Jurnal Komposit: Jurnal Ilmu-ilmu Teknik Sipil
Vol. 9 No. 2 (2025) pp. 311 - 326
DOI: http://dx.doi.org/10.32832/komposit.v9i2.20134

ISSN: 2615-3513
e-ISSN: 2655-934X

Analysis of the Effect of Evaluation and Innovation in the Development of Construction Safety Culture on the Safety Leadership Model using SEM Approach

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ABSTRACT

In the construction sector, the Construction Safety Management System (SMKK) has been determined by the Regulation of the Minister of Public Works No. 10 of 2021 as a reference for addressing the risk of industrial accidents and improving building safety. Full implementation of occupational safety (K3) can minimize the risk of work accidents. However, in reality, there are still many obstacles for companies and employees, and many accidents in the workplace are caused by unsafe behavior factors by the workers themselves. The methodology used in this study involves various approaches, such as literature review and primary data acquisition through questionnaires targeting respondents in construction project environments. The collected data will be analyzed using the Structural Equation Modeling method to identify important variables. Data processing was performed using the Smart-PLS version 4.1.0.1 application to determine the outer and inner models. Hypothesis testing was conducted using bootstrapping, considering the Original Sample values, T-statistics, and P-values. Based on the results, it is concluded that safety leadership has a significant indirect influence on improving safety performance. The strengthening of leadership aspects has the largest impact on improving safety culture, which then influences the improvement of construction safety performance, with an original sample (O) value of 0.273, a sample mean (M) of 0.277, a standard deviation (STDEV) of 0.177, a T-statistic value of 2.324, and a P-value of 0.001. Furthermore, effective safety evaluation (e.g., constructive and systematic evaluation) can help build a stronger safety culture, which in turn will improve overall safety performance. The implementation of innovation in construction processes or safety technology can also encourage better safety behavior among workers, which then contributes to improved safety performance.

Key words: *construction project leadership, innovation, evaluation, safety performance, leadership model, Structural equation modelling (SEM)*

Submitted:	Reviewed:	Revised:	Published:
May, 31th 2025	June, 30th 2025	July,18th 2025	August 1st, 2025

INTRODUCTION

The increasingly competitive industry competition requires companies to optimize all of their resources. Therefore, a reliable and rugged workforce is needed to support the company's business to compete (Rajapathirana & Hui, 2018; Sharp et al., 1999). In addition to the workforce, companies usually use high-tech machines to support the production process to increase company productivity and achieve effectiveness and efficiency (Pham & Thomas, 2011; Tortorella & Fettermann, 2018). The use of high-tech equipment creates safety and health risks for workers. This risk can affect the workforce anytime and anywhere, requiring special attention from various related parties such as workers, employers, government, and management (Edwards & Jabs, 2009; Lindgreen et al., 2009). This risk makes the workforce realize the importance of a healthy, safe and comfortable work environment. Work safety is an effort made by workers and companies to prevent work accidents and occupational diseases (Akpan, 2011; Thomason & Pozzebon, 2002). Occupational safety and health are the maintenance of human resources as the main actors so as not to get injured or sick and the maintenance of facility resources, namely facilities and infrastructure, so that they are not damaged (Friend & Kohn, 2007). Care of human resources and facility resources is carried out to prevent work accidents.

Work accidents are unwanted, unplanned, and unexpected events that can cause losses, namely injury to humans and damaged property (Duryan et al., 2020; Kirchsteiger, 1999). There are work accidents that have caused losses; such as, there have been workers who have suffered injuries, or there have been damaged equipment which is often called accidents, and accidents that have occurred but have not caused losses are called near misses or near misses. Accidents in companies also cause injury to humans, and equipment is damaged and can cause environmental damage and business opportunities for companies (Kasap, 2011; Lingard et al., 2017). Accidents occur because of causes, and accidents can be analysed using the theory of accident-causing models. The number of accidents that occur in the company describes the company's work safety performance, meaning that if more accidents happen in the company, the company's work safety performance will be low and vice versa if the number of accidents that occur is small, it means that the company's work safety performance is high (Fassa & Sofia, 2019; Kanchana et al., 2015). Work safety performance is part of the company's overall performance, and work safety performance is more focused on the frequency of accidents that occur (frequency rate), the level of accidents that occur (the incident rate), and the severity rate (the severity rate) (Yap & Lee, 2020). Safety performance is a measure of the company's success in preventing accidents (C. Wu et al., 2017).

