Factors and Impacts of Variation Orders on Building Construction Project Performance in Malaysia

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doi.org/10.51505/ijaemr.2025.1309 URL: http://dx.doi.org/10.51505/ijaemr.2025.1309

Received: Aug 12, 2025 Accepted: Aug 20, 2025 Online Published: Aug 27, 2025

Abstract

Variation orders are a common challenge in construction projects, often leading to project delays and affecting overall project performance. This study identifies the key factors contributing to variation orders and analyses their impacts on the performance of building construction projects in the Southern States of Malaysia. Specifically, the research addresses factors driving variation orders, including economic conditions and site location discrepancies, as well as their impacts on time overruns, cost overruns, work quality, and professional relationships. A survey was conducted among Grade 7 contractors registered with the Construction Industry Development Board (CIDB) of Malaysia, and the data were analysed using descriptive statistics, multivariate regression, and Spearman's rho correlation analysis. Findings revealed that variation orders significantly impact project performance metrics, including time overruns (90.2%), cost overruns (96.7%), and work quality and professional relations (95.4%), while health and safety were minimally affected. Additionally, a strong correlation (0.958) was found between construction phases and overall project performance. These results underscore the importance of addressing variation order factors early in the planning phase to minimise negative impacts on project outcome.

Keywords: variation order, building construction, contractor, project performance

1. Introduction

1.1 Introduce the Problem

Variation Orders (VOs) are a pervasive challenge in the construction industry, defined by the Public Works Department as modifications to contract documents that require amendments to project design, quality, or quantity, thereby altering the contract sum. In Malaysia, VOs occur frequently across diverse projects, including residential, non-residential, infrastructure, and special trade works, often leading to time overruns, cost overruns, and in severe cases, project abandonment. In the first quarter of 2021, the construction sector in Selangor, Wilayah Persekutuan, and Sarawak alone accounted for RM18.1 billion (57.6%) of the country's activities (Department of Statistics Malaysia, 2022), underscoring the economic significance of the industry.

Despite ongoing efforts to improve project management practices, VOs remain inevitable due to factors such as scope changes, schedule adjustments, and procurement issues. These disruptions affect not only project delivery but also the relationships between clients, consultants, and contractors. The persistence of VOs highlights the urgent need for research focusing on their root causes and impacts, particularly during the construction phase where execution risks are highest.

1.2 Explore Importance of the Problem

The prevalence of VOs in Malaysia's construction projects has far-reaching implications. For practitioners, unresolved or poorly managed VOs can lead to substantial delays, inflated costs, and diminished project quality. For policymakers and industry regulators, the issue represents a barrier to achieving efficiency, cost control, and sustainable construction practices. Although numerous studies have examined VOs in the planning and design stages, fewer have addressed their occurrence and impact during the construction phase, especially in the Southern States of Malaysia. This gap is significant because decisions and adjustments made during construction can have immediate and compounding effects on project performance.

Understanding these impacts is critical for developing proactive management strategies, enhancing contractual clarity, and aligning stakeholder expectations. Moreover, with Malaysia's commitment to infrastructure growth, reducing the negative consequences of VOs will contribute to higher industry productivity, better resource utilisation, and improved stakeholder satisfaction.

1.3 Describe Relevant Scholarship

Previous studies have identified a range of VO causes and consequences. For example, Mohammad et al. (2017) reported that owner-driven scope changes, material substitutions, and consultant-led design revisions are dominant VO sources in Selangor. Memon et al. (2014) found that poor project plan implementation, complex designs, and decision-making delays contribute to both time and cost overruns in Southern Peninsular Malaysia. Similar trends have been documented in Sarawak (Kamaruddeen et al., 2020), where material specification changes and accelerated schedules were primary cost overrun factors.

While earlier research has predominantly emphasized time and cost impacts, emerging studies (Ullah et al., 2018; Amzafi et al., 2024) also point to diminished work quality, strained professional relationships, and, in certain contexts, compromised safety standards. However, these studies are often limited to specific regions or phases, leaving a need for a more comprehensive, construction-phase-focused analysis that captures both technical and relational dimensions of project performance.

