

The Impact of Variation Orders on Public Building Projects

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Abstract Variation is common in construction projects due to the complex nature of the construction industry. Variation order is observed as one of the most frequently occurring issues in construction projects in Ethiopia. Variations are known to impact various aspects of construction projects. Due to the background of the problem in public building projects, there is a cause for a study to be made on the assessment of the impact of variation orders on public building projects. The objective of the study was to identify the impacts of variation orders on public building projects. To achieve the stated objective of the study, the scope is limited to public building projects in Addis Ababa. Through a comprehensive study of literature review, resulted in identification of 15 impacts of variation orders on building projects. A desk study, interview and questionnaire survey were carried out to identify the impacts of variation orders on public building projects. The desk study conducted on five selected public building projects and the impacts of variation orders on the projects were identified. Interviews were made with selected experienced public building project participants for expert opinion. The questionnaires were distributed to the relevant project parties and the responses were analyzed using the relative index (RI) method. A triangulation method on the desk study, survey and the literatures was done to improve the validity of the findings from the study. The result showed that completion schedule delay, increase in project cost, additional payments for the contractor, effect on progress, and increase in overhead expenses were the main impacts of variation orders on public building projects.

Keywords Variation order, Impact, Public projects

1. Introduction

The implementations of public projects are expected to provide further thrust to the construction sector. Therefore, it is important to ensure these projects are being implemented successfully without any major problems while minimizing the adverse impacts of variation orders on the project outcome. Variation orders are issued to correct or modify the original scope of work because changes during construction of projects are unavoidable. As the number of variation orders on a project increases, so does the possibility of misunderstanding among the contracting parties. Such a misunderstanding may occur because one or more of the parties lacks full knowledge of the variation order process itself, the costs involved in implementing changes, or the delays, conflicts, and interruption of the construction sequence and schedule which can adversely impact project coordination. Previous studies on variation orders are mainly focused on the sources and causes of variation orders. Many times delays, cost overrun and quality defects of a construction can be attributed to variation at various stages

of the project. Variation orders have an impact on overall project performance (Ruben, 2008). This is because variations can cause substantial adjustment to the contract duration, total direct and indirect cost, or both. Variation orders involved alteration, addition, omission, and substitution in terms of quality, quantity and schedule of work. Any addition, deletion, or any other revision to project goals and scope of work are considered to be variation, whether they increase or decrease the project cost or schedule (Ibbs et al., 1998). The work of Sun and Ming (2004) mentioned that a variation in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements. In most countries the occurrence of variation orders on building project seems usual. Variations and conflicts in construction projects, at work, and even in our daily lives are very common (Arain and Low, 2006). Due to general background of the problem in the construction industry and the specific problem within the public buildings, there was a cause for the study. The objective of this study is to assess the impact of variation orders on public building projects. There are many projects which are being implemented in Ethiopia. In order to achieve the stated objective of the study, the scope would be too large to tackle. Therefore, the study was limited to Addis Ababa which is the capital of Ethiopia where many

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public building projects are under construction. The steps outlined in this in this study were introduction, literature review, data analysis and conclusions.

2. Literature Review

There is no single definition of what constitutes a variation. The term ‘variation’ as described and/or defined by various standard forms of contract differs from one to another but in principle the definition and/or meaning is more or less similar. Usually, any standard form of building contract will contain a definition of a variation in terms of specific actions and activities. The building contract dictionary defined variations as alterations, additions or omissions in work, materials, working hours, work space, etc. Impact is defined in electronic Webster dictionary as “the force of impression of one thing on another”.

