

Overall Ranking of the Most Influential Causes and Impacts of Variation Orders in Arab Construction Projects

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Abstract: Variation order involves adding, omitting, or altering activities from the original scope of work. It has a multitude of negative impacts on the project's duration and budget. The objective of this research is to investigate the main causes and impacts of variation orders in Egyptian construction projects from the perceptions of contractors, consultants, and owners. The relative importance indices of these factors are computed by analysing thirty-three questionnaire surveys. Furthermore, the rankings of this study are aggregated with other studies to determine the top five factors affecting and resulting from variation orders in many Arab countries. The results showed that the most significant cause and impact of variation orders are change in the country's economic conditions and delay in project completion, respectively. This study aids project managers and construction practitioners in identifying the root causes of variation orders to mitigate and eliminate their negative impacts on the construction projects.

1 INTRODUCTION

The construction industry is one of the largest sectors which plays a major role in the Egyptian economy. Furthermore, the construction sector has a remarkable contribution to the employment growth (El-Sadek, 2016). Therefore, this sector is a basic building block in the development of any country. The occurrence of variation orders has become inevitable in any construction project and the magnitudes of their impacts vary from one project to another (Assbeihat and Sweis, 2015; Wali and Saber, 2019). Construction projects are often subjected to several changes that might result from the involvement of many parties in a project. This variation is either regularized by the issuance of a change order which describes its scope and impact or turns into a claim or dispute which curtails the successful completion of a project (Alaryan, 2014).

Several definitions were given to the term change/variation orders. The variation order was defined as an added or deleted work from the original scope of work and it may affect the project's budget and duration (Ibbs, 2001). Osman et al. (2009) defined variation orders as any change from the defined scope and schedule of work. The variation

orders are generally unwelcomed by the project parties such that the owners feel that they are paying for others' mistakes and contractors believe that they disrupt the workflow and require additional efforts and time. However, some contractors might benefit from the occurrence of variation orders (Mohammed et al., 2017).

The main causes of variation orders are listed as follows: change in scope, schedule or specifications, owner's and contractor's financial problems, poor decision-making, obstinate nature of the owner, change in design, conflicts among contract documents, project complexity, inadequate working drawing details, unavailability of equipment, shortage of skilled manpower, poor workmanship, inadequate design, poor procurement process, lack of strategic planning, inefficient communication, improper and ineffective integration, and environmental changes (Memon et al., 2014; Lokhande and Ahmed, 2015).

Regardless of the different causes of variation orders, they often result in delays in completion, additional costs, adverse quality, rework, logistic delays, and disputes among the project parties (Assaf and Al-Hejji, 2006; Memon et al., 2014). Improving the projects' performances could be achieved by reducing and eliminating the main causes of variation

orders (Thomas et al., 2002). Therefore, this paper aims at identifying and ranking the most influential factors affecting variation orders in many construction projects across the Arab countries.

This research is organized as follows: Section 2 provides an extensive literature review of the previous studies that were conducted in this research area. Section 3 presents the proposed model's framework and its major components. Section 4 is related to the model's development that guides the implementation of the proposed framework. Section 5 covers the data collected to develop the research framework. Section 6 illustrates the model's implementation and reports a discussion on the obtained results. Finally, section 7 summarizes the main conclusions and findings of this research.