Building on these previous works, the present research addresses identified gaps by focusing on the construction phase and expanding the range of performance indicators examined. Table 1 summarizes the scope, methodology, and focus differences between prior studies and the present research.

Table 1. Relevant researches

Research detail	Previous research	Present research
Research area	Malaysia state on Borneo (Sarawak) (Kamaruddeen, et al., 2020) Southern Peninsular of Malaysia (Johor) (Memon, et al., 2014) West Coast of Peninsular Malaysia (Selangor) (Mohammad, et al., 2017)	3 States in Southern Peninsular of Malaysia (Negeri Sembilan, Malacca and Johor)
Factor and impact of Variation Order	Determined in planning phase and construction design	Will be determined in constriction phase
Influence of Variation Order	Focus on 2 important factors: time overruns and cost overruns	Focus on 4 important factors: time overruns, cost overrun, reducing of project quality and professional relation, and reducing of health and safety
Target person	Clients, Consultants, Contractors.	Clients, Consultants, Contractors.
Research type	Survey	Survey
Software	SPSS	SPSS

1.4 State Hypotheses and Their Correspondence to Research Design

This study is guided by the hypothesis that Variation Orders during the construction phase significantly influence key performance indicators (KPIs) of building projects, including time overruns, cost overruns, work quality, professional relationships, and health and safety. The primary objective is to identify the main causative factors of VOs in the Southern States of

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ISSN: 2456-3676

Malaysia and to quantify their impacts on project performance. A secondary objective is to examine the correlation between construction phase activities and overall project outcomes in the presence of VOs.

To test these hypotheses, a survey was conducted among G7 contractors registered with the Construction Industry Development Board (CIDB) in Johor, Malacca, and Negeri Sembilan. Data were analysed using descriptive statistics, multivariate regression, and Spearman's rho correlation analysis. This design ensures that both causative and impact factors are systematically evaluated, enabling the development of targeted recommendations for VO management in the Malaysian construction context.

2. Method

This study investigates the factors and impacts of Variation Orders (VOs) on building construction project performance in the Southern States of Malaysia. The methodology is designed to ensure clarity, replicability, and validity in data collection and analysis.

2.1 Participant Characteristics

The participants in this study were G7 contractors registered with the Construction Industry Development Board (CIDB) of Malaysia. These contractors are eligible to undertake projects with a value exceeding RM10,000,000 and have extensive experience in large-scale construction, including road infrastructure, public buildings, and industrial projects. Key respondents included project managers, civil engineers, quality control engineers, and quantity surveyors who were directly involved in project execution and management.

Eligibility criteria included: Current registration as a G7 contractor with CIDB; Active involvement in construction projects within Johor, Malacca, or Negeri Sembilan during the study period.
Exclusion criteria included contractors not involved in active projects during the data collection period or those without relevant personnel to respond to the survey.

2.2 Sampling Procedures

A purposive sampling method was adopted to target only those contractors meeting the eligibility criteria. Based on CIDB records, the total population of contractors in the three states was 22,283, with 1,037 classified as G7 contractors. The sampling aimed to ensure that respondents represented the primary decision-makers and technical experts in the field.

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ISSN: 2456-3676

Table 2. Total population

Grade	Contract fee (RM)	Population			Total
		Johor	Malaka	Negeri Sembilan	
G1	≤100.000	5,835	2,067	3,492	11,394
G2	≤500.000	2,542	661	1,414	4,617
G3	≤1.000.000	2,088	529	554	3,171
G4	≤3.000.000	502	175	176	853
G5	≤5.000.000	573	198	212	983
G6	≤10.000.000	124	46	58	228
G7	>10.000.000	696	177	164	1,037
Total		12,360	3,853	6,070	22,283

Table 2 presents the detailed distribution of contractor grades and total population across Johor, Malacca, and Negeri Sembilan.

