Management and Production Engineering Review
Volume 15 • Number 4 • December 2024 • pp. 1–12
DOI: 10.24425/mper.2024.153114

Impact of Change Orders on Decreasing Labor Productivity in Road Construction Projects (Approach using Structural Equation Modeling)

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Received: 20 March 2024
Accepted: 27 September 2024

Abstract
Change order is the main factor of labor productivity decline in small scale electrical projects in the United States due to presence variables. Preliminary research on labor productivity in Malaysian infrastructure projects with six latent variables using SEM has been conducted on small projects, such as electricity and infrastructure. Therefore, this research aimed to determine the impact of change orders on large and small scale projects of labor productivity in Indonesia. Data were collected through interviews and questionnaires distribution with a return rate of 700 respondents. The collected data were processed using factor analysis and SEM. The result showed that the impact of change orders on the decline in labor productivity in Indonesia led to four latent variables with 15 indicators.

Keywords
impact of change orders; the decline in labor productivity; road construction projects; factor analysis; SEM.

Introduction

A change order is a written agreement to modify, improve, or alter the work from that outlined in the contract documents at the time of opening bids, provided such alteration tend to be within the scope of the original project. However, a contract modification was required (Fisk & Reynolds, 2014), as the main factor that reduces labor productivity (Jones, 2001; Lee et al., 2004; Yi & Chan, 2014; Hanna & Iskandar, 2017).

The impact of change orders on small projects is an important variable that significantly disrupts labor productivity (Hanna & Gunduz, 2004). In construction projects, these are issued by the owner, thereby disrupting the work of the contractor, resulting in loss of labor productivity, delays, cost overruns, and claims (Al-Kofahi et al., 2022a). Labor productivity significantly impacts construction services because these are labor-intensive. Yi and Chan, (2014), referred to it as a fundamental metric because of the numerous workers required to execute a particular job.

Labor rate refers to the main cost-related variable in any construction project, determining most expenses. As a result, labor productivity is an important factor in determining the profitability of a project by contractors (Al-Kofahi et al., 2022b).

The earlier mentioned problems are common in the Middle East, extending to other countries where several public projects experience change orders. These are usually requested during design and construction, thereby causing delays, cost overruns, and decreased labor productivity (Hanna & Iskandar, 2017).

Kermanshachi et al., (2018), focused on the impact of change orders on labor productivity levels in a large-scale water treatment construction project. Additionally, the results of the simulation caused significant labor dissatisfaction and delayed schedule.

Prior research showed that change orders had a negative impact on labor productivity (Moselhi et al., 2005; Hanna et al., 1999). The impact varies based on several reasons, intensity (amount/frequency), timing relative to project duration, type of work, and on-site management (Moselhi et al., 2005). Another incidental impact is the decrease in labor productivity. A recent research conducted by Hanna et al., (1999), stated that large and consistent change orders significantly reduced labor productivity. Meanwhile, because construction is a sequential process, change orders affects the remaining work even if it does not directly alter the job. According to Hanna et al., (1999), the number of changes, type, and time are significant predictors of

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labor efficiency. Moselhi et al., (2005), further stated that the time, intensity, type of change orders, and the impact of change orders are significant predictors of labor productivity. A significant difference was observed between actual and required performances.

Low labor productivity was identified as a major challenge for the construction industry. This was followed by change order, as reported by a research conducted in Cambodia. (Durdyev & Mbachu, 2018).

The research by Waty and Sulistio, (2022), stated that the impact of change orders on road construction projects led to a reduction in labor productivity, and quality, as well as caused disputes. The decline in labor productivity has led to further research in several provinces, such as DKI Jakarta, West Java, and Banten.

The impact of setting changes on labor productivity was measured in line with system dynamics, which uses contractor data. Furthermore, sensitivity analysis evaluates the impact of overtime, excess labor, temperature, and behavior of system dynamics model on labor productivity when simulated (Al-Kofahi et al, 2022a).

Alzraiee, (2022), proposed a new method of calculating the loss of labor productivity caused by the impact of changes to the basic scope of the project. It was further reported that measuring the impact of changes was a difficult problem, often causing conflict between employers and contractors.