Safety performance is part of the performance of non-financial companies because safety performance measures are a form of competitive advantage (Hinze, Thurman, et al., 2013). Safety performance in a company can be measured through the level of accidents, the frequency of accidents, and the severity (Singh & Misra, 2021). The company's safety performance measurement can also be calculated based on minor injuries, equipment damage, injuries that cause lost time injuries, and near misses that occur in the company (Gunduz et al., 2018). Measuring safety performance on a project is as important as measuring its success in carrying out its work, measured in time, quality, and cost. Safety leadership influences subordinates carried out by a leader to pay attention to safety aspects (Fernández-Muñiz et al., 2017; T. C. Wu et al., 2008).

Safety leadership is management's commitment to managing safety in the work area by preparing the necessary resources (Daniel, 2015). Safety leadership is part of leadership in organizations, and safety leadership focuses on how to invite workers to carry out safety rules in the workplace. As people responsible for their work areas, leaders must provide insight and direction to workers regarding safety aspects at work Safety behaviours is an action from workers to run and support company safety programs (Andi et al., 2022; Griffin & Hu, 2013). Safety behaviours includes a series of activities that individuals carry out in the workplace to keep their work area safe by aligning individual actions to comply with safety rules and procedures applicable to the organization (C. Wu et al., 2016). Behaviours is a particular action against existing safety rules or policies; if individual steps are not following the rules, an accident can occur.

Magalhães et al. (2022), stated that good leaders must realize the importance of safety culture. The more workers feel the safety culture, the better they feel the working conditions and the better they feel the safety performance. Where the indicators of working conditions are such as controlling high work demands that can cause workers to skip safety procedures or by strengthening work resources to motivate workers to be more involved in work safety. Safety performance can also be improved through a positive safety culture that ensures the transfer of knowledge between construction projects so that it can reduce risks in the workplace. To describe the development of the relationship between dimensions of work safety culture that have an influence on the performance of construction companies in Indonesia, Latief et al. (2017), obtained safety costs as the parameter that has the most influence on safety performance.

The research is intended to yield theoretical advantages, specifically the development of knowledge in the area of workplace safety. Particularly relevant to this study is the examination and analysis of the roles of safety leadership and safety behaviours in the improvement of safety performance in constructions, as well as the role of safety behaviours as a mediator between the roles of safety leadership and safety performance in the improvement of safety performance affected by implementation of innovation in construction processes and application of safety evaluation based on Occupational Health and Safety (OHS) Management System (*SMK3*) ((Ministry of Publik Works, 2014) and Construction Safety Management System (*SMKK*) 2021 (Ministry of Publik Works, 2021).

RESEARCH METHOD

Methodology and Research Strategies

Research methodology used to find the Analysis of the Influence of Evaluation and Innovation in the Development of Construction Safety Culture on the Safety Leadership Model with the Structural Equation Modeling Approach. The discussion stage in this chapter consists of research strategy, research process, research variables, research instruments, and data collection process to analysis methods. The research strategy is arranged based on each question and research objective. Thus, there are strategies that can differ according to the description of the questions and research objectives. In general, the research strategy used in each problem formulation (research questions/RQ) is as follows:

a) *RQ1*: Identifying important variables in construction project safety leadership in order to optimize the implementation of work safety. To answer RQ1, the research strategy chosen is literature study and survey. The research begins with a literature study to determine leadership patterns based on prevailing styles, especially in the construction industry. The results of the literature study are the basis for implementing the survey starting from expert validation of variables and indicators, preparation of survey instruments, implementation and analysis of survey results.
b) *RQ2*: to analyze the relationship between evaluation and innovation in the development of construction safety culture on the safety leadership model and the attitude of construction project leadership in the successful implementation of work safety. The results of the RQ1 analysis in the form of construction project leadership patterns based on the applicable leadership style are input in the implementation of the RQ2 analysis. Leadership style shows indicators that form safety leadership patterns in the project, these indicators are further sought for their relationship in forming construction project safety performance through Structural Equation Modeling (SEM) analysis based on all specified parameters.