Data collection was conducted using structured questionnaires distributed via both online and direct delivery methods. The study obtained a total of 32 completed responses: Johor (10), Malacca (8), and Negeri Sembilan (14). No monetary or material incentives were provided to respondents.

The study adhered to ethical guidelines, with informed consent obtained from all participants and confidentiality assured for all responses.

2.2.1 Sample Size, Power, and Precision

The sample size of 32 respondents represents approximately 3% of the total G7 contractor population in the study area. Although the sample is relatively small, it was considered adequate for the statistical analyses employed, given the homogeneous nature of the target population and the focus on high-expertise respondents.

2.3.2 Measures and Covariates

The questionnaire consisted of two main sections:

Independent variables (Causative factors): These included economic condition changes, site location discrepancies, work acceleration, project scope changes, technology changes, material changes, procedural changes, mistakes during construction, conflicts at the site, weather conditions, contractor financial problems, schedule revisions, equipment unavailability, lack of worker skills, poor workmanship, demolition/reconstruction, and changes in material handling.

Dependent variables (Impact factors): These included time overruns, cost overruns, work quality, professional relationships, and health and safety.

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ISSN: 2456-3676

Respondents rated the significance of each factor using a five-point Likert scale, where 1 = very low significance and 5 = very high significance. The instrument's reliability was verified through Cronbach's alpha, ensuring internal consistency for all constructs.

2.3.3 Research Design

The study employed a quantitative, cross-sectional survey design. Data were collected at a single point in time to assess the perceived causes and impacts of VOs during the construction phase. This non-experimental design allowed for statistical analysis of correlations and regressions without manipulation of variables.

2.3.4 Experimental Manipulations or Interventions

No experimental manipulations or interventions were applied in this study. The research was observational in nature, relying on participants' self-reported data and documented project experiences.

3. Results

3.1 Recruitment

Data collection was conducted targeting G7 contractors registered with the Construction Industry Development Board (CIDB) in Johor, Malacca, and Negeri Sembilan. Questionnaires were distributed both online and in person to ensure accessibility. A total of 32 completed responses were received, comprising 10 from Johor, 8 from Malacca, and 14 from Negeri Sembilan. All participants met the eligibility criteria and were included in the analysis.
The distribution of respondents across the three states is illustrated in Figure 1.