An automated clustering process, the Hierarchical Latent Dirichlet Allocation (HLDA) method, was developed to analyze and categorize the CLP research corpus (Qi et al, 2024). The method included the comprehensive extraction of 591 scientific articles from a related database. The modeling targets of HLDA were discussed in articles published within 1973 to 2023. The most relevant results were found in 291 articles discussing labor productivity in relation to the following factors, influence, management, survey, research, identification, construction process, and location (Qi et al., 2024).

The initial research gap was explored by Hanna and Gunduz, (2004) who used a specific variable, namely attendance, to measure labor productivity loss in the field of electrical projects in the United States. Similarly, the research by Durdyev et al, (2018), measured labor productivity in Malaysian infrastructure projects using six variables namely management and control, financial, external, and labor. Referring to the two gaps, this research aimed to determine the relationship between the impact of change orders on large and small scale road constructions. This research was conducted in three major provinces namely DKI Jakarta, West Java and Banten. The novelty is the impact of change orders on labor productivity in road construction projects using Structural Equation Modeling (SEM) PLS 4.0.

The introduction section focused on the research background, gaps, objectives and novelty. The literature review section described the connecting labor productivity. Furthermore, the methodology section analyzed the method adopted, including the draft questionnaire distributed and the preparatory stages. The results and discussion section proved the findings were obtained using factor analysis, followed by data processing with SEM PLS 4.0. The final section focused on the conclusion drawn from the research results and recommendations or suggestions made.

Literature review

Several preliminary research (Bröchner & Badenfelt, 2011; Page, 2010, and Hanna et al, 2008), explored the productivity of resources. Fig. 1, formulated from the main features of this definition, was adapted from the research by (Durdyev and Mbachu, (2011).

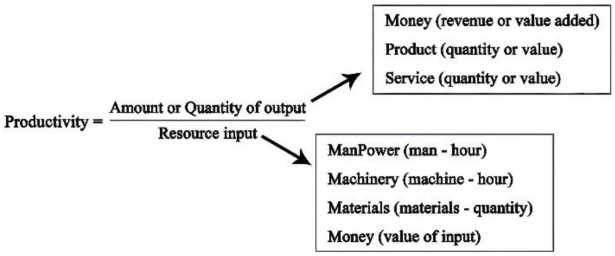

Fig. 1. Productivity (adopted from (Durdyev & Mbachu, 2011)

Over the years, extensive analyses (Kazaz et al, 2008; Dai et al, 2009; Rivas et al, 2011; Durdyev & Ismail, 2013; Durdyev & Mbachu, 2018) had been dedicated to the exploration of factors that limit labor productivity in construction. Much of this research identified the country-specific limiting factors influenced by sociocultural, legislative, and regulatory environments where construction operations had been conducted. The findings from literature were compiled to obtain current state of the art results. Examiners had identified various labor productivity constraints and research methods, including the impact of change orders (Ibbs et al., 2007), and factor engineering productivity (Dai et al., 2009). Durdyev et al., (2018), and Olomolaiye et al., (1987), ranked three major problems affecting construction productivity in Nigeria namely rework, inadequate equipment, and material shortages. Additionally, Ghoddousi and Hosseini, (2012) focused on subcontractors in Iranian construction projects, classifying factors that significantly impacted productivity into seven main categories. This included materi-

als/equipment, methods, and technologies used in construction, planning, rework, determining weather, and site conditions, as well as monitoring systems. Hanna et al, (2005), expanded on the research by examining the negative impacts of extra work on construction productivity, as well as describing spare time as working more than 40 hours per week. Meanwhile, a similar research on construction professionals, (Jarkas & Bitar, 2012) identified factors influencing labor productivity in Kuwait, classifying it into management, technology, human/labor, and external categories.

Durdyev et al., (2013), classified factors delaying the labor productivity of Turkish contractors in Turkmenistan based on the views of construction professionals. The research stated that the most significant factors influencing labor productivity were lack of experienced local labor, government-induced schedule pressure, extra work, and financial constraints. These also included contractor weaknesses, rework, inadequate government financial policies, and continuous work without holidays.