Data acquiring method

Data collection was carried out based on the stages of research carried out, according to the stages starting from RQ1, and RQ2. RQ1 with previous literature studies was strengthened by a preliminary survey related to the regulatory aspects of PUPR Regulation No. 10 of 2021 and PP No. 50 of 2012 (Safety Leadership, Safety Planning, Safety Resources, Safety Operations and Safety Evaluation and Innovation).

In answering *RQ2* using a questionnaire conducted to 100 managerial level construction implementers who have at least 5 years of experience in their field or have completed medium-large scale projects with various levels of complexity, especially BUMN Construction and national private contractors at the Project Manager level and their staff. These results were then validated by experts through the FGD approach. The next follow-up was then carried out qualitative and quantitative analysis, as well as by conducting Structural Equation Modelling - Partial Least Square (SEM-PLS) analysis.

Data analyzing using Structural Equation Modelling - Partial Least Square (SEM-PLS)

Structural Equation Modeling (SEM) is a set of statistical techniques that allow testing a relatively complex series of relationships simultaneously. The relationship is built between one or more dependent variables with one or more independent variables. This method was developed by Sewal Wright starting in 1934. Initially, SEM was better known as the path analysis technique. SEM is a data analysis technique used to explain the relationship between variables in research as a whole. In addition, SEM is also a multivariate analysis method that involves the relationship between a number of exogenous (independent variables) latent variables and endogenous (dependent) latent variables that will form a model (Kline, 1998). The variables in SEM include:

a) Latent variables are variables that cannot be measured directly, for example behavior, feelings and motivation. Latent variables are divided into two, namely exogenous and endogenous variables. Exogenous variables are variables that have equality with independent variables, namely they do not depend on the value of other variables. While endogenous variables have equality with dependent variables, namely they depend on the value of other variables.
b) Manifest variable (observed variable) or measured variable (measured variable) is a variable that can be observed and measured empirically. This variable is also called an indicator. This variable is considered the effect of the latent variable.

Basically, SEM is not used to design a theory but is used to check and justify a model that has been created. The approach of the SEM statistical method is also called a confirmatory approach because it can be used to test hypotheses in the analysis of the theory structure that explains a particular phenomenon. The main requirement before using SEM is to build a hypothesis model consisting of a structural model and a measurement model. The structural model is used to describe the relationship between latent variables. While the measurement model is used to connect latent variables with observed variables (indicators). SEM is very cross-sectional, linear and general.

Construction, which is one of the largest industries in Indonesia and the world, has become a major research object or topic for researchers. The relationship between safety leadership in supporting safety performance through safety culture has been widely proven (Yap & Lee, 2020). The relationship between the contribution of project owners in shaping safety performance has also been proven by research by (Hinze, Hallowell, et al., 2013). Therefore, this study focuses on proving the relationship between variables that have been proven previously based on the context of government construction projects in Indonesia, where the representation of the project owner is the PPK. Through the previous explanation that SEM is a method that can confirm the relationship between latent variables described by their indicators, the selection of SEM as an analysis method based on the hypothesis model created can be the right data analysis tool to confirm the relationship between latent variables.

The explanation above is reinforced by the reasons for using SEM which are also the advantages of this method (Hair et al., 2019). Each point below is further linked to the context of this study to strengthen the justification:

a) SEM can analyze the relationship between variables simultaneously. The high need for safety leadership in a construction project is the basis for the high urgency of excellent safety performance. The relationship between simultaneous variables can produce fast and precise solutions in improving safety performance through leadership maturity.
b) In addition to being described through its indicators, SEM can also produce findings from the relationship between latent variables. Through this advantage, government construction project organizers in Indonesia can find out the safety leadership factors of project owners that can shape safety performance.
c) SEM has a feature in estimating errors that are described through a number of review parameters. This can reduce the level of subjectivity in filling out respondent questionnaires regarding safety leadership which is difficult to measure.