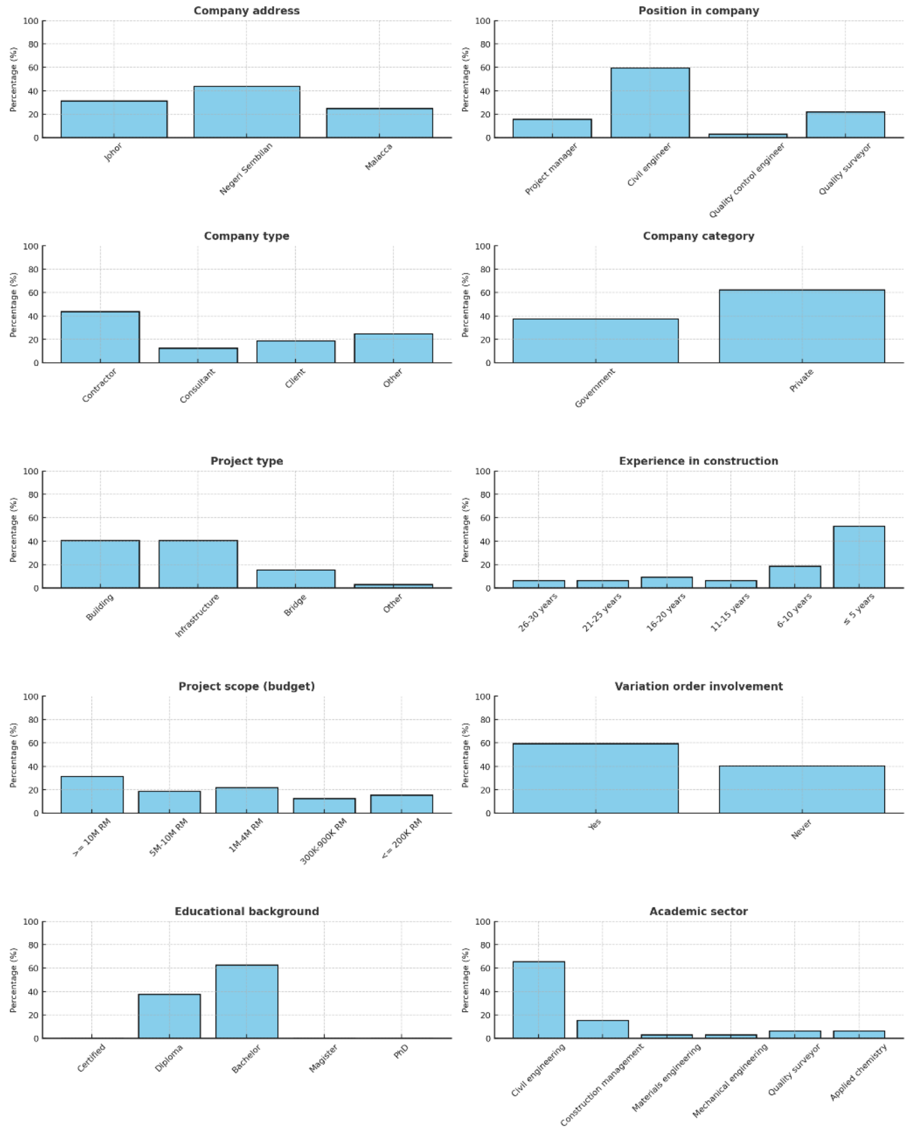

Figure 1. Distribution of respondents by state

Figure 1 illustrates the geographical distribution of survey participants across the three states involved in the study, with the largest proportion from Negeri Sembilan, followed by Johor and Malacca.

3.2 Statistics and Data Analysis

Descriptive statistics were used to rank the significance of each causative and impact factor of Variation Orders (VOs). Multivariate regression analysis tested the effect of causative factors (independent variables) on four dependent variables: time overruns (Y1), cost overruns (Y2), work quality/professional relations (Y3), and health and safety (Y4). Spearman's rho correlation was applied to measure the strength of association between VO factors and project performance. The most significant VO factors were economic condition changes (mean = 3.69) and differences in site location (mean = 3.56). Cost overruns (96.7%), time overruns (90.2%), and effects on work quality and professional relations (95.4%) were identified as the most substantial impacts, while health and safety was less affected (78.1%).

The results of the multivariate regression analysis are presented in Table 3, followed by the between-subjects effects in Table 4. These statistical outputs confirm the significance levels and effect sizes for each dependent variable.

Table 3. Summary of multivariate T-tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	5,048.896[b]	4.000	5.000	0.000
	Wilks' Lambda	0.000	5,048.896[b]	4.000	5.000	0.000
	Hotelling's Trace	4,039.117	5,048.896[b]	4.000	5.000	0.000
	Roy's Largest Root	4,039.117	5,048.896[b]	4.000	5.000	0.000
X	Pillai's Trace	3.350	1.794	92.000	32.000	0.032
	Wilks' Lambda	0.000	3.790	92.000	22.288	0.000
	Hotelling's Trace	207.108	7.879	92.000	14.000	0.000
	Roy's Largest Root	169.316	58.893[c]	23.000	8.000	0.000

a. Design: Intercept + X
b. Exact statistic
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Table 3 presents the results of the multivariate regression analysis, showing that all four statistical tests (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root) indicated significant relationships between VO factors and the dependent variables.