Durdyev et al., (2018), analyzed the relationship between various factors and productivity performance in Malaysian infrastructure projects. The research reported that management and control had the most significant impact on labor productivity (0.92), followed by labor (0.84) and external factors (0.79). Furthermore, labor played an important role in the construction sector (Hanna & Gunduz, 2004), and poor productivity resulted in delays (Jang et al., 2011).

SEM (Structural Equation Modeling)

SEM is a multivariate approach developed by psychologists and sociologists to conduct quantitative calculations interconnected between dependent and interdependent variables (Rovine & Molenaar, 2000). The research by (Durdyev et al, (2018), identified and measured factors affecting labor productivity using SEM. In addition, the factors included management and control, as well as external, and project.

Methodology

The impact of change orders on labor productivity was determined in three major regions, namely West Java, DKI Jakarta, and Banten using questionnaires. Specifically, the questionnaire with five scales from insignificant to very serious impact was applied. This research was conducted from July 2022 to October 2023.

The initial Draft Questionnaire

The initial draft of the questionnaire was inspired by a combination of prior research (Hanna & Gunduz, 2004). These included the findings (Durdyev & Mbachu, 2011; Jang et al., 2011; Ghoddousi & Hosseini, 2012; Durdyev & Ismail, 2016), and methods adopted from the design formulated by Durdyev et al., (2018).

During the entire development of the questionnaire, certain similarities were identified (Hanna & Gunduz, 2004; Durdyev et al., 2018). Consequently, the questionnaire was simplified into a draft as shown in Table 1. Before distribution, interviews were conducted with practitioners and academics who participated in

Table 1
Draft questionnaire (compiled by the Authors)

Num	Describe	Source
X1	Presence	(Hanna & Gunduz, 2004)
X1.1	Actual working hours	
X1.2	Design priorities for project work	
X2	External	(Durdyev et al., 2018)
X2.1	Bad weather	
X2.2	Delay in local authority approval	
X2.3	Termination of work order	
X2.4	Accidents in the field/natural disasters	
X3	Workforce	(Durdyev et al., 2018)
X3.1	The skill level and experience of the workforce	
X3.2	Level of motivation/commitment of the workforce	
X3.3	Level of familiarity with the work and current conditions	
X3.4	Workforce absenteeism	
X3.5	Level of empowerment (training and resources)	
X4	Management and Controlling	(Durdyev et al., 2018)
X4.1	Supervision, monitoring, and control of performance	
X4.2	Project manager competencies	
X4.3	Loss of Productivity due to change orders	
X4.5	Project management risks	

Table 1 continued

X4.7	Unrealistic time limits for project completion	
X4.8	The influence of the owner on the construction process	
X4.9	Delays in the supply of building materials	
X5	Project	(Durdyev et al., 2018)
X5.1	Site conditions, access, soil layers, topography and traffic	
X5.2	Field conditions require revision	
X5.3	Project Complexity, scale, and design	
X5.4	Poor construction skills	
X6	Materials and Equipment	(Durdyev et al., 2018)
X6.1	Lack of heavy tools and equipment	
X6.2	Disadvantages of the plant and heavy equipment used	
X6.3	Adequacy of the technology used	
X6.4	Lack of materials at the project site	
X7	Financial	(Durdyev et al., 2018)
X7.1	Insufficient supply or expensive resources, work, materials, machines	
X7.2	Rework due to location errors in the field	
X7.3	Late payment	

road projects. After formulating the survey, further interviews with experts were conducted, accompanied by a pilot project, and the finalized form was distributed to respondents. The impact of change orders based on findings (Waty & Sulistio, 2022) are shown in Table 2.

Table 2
Impact of Change Orders. Source: (Waty & Sulistio, 2022)

Num	Describe
Y1	Disputes in project
Y2	Increase in project duration
Y3	Reduce quality of work

Variable X consisting of X1 to X7 was a latent variable. Furthermore, the impact of change orders was also expressed using Y. In total, 31 indicators were obtained in seven variables X and the impact of change orders (Y) consisted of three indicators.