2 LITERATURE REVIEW

The variation orders might occur in construction projects for many reasons, such as errors and omissions, change in scope, and unforeseen conditions (Hinze, 2001). Assaf and Al-Hejji (2006) pointed out that change order was the most common cause of delays in Saudi Arabia's construction projects. Alnuaimi et al. (2010) discussed the causes, impacts, and remedies of variation orders in construction projects in Oman. The authors concluded that client changes and lack of national information and databases were the main reasons for variation orders. Besides, it was found that the contractor benefited the most from change orders followed by the consultant and then the client. In another study, Ijaola and Iyagba (2012) conducted a comparison of causes, effects, and remedies of change orders in the public construction project in Nigeria and Oman using the relative importance indices. It was reported that additional work requested by the owner and design modifications were the most important causes of a change order in both countries. Besides, claims and disputes as well as time and cost overruns were listed as the major impacts of change orders in Nigeria and Oman, respectively. It was pinpointed that the contractors were the party benefiting the most from the change order. Finally, the most important remedies were the assignment of a specialized quantity surveyor/ cost controller and project manager to large construction project and assignment of a high tech consultant company in Nigeria and Oman, respectively. Alaryan (2014) ranked the most common causes of changes in the public and private construction projects in Kuwait. Besides, the effects and control measures to

address these changes were discussed from the perspectives of owners, consultants, and contractors. The importance index of each effect and control measure was utilized to rank the collected factors. The agreements among the means of the responses were verified using the hypothesis testing. The most common causes of change orders were identified as a) plan changes by the owner, b) scope changes by the owner, c) site problems, d) design errors and omissions, and e) poor design and working drawing details.

Assbeihat and Sweis (2015) classified the factors affecting change orders in public construction projects in Jordan according to Drewin's open conversion system. The relative significance of these factors was estimated based on the average scores of responses received from the consultants, owners, and contractors. The respondents stated that modifications of design and specifications, additional work, ambiguities and errors in specifications and drawings, and inappropriate coordination among the project parties were significant causes of change orders. Finally, the solutions proposed to minimize change orders leading to time and cost overruns were recommended. In another study, Alshdiefat and Aziz (2018) classified the causes of change orders in the Jordanian construction industry into client-related, engineering-related, and project-related aspects. Then, the severity indices of these factors were applied for ranking and analysis. The analysis showed that the top three causes of variation orders were changes requested by clients, design errors, and conflicts between contract documents. Finally, correlation analysis was performed to capture the relationships between different categories of causes of change orders. Lokhande and Ahmed (2015) discussed the causes and impacts of change orders in the construction industry of Yemen. The authors also recommended some practices to manage and control variation orders. Albhaisi (2016) surveyed the causes of variation orders in the Gaza strip from the perspective of owners, consultants, and contractors. It was concluded that the most influential factors causing variation orders were schedule change by the owner, design complexity, lack of contractor's involvement in the design, late delivery of equipment and materials, and site safety considerations. Finally, the appropriate solutions to minimize and control variation orders were proposed.

Senouci et al. (2016) investigated the causes of change orders in residential and commercial projects in Qatar. The level of association between these causes and cost overruns was analysed using Pearson correlation analysis. The analysis showed that design

errors, change in design, change in quantities of work, change in plan or scope of work, and differing site conditions factors had the highest correlation coefficient. The analysis of variance revealed that change orders in the design and construction phases had the same cost overrun impact. A regression analysis was performed to predict the cost overruns concerning the project size/contract value. Finally, recommendations were presented to tackle the problem of change orders in the Qatari construction industry. El-Sadek (2016) ranked the causes of change orders in the Egyptian construction industry based on their relative importance indices. The results revealed that additional work, ambiguities and conflicts in the contract documents, change of the project's schedule, and inappropriate communication among project parties were listed as the most significant causes of change orders. Finally, the rectification methods that could be taken to mitigate the probability of occurrence of variations were presented. Sherif (2016) studied the causes and consequences of variation orders in the repetitive residential projects in Egypt. The relative importance indices of these factors were computed to conclude that change in plans or scope, schedule, and specifications were the top three causes of variation orders. Moreover, the level of agreement among the responses of each party was measured using Spearman correlation analysis. Finally, the non-value adding activities associated with variation orders were identified to enhance the construction projects' performances.