ISSN: 2456-3676

Table 4. Tests of between-subjects effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Y1	159.625[a]	23	6.940	3.219	0.046
	Y2	307.375[b]	23	13.364	10.182	0.001
	Y3	416.219[c]	23	18.096	7.149	0.004
	Y4	64.375[d]	23	2.799	1.659	0.234
Intercept	Y1	6,376.581	1	6,376.581	2,957.255	0.000
	Y2	9,203.325	1	9,203.325	7,012.057	0.000
	Y3	10,275.328	1	10,275.328	4,059.389	0.000
	Y4	1,128.145	1	1,128.145	668.530	0.000
X	Y1	159.625	23	6.940	3.219	0.046
	Y2	307.375	23	13.364	10.182	0.001
	Y3	416.219	23	18.096	7.149	0.004
	Y4	64.375	23	2.799	1.659	0.234
Error	Y1	17.250	8	2.156		
	Y2	10.500	8	1.313		
	Y3	20.250	8	2.531		
	Y4	13.500	8	1.688		
Total	Y1	7,680.000	32			
	Y2	11,196.000	32			
	Y3	12,879.000	32			
	Y4	1,456.000	32			
Corrected Total	Y1	176.875	31			
	Y2	317.875	31			
	Y3	436.469	31			
	Y4	77.875	31			

a. R Squared = 0.902 (Adjusted R Squared = 0.622)
b. R Squared = 0.967 (Adjusted R Squared = 0.872)
c. R Squared = 0.954 (Adjusted R Squared = 0.820)
d. R Squared = 0.827 (Adjusted R Squared = 0.328)

Table 4 details the between-subjects effects for each dependent variable. The results confirm that VO factors significantly affect time overruns ($p = 0.046$, $R^2 = 0.902$), cost overruns ($p = 0.001$, $R^2 = 0.967$), and work quality/professional relations ($p = 0.004$, $R^2 = 0.954$), but not health and safety ($p = 0.234$, $R^2 = 0.827$).

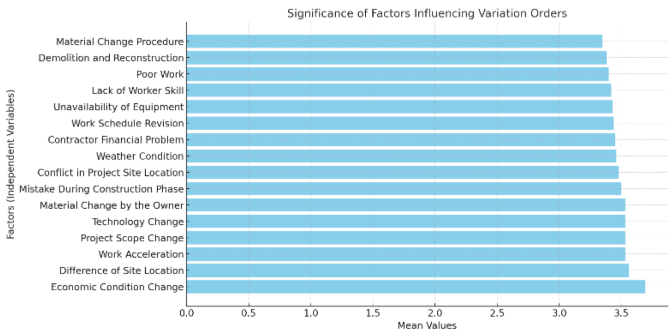

Figure 3. Mean value of factors influencing Variation Orders

Figure 3 illustrates the ranking of mean values for the factors influencing VOs, highlighting that economic condition changes and differences in site location were rated the highest by respondents, followed by work acceleration, project scope changes, and technology changes.

3.3 Ancillary Analyses

No subgroup or adjusted analyses were conducted beyond the primary regression and correlation tests.

3.4 Participant Flow

As this was a cross-sectional survey study, all participants completed the questionnaire, and no dropouts occurred.

3.5 Intervention or Manipulation Fidelity

Not applicable. This study did not involve interventions or experimental manipulations.

3.6 Baseline Data

Respondents included project managers, civil engineers, quality control engineers, and quantity surveyors, all actively engaged in managing large-scale building projects valued above RM10,000,000.

3.6.1 Statistics and Data Analysis

Regression analysis indicated significant effects of VO factors on time overruns ($p = 0.046$, $R^2 = 0.902$), cost overruns ($p = 0.001$, $R^2 = 0.967$), and work quality/professional relations ($p = 0.004$, $R^2 = 0.954$). No significant effect was found for health and safety ($p = 0.234$, $R^2 = 0.827$). Spearman's rho correlation produced a coefficient of 0.958 ($p < 0.001$), confirming a very strong positive association between VO factors and project performance.

3.6.2 Adverse Events

Not applicable. The study did not involve interventions that could produce adverse events.

4. Discussion

This study set out to test the hypothesis that Variation Orders (VOs) occurring during the construction phase significantly affect key project performance indicators, namely time overruns, cost overruns, work quality/professional relationships, and health and safety. The findings supported the primary hypotheses for time overruns, cost overruns, and work quality/professional relationships, as these were all significantly influenced by VO factors. The secondary hypothesis regarding health and safety was not supported, indicating that VO occurrence did not substantially alter safety performance in the surveyed projects.
The magnitude of these impacts is illustrated in Figure 4, which presents the mean values of the impacts of VOs on project performance. The figure shows that cost overruns, time overruns, and work quality/professional relations were perceived as the most critical consequences, while health and safety was less affected.