The return of the respondent

The questionnaire was distributed to 350 respondents, including consultants, contractors, private and government owned projects, resulting in an impressive 700 responses. Latent variables X and Y were analyzed using SEM through Smart PLS 4.0 for model validity testing. In addition, this was followed by factor analysis using SPSS.

Result and Discussion

Factor analysis

The KMO and Barlett test (Kaiser–Meyer–Olkin and Bartlett tests) produced a result of 0.8, showing the viability of the research, with a significance of 0.00 confirming the correctness. Furthermore, all indicators were considered usable based on the anti-image results, while the eigenvalue calculation produced 31 grouped signs categorized into nine influencing factors, approximately 76.604% as shown in Table 3 regarding the total variance.

Table 3
Impact of Change Orders . Source: (Waty & Sulistio, 2022

	Initial Eigenvalues			Extraction Sums of Square Loadings		
Component	*Total*	*% Variance*	*Cumulative %*	*Total*	*% Variance*	*Cumulative %*
1	10.76	34.71	34.71	10.76	34.71	34.71
2	2.73	8.83	43.55	2.73	8.83	43.55
3	2.53	8.16	51.71	2.53	8.16	51.71
4	1.77	5.73	57.44	1.77	5.73	57.44
5	1.40	4.54	61.98	1.40	4.54	61.98
6	1.28	4.13	66.12	1.28	4.14	66.12
7	1.13	3.65	69.77	1.13	3.65	69.77
8	1.11	3.58	73.35	1.11	3.58	73.35
9	1.00	3.24	76.60	1.00	3.24	76.60

The initial grouping of seven factors was changed to nine. Based on the component transformation matrix, it was observed that the three factors showed lesser correlation values exceeding 0.5. Therefore, the following values x3, x7, and x8 which exceeded 0.68, were used. The grouping included x1, x2, x4, x5, x6, as x9 comprising a sole indicator that needed deletion. However, the final grouping consisted of five variable factors,

namely x1, x2, x4, x5, x6, with corresponding indicators shown in Table 4. The factor groups included Management and control (X1), Material, owner, and buildability (x2), Workforce (x4), External (x5), and Project (x6).

Calculations using SEM with the Smart PLS 4.0 tool. The analysis produced five factor groups with 23 indicators, resulting in the formulation of the following hypotheses:

1. Management and control (X1) had a significant impact on the impact of change orders on road construction projects.
2. Material, owner, and buildability (X2) had a significant impact on the impact of change orders.
3. External (x4) had a significant impact on the impact of change orders.
4. Workforce (X5) had a significant impact on the impact of change orders.
5. The project (X6) had a significant impact on the impact of change orders.

The impact of change orders included:

1. Disputes in project (Y1)
2. Increase in project duration (Y2)
3. Reduce the quality of work (Y3)

Calculations with PLS Algorithm

The initial model for this research is shown in Fig. 2. Additionally, when the calculations in stage 1 were completed, it became evident that certain indicators did not meet the criteria. The outer loadings of the signs were less than 0.6 (Singh et al., 2022), depicting the indicators must be removed. After rerunning the test, an outer loading that fulfilled all the criteria was

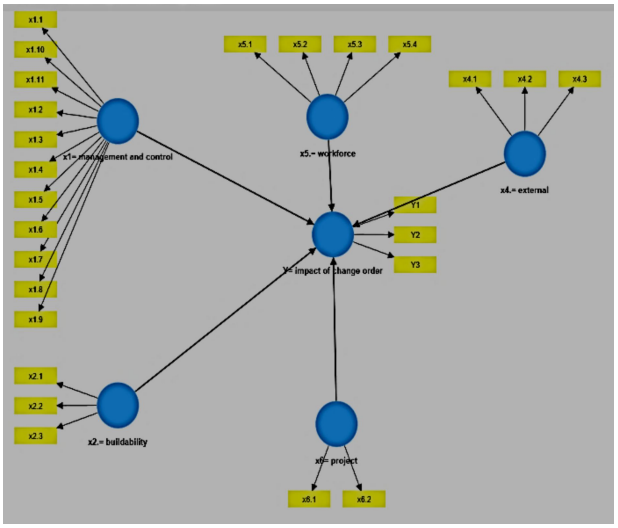

Fig. 2. Initial research model. Source: Authors created

Table 4
Impact of Change Orders. Source: (Waty & Sulistio, 2022)