Mohammed et al. (2017) identified the factors causing variation orders in the building projects in Sudan from the perceptions of owners, consultants, contractors, and project managers. The weighted average for each factor was computed to measure its relative significance. The top five significant factors were listed as follows: a) instable prices and exchange rates, b) new imposed governmental regulations, c) unavailability of manuals for construction projects, d) design errors and omissions, and e) failure of owners to make decisions or review documents at the right time. The study showed an agreement among the involved parties regarding the ranking of factors. Khalifa and Mahamid (2019) studied the causes, impacts, and remedies of variation orders in construction projects in Saudi Arabia. The top five causes of change orders from the contractors' view were: a) owner's additional works, b) design errors and omissions, c) lack of coordination among construction parties, d) defective workmanship, and e) financial difficulties faced by the owner. The consultants agreed with the contractors on the top

three factors but, they ranked the owners' financial problems and differing site conditions as the third and fourth causes of variation orders. Wali and Saber (2019) applied the fishbone diagram to determine the root causes of change orders in construction projects in Iraq. Furthermore, an analysis of the collected factors was performed using the relative importance index. The analysis showed that the top five significant factors causes of the change orders were the poor project management, change in the country's economic conditions, lack of contractor's experience and mistakes during construction, poor cost estimation, and quality assurance/control. This research aids construction professionals in managing and controlling the change orders.

The novelty of this research is the evaluation of the significant causes and impacts of variation orders in many Arabian construction projects from the perspective of owners, contractors, and consultants. This research is expected to assist project managers and construction professionals in identifying the causes of variation orders at an early stage of the project for possible reduction or elimination.

3 RESEARCH METHODOLOGY

The flowchart of the proposed model is presented in Figure 1. It starts with reviewing the previous research studies related to variation orders in the construction industry in many Arab countries. Then, questionnaire surveys are conducted to rank the collected factors based on their relative importance indices. Finally, the obtained rankings are aggregated to acquire a comprehensive view of the most significant causes and effects of variation orders in Arab countries.

4 MODEL DEVELOPMENT

The objective of this research is to investigate the most influential factors of variation orders in the Arab construction industries. The relative importance index establishes a mean rating point for each cause of variation order as per Equation 1 (Wali and Saber, 2019). Therefore, it is applied in this research for evaluating the significance of the assessed factors.

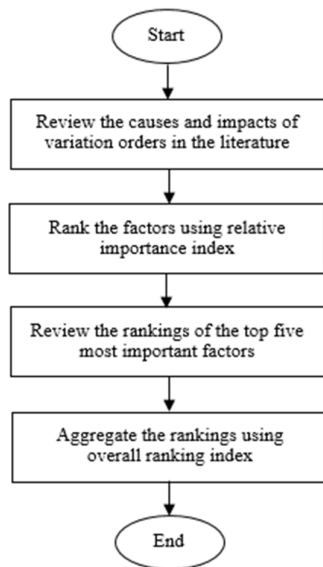


Figure 1: Model development framework.

$$RII = \frac{\sum W}{A * N} \quad (1)$$

Where, W represents the rating of each factor, A represents the highest weight, and N represents the total number of responses. It could be noted that a higher value of this index indicates the greater significance of this factor. The different rankings obtained from different studies are aggregated to obtain a comprehensive view of the most significant causes and impacts of variation orders in many Arab countries using Equation 2 (Zidane and Andersen, 2018).

$$ORI = \frac{1}{F} \times \sum_{i=1}^5 (N_i) \times \sum_{i=1}^5 \left(\frac{N_i}{i}\right) \quad (2)$$

Where ORI represents the overall ranking index, F refers to the total number of research studies, i represents the actual ranking of each variation order cause, and N_i represents the frequency of each factor's ranking in all the research studies. It could be noted that a higher value of this index indicates a higher ranking of this factor.

5 DATA COLLECTION

The major sources of data collection in this research are literature reviews and questionnaire surveys. The preliminary list of variation order factors in construction projects was identified based on an

extensive literature review. The collected factors are evaluated by conducting thirty-three questionnaire surveys among different contractors, consultants, and owners in the Egyptian construction industry.