No matter how carefully a project is planned and scheduled, it is almost certain that there will be variations before the project is completed. Variations in construction projects are very common and likely to occur from different bases. Ming *et al.* (2004) noted that project variations can be classified as “anticipated variation” and “emergent variation”. Anticipated variations are planned in advance and occur as intended. On the other hand, emergent variations arise spontaneously and are not originally anticipated or intended. Another way to view project variation is through its necessity. In this way, project variation can be classified as “elective variation” and “required variation” (Ming *et al.*, 2004). An elective variation is where one may choose whether or not to implement; and a required variation is where there is no option but to make the variation. Arain & Pheng (2005) distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

As Arain & Pheng (2005) described, a beneficial variation order is one issued to improve the quality standard, reduce cost, schedule, or degree of difficulty in a project. This type of variation order eliminates unnecessary costs from a project as a result; it optimizes the client's benefits against the resource input by eliminating unnecessary costs. This means beneficial variation orders 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 is an organized approach to the identification and elimination of unnecessary costs which are defined as costs which provide neither use, nor life, nor quality, nor appearance, nor customer features (Kelly & Male, 2002). According to Arain & Pheng (2005), a detrimental variation order is one that negatively impacts the client's value or project performance. For example a client who is experiencing financial problems may require the substitution of quality standard expensive materials to substandard cheap materials. Arguably, a detrimental variation order compromises the client's value system. For example, in marine construction, steel window frames result in steel oxidation if selected instead of timber or aluminum

frames.

In construction, many professionals agree that variation orders impact portions of the project directly or indirectly and result in reduced productivity. This is always a subjective issue as the contractor feel that the loss due to variation order is the fault of the designers and owners. Conversely, owners typically claim that the loss in productivity is due to poor management on the part of the contractors. However, not every variation order will impact the productivity of the project. Variations in any planned activity will cause a disturbance and will require the rearrangement or review of the existing plan under the recent developments.

The occurrence of variation order was observed by many researchers and it had an adverse impact on project performance. Ruben (2008) found that variation orders had an impact on overall project performance and the major adverse impact of variation orders are time and cost overruns and disputes between the parties to the contract. Thomas *et al.* (2002) noted that variability impedes project performance. Ibbs (1997) concluded that variation orders affect project performance as they adversely affect productivity and project costs. According to Arain and Pheng (2005) variation orders are an unwanted but inevitable reality of any construction project. Further, Hanna *et al.* (2002) found that a project with many variation orders causes the contractor to achieve lower productivity levels than planned. Variation orders adversely impact project performance in terms of cost overruns, time overruns, quality degradation, health and safety issues and professional relations. Numerous studies have been done to identify the impacts of variations, relationships between variation and its impacts (Hanna *et al.*, 2002; Hester *et al.*, 1991; Thomas and Napolitan, 1995; Osman *et al.*, 2009; Ibbs, 1997; Arain and Pheng, 2005; Haldun, 1998; CII, 1990; Ibbs, 1998). According to the above authors, the various impacts of variation orders were:

- Increase in project cost
- Progress is affected but without any delay
- Increase in overhead expenses
- Delay in payment
- Quality degradation
- Productivity degradation
- Procurement delay
- Rework and demolition
- Logistics delays
- Blemish firm's reputation
- Poor safety conditions
- Poor professional relations
- Additional payments for contractor
- Disputes among professionals
- Completion schedule delay

From the literatures, the frequent occurrence of variation order impacts building projects for example, by contributing to cost overruns and completion schedule delays. If not carefully managed, a variation order may give rise to disputes between parties to the contract.

3. Research Methodology

Due to the nature of data to be collected from the relevant parties for the study, a purposive sampling method was adopted to select the population for the study. A combination of qualitative and quantitative approaches was used in the study.

Due to the nature of data to be collected from the desk study and the expected participants for survey study, a purposive sampling method was adopted to select the population for the study. The interviewee and the respondents were selected depending on their direct exposure to public building project activities. A desk study, interview and questionnaire survey were carried out to identify the impacts of variation orders on public building projects. These three units of analysis are applied in the study in order to gather data directly from the concerned population. A triangulation method on the desk study, survey and the literatures was done to improve the validity of the findings from the study. The desk study conducted on selected public building projects and the impacts of variation orders on the projects were identified. In order to have information on the stated problem, data was extracted from the project payment certificates and monthly progress reports. This helps to understand the relationship between the theories and actual practices in building projects. The data collected through the desk study was determined the worthiness of the topic for research. Interviews were made with selected experienced public building project participants for expert opinion. The questionnaire responses were analyzed using the relative index (RI) method. Relative index is the simplest method to measure variables in a quantitative research. Qualitatively, the study focused to obtain the perceptions of public building construction stakeholders relative to the impacts of variation orders. The variables that identified from the literatures were quantitatively measured to determine the most frequent impacts of variation orders on public building projects.