Num	Causes	Grouping Factor
X1.1	Missing planning and risk management processes	X1
X1.2	Project management risks	X1
X1.3	Lack of coordination between construction parties	X1
X1.4	Unrealistic time limits for project completion	X1
X1.5	Delay in supply of building materials	X1
X1.6	Site conditions, access, soil layers, topography, and traffic	X1
X1.7	Lack of heavy tools and equipment	X1
X1.8	Disadvantages of the plant and heavy equipment used	X1
X1.9	Insufficient supply or expensive resources, work, materials, machines	X1
X1.10	Rework due to location errors in the field	X1
X1.11	Late Payment	X1
X2.1	Lack of materials at the project site	X2
X2.2	The influence of the owner on the construction process	X2
X2.3	Poor construction Skills	X2
X4.1	Level of familiarity with the work and current conditions	X4
X4.2	Level of empowerment (training and resources)	X4
X4.3	Supervision, monitoring and performance control	X4
X5.1	Termination of work order	X5
X5.2	Work accidents/natural disasters	X5
X5.3	The skill level and experience of the workforce	X5
X5.4	Level of motivation /commitment of the workforce	X5
X6.1	Loss of productivity due to change orders	X6
X6.2	Project complexity, scale, and design	X6

obtained. On examining the results of multicollinearity, the indicator exceeded the threshold of five, which required the removal. Furthermore, through the calculation of the PLS algorithm, the outer and inner models were generated as follows:

Outer model

The outer model was calculated as follows:

1. Outer loading
   The results of the outer loading meet the requirements because it exceeded 0.6.
2. Construct Reliability
   In accordance with the construct reliability, Cronbach alpha must exceed 0.6 (Ghozali & Latan, 2015) and this was supported by the calculated results.

Inner model

The results of the inner model were determined by

1. R square
   The results of the adjusted R square showed that the coefficient of determination was 0.749. This implied that change orders had a 74.9% influence on material waste. R square met the requirements because it exceeded 0.67, implying a strong relationship (Chin, 1998; Sarstedt et al., 2022).The endogenous change orders were used to describe the exogenous variables X1, X2, and X4.
   Adjusted R Square value in respect to the joint influence of X1, X2, X4, X5, and X6 on Y was 0.749. The independent variables X1, X2, X4, X5 and X6 simultaneously influenced Y by 74.9%, depicting a strong relationship between X1, X2, X4, X5, X6 in correlation with the impact of change orders.

Feasibility of the mode

The variable was expressed by a model fit with an NFI value of 0.514. The results of the model fit showed that the NFI was 0.514, signifying that a model closer to 1 was considered better.

The observed SRMR value of 0.115 exceeded the 0.1 threshold. This result implied that the model was not feasible, although approximately 0.115.

Multicollinearity test

The results of the multicollinearity test showed that all indicators were less than 5. In addition, the finding confirmed the absence of multicollinearity.

Bootstrapping Results

During calculations, the correlation or regression relationship of each latent variable was examined, including the path coefficient, as shown in Fig. 3.