The structure of the questionnaire consists of three parts: consent form, general information, and questions about causes and impacts of variation orders. The informed consent form informs the participant about the purpose of the study and the benefits of participation. The general information section covers the participant's occupation and years of experience. The experts are finally requested to state the relative weights of importance of the factors collected from the literature review. The experts shall express their preferences according to Likert scale, ranging from "1", which means not at all important, to "5", which means very important. The rankings of the top five causes and impacts of variation orders in many Arab countries are shown in Tables 1 and 2, respectively.

6 RESULTS AND DISCUSSION

The construction industry is exposed to several changes leading to the issuance of variation orders. That is why, it is crucial to investigate the causes of variation orders in order to manage and control their negative impacts on the projects. The common causes and effects of variation orders are mainly collected from the literature review. These factors are evaluated by conducting thirty-three questionnaire surveys with experts in the Egyptian construction industry. Measuring the reliability of this research is crucial to ensure getting the same results if more data is collected using the same procedure (Saunders et al., 2009). The reliability of the collected responses is measured by measuring the Cronbach's alpha coefficient. The value of this coefficient ranges between 0% and 100% whereas, the higher values represent more consistent values and reflect greater reliability. In this research, the Cronbach's alpha coefficient of causes of change orders is 0.98, which means reliable and consistent results. The frequencies of importance levels of each cause and impact of variation orders are shown in Figures 2 and 3, respectively.

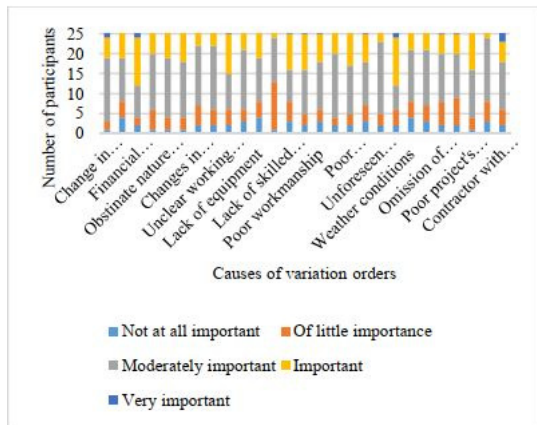


Figure 2: Frequencies of importance level for causes of variation orders.

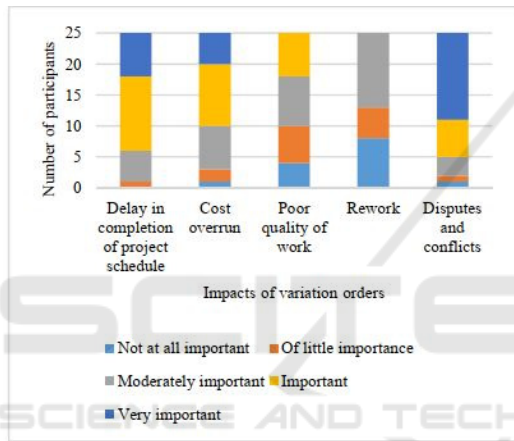


Figure 3: Frequencies of importance level for impacts of variation orders.

The relative importance index of each cause of variation order is computed as shown in Figure 4. The analysis shows that the top five most significant causes of variation orders are financial difficulties faced by the owner, unavailability of a strategic plan, change of schedule of work, unclear working drawings, and financial difficulties faced by contractors. On the other side, the least ranked factors are the change of specifications of work by the consultant, non-involvement of contractor in the design phase, adverse weather conditions, replacement of materials, and change in site conditions.