The questionnaire was designed to gather data from professionals that were involved in public building projects. The ranking of the responses was by using Likert’s scale of five ordinal measures which arranged in ascending order from 1 to 5. The main approach used for data analysis was the Relative Index (RI) technique.

$$RI = \frac{(5n_5 + 4n_4 + 3n_3 + 2n_2 + n)}{5(n_5 + n_4 + n_3 + n_2 + n)}$$

Where:

RI: Relative Index

n_5, n_4, n_3, \dots : number of responding indices.

The responses were analyzed using the Microsoft Excel software package. The analysis included ranking the factors in terms of degree of effecting. The Spearman (rho) rank correlation coefficient is used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors).

$$Rho (\rho_{cal}) = 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$$

Where:

Rho (ρ_{cal}): Spearman's rank correlation coefficient;

d_i : the difference in ranking between each pair of factors; and

N: number of factors (variables).

The value of the Spearman (rho) rank correlation coefficient varies between -1 and $+1$. A correlation coefficient of $+1$ implies perfect positive correlation, 0 implies no correlation and -1 implies perfect negative correlation.

4. Result Analysis and Discussion

This part of the paper analyses the data collected using questionnaires, desk study and interviews. The collected data from the questionnaires was tabulated and analyzed according to their ranking on Relative Index (RI). Interview results from selected respondents are presented, together with observations from desk study.

4.1. Result Analysis

Desk Study Result

During the desk study, five (5) completed public building projects in Addis Ababa in which variation orders (VO) approved were selected for desk study in order to fully understand the impacts of variation orders. These projects were 100% completed and selected as a representative to the occurrences of variation orders of each of the public building projects. The list of selected projects for the desk study is shown in **Table 4.1**.

Table 4.1. List of selected public building projects

Project Code	Project Name	Contract Amount (Birr)	V.O (Birr)	Percent of V.O (%)
Project A	Sport Commission Building	51,935,122.89	8,284,485.09	15.95
Project B	Education Bureau Building	60,343,438.45	4,091,699.06	6.78
Project C	Police Commission Building	99,444,398.79	8,152,255.70	8.20
Project D	Credit & Savings Institution Building	36,914,578.87	7,234,368.3	19.60
Project E	Fire and Emergency Service Building	58,076,253.18	5,150,610.80	8.87

(Source: Addis Ababa Housing Development & Construction Bureau (2012))

From the desk study, project A, project B, project C, project D and project E were exposed to increase in a project cost amounting to 15.95%, 6.78%, 8.20%, 19.60% and 8.87% of the contract amount respectively. The followings are also summary of the impacts of variation orders found from the desk study as shown in **Table 4.2**. The variables were further synthesized according to their repetition on the projects which were be used in the questionnaire for the verification and validation process to evaluate their degree of important.

Table 4.2. Summary of the impact of variation orders from the desk study

Project	Impact of V.O
Project A	<ul style="list-style-type: none"> • Increase in project cost • Completion schedule delay
Project B	<ul style="list-style-type: none"> • Increase in project cost • Completion schedule delay • Disputes among the parties • Payment delay to the contractor
Project C	<ul style="list-style-type: none"> • Increase in project cost • Completion schedule delay
Project D	<ul style="list-style-type: none"> • Increase in project cost • Completion schedule delay • Payment delay to the contractor
Project E	<ul style="list-style-type: none"> • Increase in project cost • Completion schedule delay

From the above desk study findings, the impacts of variation orders were identified. These were:

- Increase in project cost
- Completion schedule delay
- Payment delay to the contractor
- Disputes among the involved parties

Interview Result

These interviews were made between selected public building project participants focusing on their perceptions on impact of variation orders. In total three interviews were conducted, namely with a senior project supervisor from the

clients' group, a senior contract administrator from the consultants' group, and a senior project manager from the contractors' group. The interview aimed at discovering the impacts of variation orders on public building projects. From the interview, the common impacts of variation orders were found as shown in **Table 4.3** below.