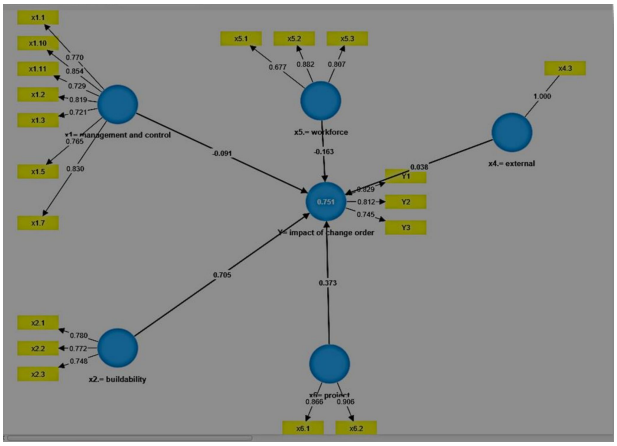

Fig. 3. Final model. Source: Authors Developed

Path coefficient

The results of the relationship are shown in Table 5. A review of the path coefficient showed that all four hypothesis test results associated with 1) Management and control, 2) buildability, 3) workforce, and 4) project were connected to the impact of change orders, because the p-value was < 0.05. A specific result was rejected because it lacked correlation, namely External.

Table 5
Path coefficient Source: Authors created

	Sample (O)	Mean (M)	ST DEV	O/ STDEV	P-Values
X1 = management and control →Y = impact of change order	-0.091	-0.09	0.035	2.597	0.009
X2 = buildability – > Y = impact of change order	0.705	0.707	0.039	17.881	0.000
X4 = external → Y = impact of change order	0.038	0.038	0.022	1.700	0.089
X5 = workforce → Y = impact of change order	-0.163	-0.16	0.023	7.019	0.000
X6 = Project → Y = impact of change order	0.373	0.370	0.029	12.82	0.000

The results of the path coefficient showed that the regression relationship occurred in:

1. Management and control –0.091
2. Buildability 0.705
3. Workforce –0.163
4. Project 0.373

Among the four results which had a relationship, a distinct variable with outstandingly strong correlation buildability was characterized by a coefficient and surpassing threshold of 0.705, and 0.6, respectively. The measurement of path coefficients between constructs was essential for assessing the significance and strength of the relationship. This also included testing of hypotheses with the path coefficient ranging from –1 to +1. A path coefficient closer to +1 and –1 showed stronger and weaker relationships, respectively (Sarstedt et al., 2021). A strong relationship was identified in X2 (buildability), X1 (management and control), X5 (workforce), and X6 (Project) with a coefficient of 0.705, –0.091, –0.163, and 0.373, respectively.

The following results were obtained based on the inferences drawn from the five X variables:

1. Led to four variables that had a direct and significant relationship
2. Led to one variable that had an indirect and insignificant impact
3. Led to four variables that had a significant relationship with the decline in labor productivity and impact of change orders
   (a) 3 x variables had a moderate impact because these were less than 0.6.
   (b) 1 variable x had a very strong influence of 0.703 on buildability.

Based on the results obtained, four variables were determined. 4 X variables that had an influence when viewed from the path coefficient, including:

1. Variable X1 management and control (0.091), weak
2. Variable X2 Buildability (0.705), strong
3. Variable X5 Workforce (–0.163), weak
4. Variable X6 Project (0.373), Moderate

Blindfolding

The results of the model prediction accuracy was determined using the blindfolding test where the three impacts produced a validity exceeding 0.05. These included:

1. Disputes in project (Y1)
2. Increase in project duration (Y2)
3. Reduce the quality of work (Y3)

The results showed that the three impacts were significant due to change orders in respect to model prediction accuracy values of Y1, Y2, and Y3 = 0.398, 0.408, and 0.564, respectively. The model prediction accuracy of 0.746, was obtained due to the impact of change orders on reducing labor productivity in the form of disputes in projects. The prediction accuracy was 0.398, for an increase in project duration and reducing the quality of work, the values obtained were 0.408 and 0.564, respectively. The results affirmed the accuracy of the model in predicting the impact of three types of change orders, showing a strong relationship as all values surpassed 0.35 (Ali et al., 2022).The calculated results showed that the accuracy of the model in predicting the impact of resulting change orders was 74.6%.

Feasible indicators from five hypothesis test results were:

1. Management and control seven indicators,
2. Buildability three indicators
3. Workforce three indicators
4. Project two indicators

A total of 15 indicators were generated that met the specified requirements.