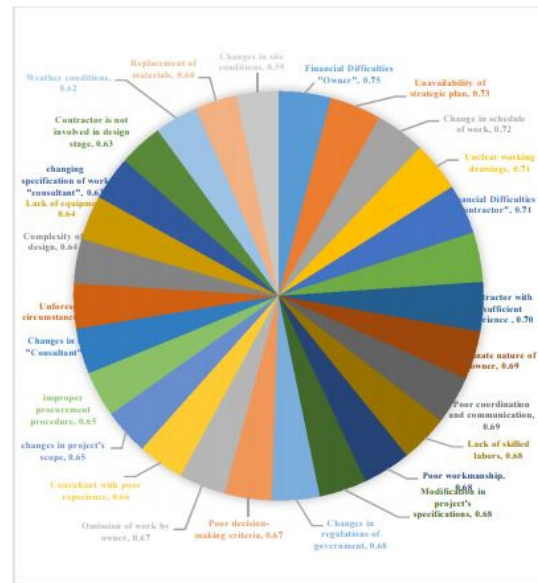


Figure 4: Relative importance indices of significant causes of variation orders.

The relative importance index of each impact of variation order is computed as shown in Figure 5. The analysis shows that the disputes and conflicts, delay in project completion, cost overrun, bad quality of work, and rework are the most significant impacts of variation orders.

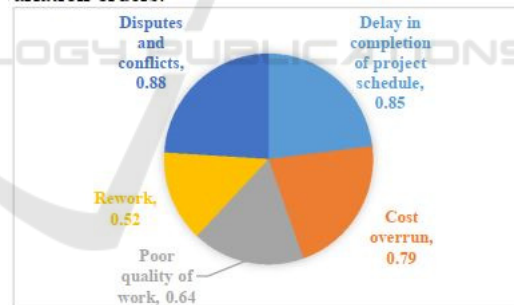


Figure 5: Relative importance indices of significant impacts of variation orders.

The overall ranking indices of the top five most important causes of variation orders are illustrated in Figure 6. The analysis shows that the top five most significant causes of variation orders are change in the country's economic conditions, change of project scope and plans, design errors and omissions, and design modifications. On the other side, the least important factors are modification in specifications of materials, incomplete design, contractor's financial problems, unsafe site, and change in design by the consultant.

Table 1: Rankings of top five casual factors of variation orders in different Arab countries.

No.	Country	Saudi Arabia	Oman	Kuwait	Jordan		Palestine	Egypt		Sudan	Iraq
	Authors Causal factors	Al-dubaisi (2000)	Ijaola and Iyagba (2012)	Alaryan (2014)	Assbeihat and Sweis (2015)	Alshdiefat and Aziz (2018)	Albhaisi (2016)	El-Sadek (2016)	Sherif (2016)	Mohammed et al. (2017)	Wali and Saber (2019)
1	Change in the country's economic conditions							1	2	1	2
2	Changed governmental regulations							2		2	
3	Change of plans by owner	1		1		1					
4	Change of project scope by owner		1	2	2	1					
5	Poor project management							1			1
6	Site problems			3							
7	Lack of contractor's experience on-site							3			3
8	Design errors and omissions	3		4		2		4		4	
9	Change of schedule by owner			5		1	1				
10	Design complexity						2				
11	In complete design					5					
12	Lack of contractor's involvement in the design						3				
13	Inefficient decision-making by owner							5		5	
14	Owner's financial problems	4									
15	Poor cost estimation							4			4
16	Late delivery of equipment and materials						4				
17	Site safety problems						5				
18	Modification in design by owner		2		1	1					
19	Change in design by consultant	5									
20	Conflicts between contract documents					3					
21	Poor quality assurance/control							5			5
22	Non-availability of manuals and procedures		3					3		3	
23	Poor quality of consultancy services		4								
24	Lack of coordination among project parties		5		5	4					
25	Ambiguities in contract documents				3						
26	Modification in specifications of materials				4						
27	Substitution of materials and procedures	2									

Table 2: Rankings of top five impacts of variation orders in different Arab countries