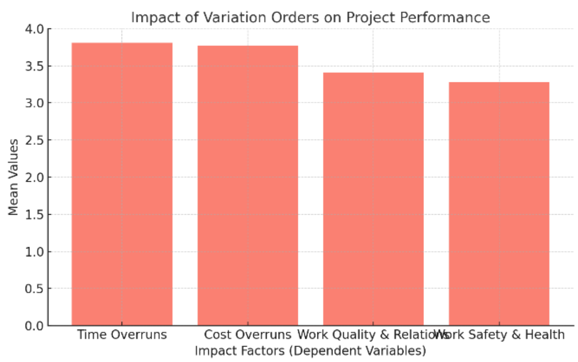

Figure 4. Mean Value of Impact of Variation Orders on Project Performance

These findings are consistent with previous research by Memon et al. (2014), Ullah et al. (2018), and Mohammad et al. (2017), which emphasised that scope changes, site-related challenges, and resource constraints are major contributors to delays and budget escalations. However, the relatively low perceived impact on health and safety differs from studies such as Shamsuddin et al. (2015), where VOs were found to indirectly increase accident risks due to compressed schedules and rework. This discrepancy may be due to stricter safety regulations and enforcement in the Malaysian construction industry in recent years, as well as more mature safety management systems implemented by G7 contractors.

From a practical perspective, the results highlight that early identification of VO factors, particularly economic condition changes and site location differences, is essential for preventing major disruptions. Proactive cost estimation, rigorous site investigations prior to contract award, and comprehensive stakeholder consultations can significantly reduce VO frequency. In addition, contractual mechanisms such as clearly defined change-order procedures and contingency allowances can mitigate financial impacts when VOs do occur.

From a theoretical standpoint, the study reinforces the applicability of change management theories in construction, demonstrating that unmanaged changes disrupt not only project timelines and budgets but also the professional relationships necessary for collaborative delivery. The high R^2 values (0.902-0.967) suggest that a relatively small set of VO factors can explain most of the variation in performance outcomes, supporting the notion that targeted risk management is both effective and efficient.

Despite its contributions, this research has limitations. The reliance on self-reported survey data may introduce bias, as responses could be influenced by personal perceptions or organizational culture. The sample size, while comprising experienced G7 contractors, is relatively small ($n = 32$) and geographically confined to the Southern States of Malaysia, limiting the generalizability of results. Moreover, the cross-sectional design prevents causal inference; longitudinal studies could provide a better understanding of how VOs evolve over the project lifecycle and their long-term effects on performance metrics.

Future research could extend this work in several directions. Expanding the study to include projects in other regions and countries would allow for cross-cultural comparisons and the identification of universal versus context-specific VO factors. In-depth qualitative studies involving interviews with project stakeholders could provide richer insights into decision-making processes behind VOs. Additionally, exploring the role of digital technologies such as Building Information Modelling (BIM) and project management software in reducing VO frequency and severity would address an important gap in the literature.

The findings of this study underscore the critical need for systematic VO management in construction projects. By focusing on the most influential factors, economic conditions and site location differences, project stakeholders can develop targeted strategies to safeguard project timelines, control costs, and maintain professional relationships. These strategies, coupled with robust planning and effective communication, have the potential to improve overall project performance and contribute to the broader goal of sustainable construction practices.

Acknowledgments

This research was conducted through a collaborative effort between Universitas Muhammadiyah Aceh and Universiti Malaysia Perlis. The authors extend their appreciation to the participating G7 contractors in Johor, Malacca, and Negeri Sembilan for their valuable contributions during data collection. Special thanks are also conveyed to colleagues who provided constructive feedback on the study design and manuscript preparation.

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