The data set that enters the SEM hypothesis model must be clean data from all outliers, valid, and reliable. SEM pre-test steps include the following points:

a) Checking for Lost Data. This check aims to ensure that each indicator assessed is the same and that no data is missing. Because the number of respondents and indicators used is quite large, this check is important.
b) Outliers Checking. Outliers are respondents who have answers outside the average answers of other respondents. The presence of outliers can disrupt the balance of the SEM modeling analysis as a whole. Checking for outliers is carried out for each indicator or observed variable. Respondents who are considered outliers by the SPSS software need to be removed from the respondent list and not included in further analysis.
c) Implementation of Validity Testing. Validity shows the extent to which a measuring instrument can be used to measure what should be measured (Sugiyono, 2008). A measuring instrument, a questionnaire, can be said to have high validity if it can carry out its measuring function as it should and is able to provide measurement results that are in accordance with the measurement objectives. The validity test is reviewed on each indicator or observed variable. Indicators that do not meet the criteria or parameters accepted need to be removed from the analysis. After the indicator is removed, the analysis is only carried out using variables that have passed the validity test parameters.
d) Implementation of Reliability Test. Reliability test is conducted to ensure that the survey instrument used can consistently produce consistent answers between respondents. The reliability test is carried out using the Cronbach's Alpha parameter which is

automatically generated by the SPSS software. Unlike the validity test whose review is on each indicator, the reliability test is carried out on each latent variable, not on each indicator / observed variable.

e) Implementation of Normality Test. The normality test is conducted to ensure the distribution of data in a relationship between variables to be normally distributed. The calculation of the normality test uses the Test Statistic / Kolmogorov-Smirnov Z score parameters. The test statistic parameters are reviewed based on the relationship between latent variables in a SEM hypothesis model.

The results of the SEM pre-test and the adjustments needed based on the parameter achievements are input into the SEM analysis using SEM-PLS software. Hair et al (2018) explained that there are several stages in SEM analysis which are explained in the points below.

a) Conceptualization and Model Development through Path Diagrams The first step taken in SEM is to formulate the individual constructs/variables used in the study. According to Hair et al., (2018), a construct or variable is a latent concept that can be determined but cannot be measured directly. The formulation of constructs or variables is carried out by considering relevant theories to solve the problems raised. At this stage, the formulation of indicators or observed variables that can represent the latent variables used is also carried out. The next step is to justify the causal relationship between variables to be described in the form of a path diagram in order to visualize the hypothesis.

b) Test of fit of the Measurement Model - Goodness of Fit. At this stage, a test of fit is carried out in accordance with the goodness of fit based on the existing parameters. Goodness of fit is used to test whether the resulting model describes the actual conditions. In general, the test of fit Model consists of absolute fit, incremental fit, and parsimonious fit.

c) Testing the Structural and Measurement Models. This stage aims to describe the suitability of the indicators (observed variables) with their latent variables. This stage is called Confirmatory Factor Analysis (CFA). The first step taken at this stage is to evaluate the significance of the indicators to their latent variables. Indicators that have insignificant results must be removed in order to produce a feasible model. After that, iteration is carried out again until all indicators are significant.

Model Hypothesis

The safety leadership existing model is shown in figure 1, and hypothesis model development of safety leadership is shown in figure 2.