No.	Country	Oman	Kuwait	Jordan	Palestine	Egypt	Sudan
	Authors Impacts	Ijaola and Iyagba (2012)	Alaryan (2014)	Msallam et al. (2015)	Staiti (2015)	Sherif (2016)	Mahmoud and Elshaikh (2019)
1	Delay in project's completion	1	3	1	1	1	3
2	Claims and disputes	2			3	2	4
3	Cost overruns	3	1	2	2	3	2
4	Delay in activities' completion		2				
5	Increase in overhead expenses			3			
6	Difficulty of adopting new technologies			4			
7	Delay in payments		4		4		
8	Bad performance and moral of parties	4		5	5	4	1
9	Demolition and rework		5				
10	Additional cost incurred by the contractor	5					
11	Poor quality of work	6				5	5

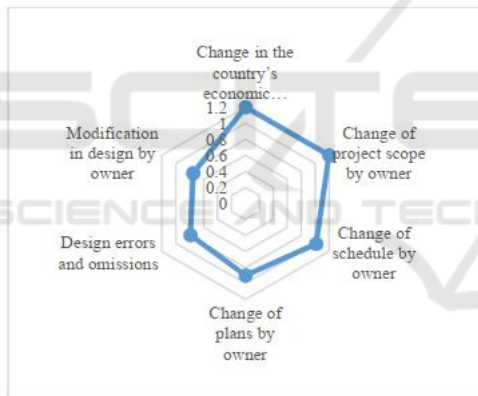


Figure 6: Overall ranking indices of the top five causes of variation orders.

The overall ranking indices of the top five most important impacts of variation orders are illustrated in Figure 7. The analysis shows that the top five most significant impacts of variation orders are delay in project completion, cost overruns, claims and disputes among project parties, adverse impact on the performance and moral of parties, and poor quality of work. On the other side, the least important factors are demolition and rework, delay in completion of activities, excessive overhead expenses, difficulty in adapting new technologies, and incurrence of additional costs.

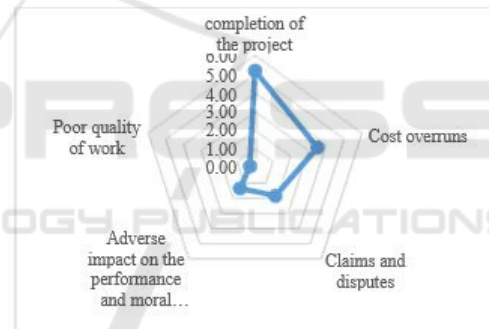


Figure 7: Overall ranking indices of the top five impacts of variation orders.

These results were validated through an interview with a professional whose experience is more than 25 years in the Egyptian construction industry. The expert was asked about the most influential causes and impacts of variation orders in the Egyptian construction industry. The most influential causes of variation orders were stated as follows:

- Change in the country's economic conditions because of the instable economic situation in Egypt.
- Design errors and omissions which generate variations and adversely impact the project's cost and schedule.
- Change of project scope and modifications/alterations due to insufficient

owner's knowledge in the project and lack of planning in the initial stages of the project.

- Change in design or specifications of the project which frequently occurs in projects where construction initiates before the design is finalized.

On the other hand, the most significant impacts of variation orders were described as cost and time overruns, claims and disputes among project parties, and poor quality of work.

7 CONCLUSION

This study investigated the variation orders in the Egyptian construction industry. These factors were analysed by conducting thirty- three questionnaire surveys among professionals in the construction industry. The significance of these factors was determined by calculating the relative importance indices of the collected responses. Furthermore, this research explored the most important causes and impacts of variation orders from previous research studies in Arabian construction projects. Furthermore, the most significant impacts of variation orders were delay in project completion, cost overruns, claims and disputes among project parties, adverse impact on the performance and moral of parties, and poor quality of work. This emphasizes the importance of tracking the causes of variation orders to mitigate their negative impacts on the construction projects. This will lead to better planning and management of resources, saving time and money, and enhancing the projects' performances.

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