficients in model one meaning as they increase the cost of variation also increases.

In model two, the contract sum turns to have a negative relationship with percentage variation, hence its negative coefficient. The numbers of types of variation and duration of projects have positive coefficients in model two showing a positive impact on percentage variation. There is an overwhelming evidence in Model one to infer that a linear relationship exist between contract sum and cost of variation. The R– squared for model one and two are 0.968 and 0.14 respectively. This explains that 96.8% of the variation in cost of variation is explained by contract sum, duration of project, type of variation and number of types of variation (the remaining 3.2% is unexplained, but may be due to other factors). The R– squared in model two explains that 1.4% of the variation in percentage variation is explained by contract sum, duration of project, type of variation and number of types of variation. Model one is a very good model than model two because it has a p– value of 0.000 which is greater than 0.05 significant level, unlike Model two whose p– value is 0.105, greater 0.05 significant level. These results indicate that contract sum, duration of project, type of variation and number of types of variation can be explained by the cost of variation but not the percentage variation.

Recommendations

The paper recommends based on the conclusions that: Clients should provide detail project briefs to design teams to assist designers to arrive at conclusive designs so that frequent variations to original plans or material type will be minimized or eliminated during the construction phase. This should be preceded by comprehensive planning and thorough identification of needs by clients before embarking on any developmental project. The scope of work should properly define the works to be carried out by the contractor without ambiguity. Specifications should be comprehensive enough to assist contractors to deliver the quality that is expected of them by clients. With complex building projects which involve huge sums of monies, clients and consultants should try to avoid or reduce to the barest minimum any occurrence of multiple variations because of the positive correlation between contract sum, duration of projects and cost of variation. Clients and their consultants should try as much as possible to reduce single and multiple variations on building projects since they have greater influence on the outcome of the final cost of projects. Specialists and experts should be involved in the design planning and process stages of the construction work in order to explain and provide solutions to technical bottlenecks. A detailed design should be in place to prevent any unnecessary interference from consultants and beneficiaries.

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Conflict of interest

The author declares there is no conflict of interest.

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