The interview result shows that the main impacts of variation orders which frequently occur on public building projects were increase in project cost which termed as cost overrun, completion schedule delay termed as time overrun, disputes among the parties, it degrades quality and it results in rework and demolition.

Questionnaire Survey Result

The respondents were grouped into three major groups namely client, consultant and contractor. The returns from the three groups are tabulated in **Table 4.4** below which shows the response rate. Out of 45 targeted responses, only 32 (71%) of them completed and returned the questionnaire. Thirty one questionnaires from 9 clients, 4 consultants and 19 contractors were received.

In the structured part of the questionnaire, the respondents were asked to rate the degree of contribution of the variables drawn from the literature review. Furthermore, the respondents were also asked to add other variables or impacts of variation orders. The responses were analyzed using the Microsoft Excel software package.

Fifteen (15) impacts of variation orders on building projects which identified from the literatures were used in the survey question as shown in **Table 4.5** below.

A ranking system using the Relative Index (RI) method was calculated to find the most significant factor for each section. The value of RI ranges from 0.2 to 1. The value 0.2 represents the lowest strength and the value 1 representing the maximum strength. The impact was determined using a 5 point Likert scale, namely No impact = 1; Low impact = 2; Medium impact = 3; High impact = 4; and Very high impact = 5. The impact of variation orders were ranked by comparing their relative index.

Table 4.3. Interview result

Question	Interviewee A	Interviewee B	Interviewee C
What are the various impacts of variation orders on public building projects?	<ul style="list-style-type: none"> ▪ Increase in project cost ▪ Completion schedule delay ▪ Degrades quality 	<ul style="list-style-type: none"> ▪ Disputes among the professionals ▪ Increase in project cost ▪ Completion schedule delay ▪ Rework and demolition 	<ul style="list-style-type: none"> ▪ Increase in contract and over head costs ▪ Disputes among parties ▪ Completion schedule delay

Table 4.4. Questionnaire return rate

Group	Number of Questionnaires distributed	Number of Questionnaires Returned	Response Rate (%)
Client	12	9	75
Consultant	5	4	80
Contractor	28	19	68
Total	45	32	71

Table 4.5. Survey questions

S.N	Impact of Variation Orders	No Very high impact				
		1	2	3	4	5
1	Increase in project cost					
2	Progress is affected					
3	Increase in overhead expenses					
4	Delay in payment					
5	Quality degradation					
6	Productivity degradation					
7	Procurement delay					
8	Rework and demolition					
9	Logistics delays					
10	Blemish firm's reputation					
11	Poor safety conditions					
12	Poor professional relations					
13	Additional payments for contractor					
14	Disputes among professionals					
15	Completion schedule delay					

A correlation test is done between different groups of respondents. As shown in **Table 4.6** below, the correlation coefficient indicates that there is a strong correlation between all groups. This implies that most of the respondents have the same perception about the impact of variation orders.

Table 4.6. Summary of correlation test on the ranking of the impact of variation orders

Respondents	Rho (ρ_{cal}) $= 1 - \frac{6 \times (\sum d_i^2)}{N \times (N^2 - 1)}$	Relation of the respondents
Client Vs Consultant	0.994	strong
Consultant Vs Contractor	0.999	strong
Client Vs Contractor	0.997	strong

As it can be seen in **Table 4.7** below, the most ranked impacts of variation orders from the combined responses of all respondents were completion schedule delay (RI=0.794) followed by increase in project cost (RI=0.793). Additional payments for contractor (RI=0.742) and effect on progress (RI=0.731) were the next and then increase in overhead expenses (RI=0.697). Poor safety condition (RI=0.537) were the least ranked impact of variation orders as responded by all participants.