Hypothesis test results included:

1. Change orders had a significant impact on management and control,
2. It had a significant impact on buildability,
3. Change orders had a significant impact on the workforce,
4. The variable had a significant impact on project
5. Change orders had an insignificant impact on External

From the results of the five hypothesis tests, four hypotheses had a significant relationship with the impact of change orders. This was determined by the t-statistical results from largest to smallest as shown in Table 6.

The analyses of indicators for the impact of change orders on reducing labor productivity included:

1. Lack of materials at the project site
   Material shortages at the project site affected labor productivity performance (Durdyev et al., 2018; Tariq & Shujaa Safdar, 2022; and Hamza et a., 2022), influencing change orders.
2. Influence of the owner on the construction process.
   Considering the management and control variable, the influence of the owner on the construction process was the lowest indicator, particularly affecting the decline in labor productivity due to change orders. This also led to the poor scope definition (Khalafallah & Shalaby, 2019), management project (Tariq & Shujaa Safdar, 2022) and delay (Vacanas & Danezis, 2021).
3. Poor construction skills
   Poor construction capabilities was the largest contributing factor in the project variable, influencing the decline in labor productivity due to change orders in Malaysia (Durdyev et al., 2018)

Table 6
Path coefficient Source: Authors created

Num	Causes	Grouping Factor
X2.1	Lack of materials at the project site	X2
X2.2	The influence of the owner on the construction process	X2
X2.3	Poor construction skills	X2
X6.2	Project complexity, scale, and design	X6
X6.1	Loss of productivity due to change orders	X6
X5.2	Work accidents/natural disasters	X5
X5.3	The skill level and experience of the workforce	X5
X5.1	Termination of work order	X5
X1.10	Rework due to location errors in the field	X1
X1.7	Lack of heavy tools and equipment	X1
X1.2	Project management risks	X1
X1.5	Delay in supply of building materials	X1
X1.1	Adequacy of planning and risk management processes	X1
X1.3	Lack of coordination between construction parties	X1
X1.11	Late Payment	X1

4. Project complexity (scale and design)
   Project complexity, particularly scale and design, was the highest indicator of this variable. It represented a significant impact of change orders on road construction projects. In addition, scale and design played a crucial role in project implementation. Related issues, such as design alterations, tend to trigger change orders (Assaad, et al., 2022; Abdul Nabi & El-adaway, 2021).
5. Loss of productivity due to change orders
   Loss of productivity due to change orders ranked second, following project management risk, in terms of influencing labor productivity (Al-Kofahi et al., 2022a) in the management and control variables. Based on a research conducted in Cambodia, change orders was ranked second among the obstacles affecting labor productivity (Durdyev & Mbachu, 2018), leading to the need for serious attention and handling were necessary.
6. Work accidents/natural disasters
   Frequent occurrences, such as work accidents in the field or natural disasters, impact the decline in labor productivity due to change orders. Additionally, this had a significant influence on the total decline in labor productivity in Malaysia (Durdyev et al., 2018). Natural disasters, including adverse weather conditions, could lead to scheduled delays and work changes, demanding consideration during project planning and cost estimation stages.
7. Skill level and experience of the workforce
   The ability and experience of the workforce played a significant role in the decline of productivity caused by change orders (Alshihri & Al-gahtani, 2022). In Indonesia, the skill level and experience of the workforce were recognized as crucial challenges affecting on-site construction productivity. A similar situation was observed in Malaysia (Durdyev & Ismail, 2016). These findings were supported by the research by Horner et al. (1989), and Durdyev & Ismail, (2016), which identified skill level and experience as the main factors influencing construction productivity in the United Kingdom.
8. Termination of work order
   Change orders leading to work order termination impacted labor productivity, a trend also observed in Malaysia (Durdyev et al., 2018).
9. Rework due to location errors in the field
   Rework resulting from location errors in the field led to increased expenses and altered cash flow. In accordance with preliminary research, it was associated with location errors during construction (Durdyev & Ismail, 2016). Moreover, Rivas et al., (2011), and Durdyev & Ismail, (2016), stated that rework was mainly caused by client-initiated change orders and design errors. In Pakistan, rework due to errors is perceived as a major cost overrun (Kamal et al., 2022).
10. Lack of heavy tools and equipment
    Based on research conducted in Malaysia, the shortage of heavy plants and equipment impacted the decline in labor productivity (Durdyev et al., 2018).
11. Project management risks
    Project management risks were carefully considered, as every project was inherently associated with risks that affected workforce productivity performance (Durdyev et al., 2018). These contributed the most to the management and control of latent variables, affecting labor productivity due to change orders in road construction projects.
12. Delay in supply of building materials
    Delays in the supply of building materials was ranked the third-largest contributor to management and control variables, impacting labor productivity due to change orders in road construction projects. These delays were recognized as a factor causing the decline in labor productivity in Malaysia (Durdyev et al., 2018).