Table 4.7. Frequency of impact of variation orders on public building projects

Impact of variation orders	RI	Ranking
Completion schedule delay	0.794	1
Increase in project cost	0.793	2
Additional payments for contractor	0.742	3
Progress is affected	0.731	4
Increase in overhead expenses	0.697	5
Delay in payment	0.694	6
Procurement delay	0.679	7
Logistics delays	0.667	8
Disputes among professionals	0.661	9
Rework and demolition	0.642	10
Productivity degradation	0.594	11
Blemish firm's reputation	0.576	12
Quality degradation	0.566	13
Poor professional relations	0.560	14
Poor safety conditions	0.537	15

4.2. Discussion

According to the findings from the desk study, the interview, the questionnaire survey and the literatures, completion schedule is the first major impact on public building projects. Previously (Ibbs, 1997) pointed out that completion schedule delay was a frequent result of variations in construction projects which increases the consistency of the response to conclude. This confirmed that variations impact the project adversely, leading to delays in the project completion.

The second major impact is increase in project cost or cost overrun on public building projects. Project cost overrun is also the major impact of variation order as noted in the literature review. For example Koushki (2005) found that variation orders impacted both the completion time and costs of projects. These impacts are due to detrimental variation orders since they negatively impacted the client's value. Any major additions or alterations in the design may eventually increase the project cost. It was not unexpected for the project cost to increase due to frequent variations in the project. This is because variation orders may impact the project's total direct and indirect costs. Therefore, any major addition or alteration in the design may eventually increase the project cost.

An additional payment for the contractor is the third major impact of variation orders. As O'Brien (1998) described, variations are considered to be a common source of additional works for the contractor. This is because as the volume of work increases, payment to the contractor increases when the varied items are measured. This adds value to the contractor.

The fourth major impact was the effect on the progress. This impact was not uncommon that project progress can be affected due to variations. Since variation management

passes through different stages, most clients do not approve variation orders on time and the contractor refuses to continue the work. The contractor can also need new materials, new equipments and specialized man power. These affect the project progress.

The fifth major impact of variation orders on public building projects was the increase in overhead expenses. This cost can be incurred directly or indirectly during the process and implementation of variation orders. Because the overhead expenses for all involved parties increase as lots of professional and paper works need to be done. Arguably, the more the variation orders, the more likely they increase the overhead expenses which impact public building projects.

5. Conclusions and Recommendations

The study found that variation orders had adverse impacts on public building projects. A desk study on five public building projects was conducted. According to the desk study findings, increase in project cost was the major impact on public building projects. The interview result indicated that variation orders increase project costs. From the questionnaire response, the major impacts of variation orders on public building projects were completion schedule delay and increase in project

From the study findings, it is concluded the main impacts of variation orders on public building projects are completion schedule delay, increase in project cost, additional payments for the contractor, effect on progress, and increase in overhead expenses. It is recommended that the client should allow sufficient time to prepare an elaborately detailed project brief. This will eliminate frequent variations to the original plan of the project due to client change of mind. Consultants should produce a complete design and contract document to minimize schedule delays due to variations. Consultants should give sufficient time for planning and design phase, this will assist in minimizing cost overruns. The consultants should also prepare completed design and contract document before the tendering stage to minimize extra payments to the contractor due to variation orders. Contractors should identify and inform the varied item of work to the client before the activity starts to reduce variations to help the client to give work order at minimum variations. There should be improvement in project management, and improved decision making process by all the parties during project execution stage so as to minimize the impact of variation orders on project progress.

For further research, since this study is focused on public building projects in Ethiopia, it would be interesting to study the impact of variation orders in other countries and compare the results.

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