13. Adequacy of planning and risk management processes
    The planning process and risk management played a crucial role in project implementation, and throughout the execution process. The effectiveness of both influenced labor productivity performance (Durdyev et al., 2018).
14. Lack of coordination between construction parties
    Lack of coordination between construction parties led to design alteration, change orders and reduced labor productivity, both in the field and office.
15. Late payment
    Late payment of contractors led to challenges, difficulties, and potential delays in paying salaries to workers and laborers, thereby leading to decreased labor productivity. Prior research stated that this also contributed to project delays in Egypt (Muhwezi et al., 2014; Vacanas & Danezis, 2021).

Conclusions

In conclusion, the conducted factor analysis using SmartPLS 4.0 application program showed that:

1. Five variables, and 23 indicators suitable for use were produced.
2. The results of the hypothesis tests showed the significant impact of change orders on labor productivity in road construction projects. These also had great impact on:
   (a) Variable X1 management and control of –0.091
   (b) Variable X2 Buildability of 0.705
   (c) Variable X4 Workforce of –0.163
   (d) Variable X 5 Project of 0.373
3. The influence of change orders on labor productivity was quantified at 74.9%, comprising 70.5%, 37.3%, 9.1%, and –16.3% impact on buildability, projects, management and control, and workforce respectively. This translated to a model prediction accuracy of 74.6%, effectively capturing the consequences of change orders, such as disputes, increased, and reduced project duration and quality.
4. The results of the 15 indicators that influenced the impact of change orders included:
   (a) Lack of materials at the project site
   (b) Influence of the owner on the construction process
   (c) Poor construction skills
   (d) Project complexity, scale and design
   (e) Loss of productivity due to change orders
   (f) Work accidents or natural disasters
   (g) Skill level and experience of the workforce
   (h) Termination of work order,
   (i) Rework due to location errors in the field
   (j) Lack of heavy tools and equipment
   (k) Project management risks
   (l) Delay in supply of building materials
   (m) Adequacy of planning and risk management processes
   (n) Lack of coordination between construction parties
   (o) Late payment

Limitations of the research

The research provided relevant information, but the reliance on self-reported data considered as a limitation led to bias. Future research should improve generalizability by using more objective data sources or broader sectoral analyses.

Research Implications

The construction project governance system in Indonesia is still simple, characterized by planning in advance before carrying out the specified work. For example, planning in the previous year, and executing the construction work in the subsequent one.

The outcome of construction alterations refers to change orders. The phenomenon occurs when the construction contract changes, resulting in decreased labor productivity. This also included changes in working hours, payroll structure, and overtime.

Some aspects of change management such as change orders are undeniabler despite being regulated during construction process in Indonesia. This can occur either at the initiative of the owner, contractor or consultant.

The results contributed to labor productivity reduction as it relates to industrial sustainability, resilience, innovation and reliable infrastructure. However, future research should focus on identifying specific developments to reduce labor productivity by exploring buildability, management and control, projects and finance in a broader scope.

Recommendation

Based on these findings, recommendations could be made to prioritize management and control, buildability, workforce, and project variables to alleviate the impact of change orders on declining workforce productivity.

Acknowledgments

The authors are grateful to the Tarumanagara University Research and Community Service Institute for funding this research to completion.

Conflict of Interest

The authors declared no conflicting interests.

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