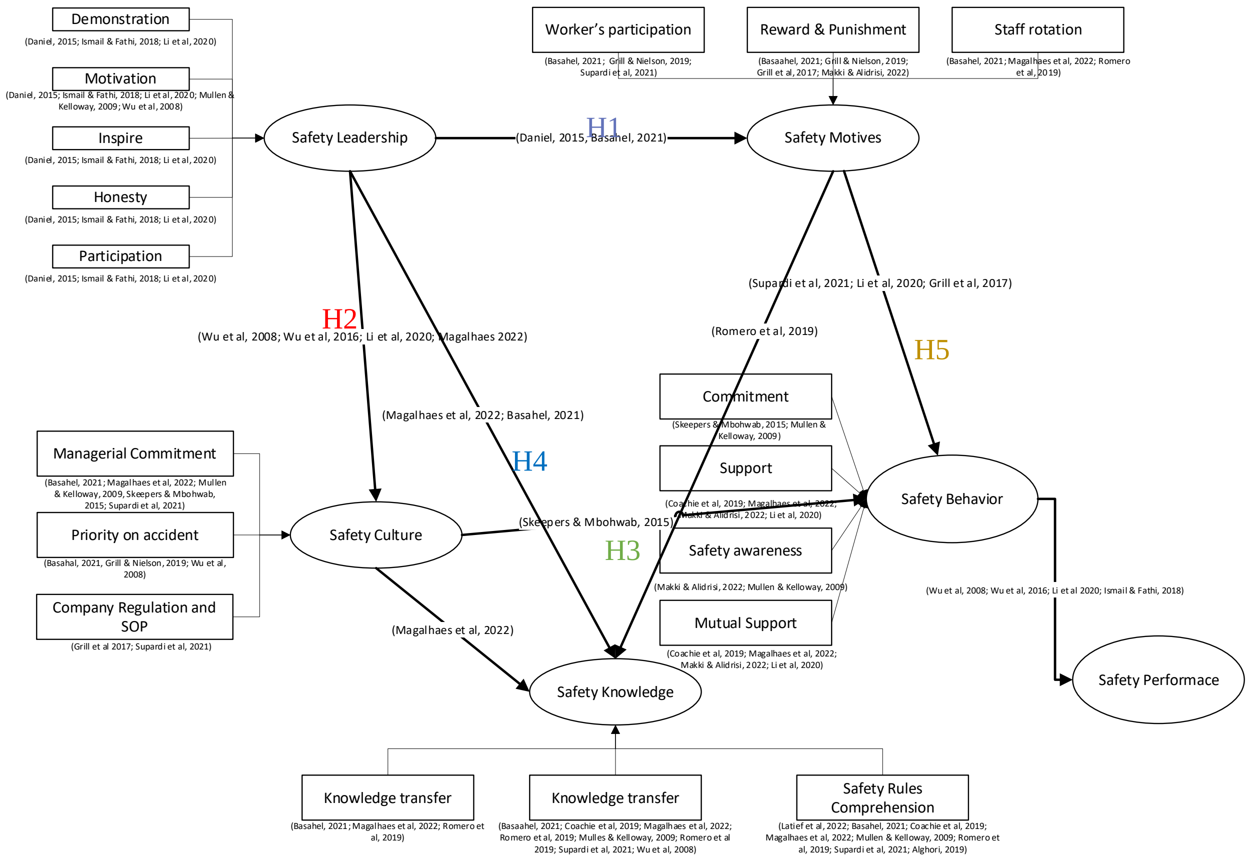

Figure 1 safety leadership existing model

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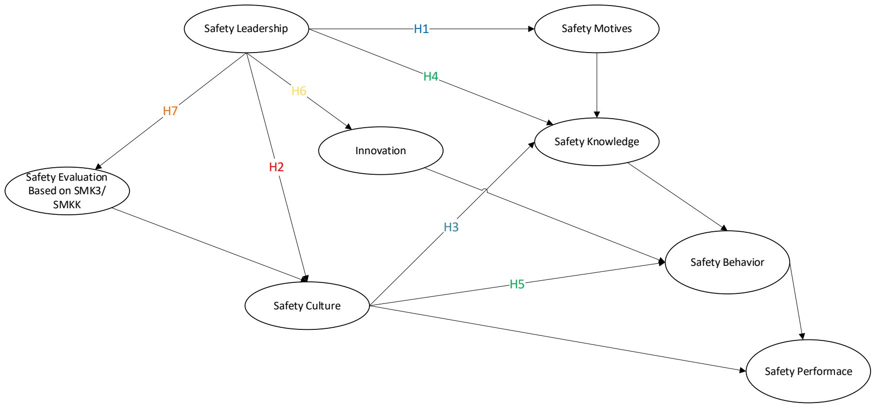

Figure 2 Development of existing safety leadership model

The descriptions of each hypothesis of each effect paths, as follows:

a) H1 is Safety Leadership influences Safety Motivation, influences Safety Behavior, influences Safety Performance.
b) H2 is Safety Leadership influences Safety Culture, influences Safety Behavior, influences Safety Performance.
c) H3 is Safety Leadership influences Safety Culture, influences Safety Knowledge, influences Safety Behavior, influences Safety Performance.
d) H4 is Safety Leadership influences Safety Knowledge, influences Safety Behavior, influences Safety Performance.
e) H5 is Safety Leadership influences Safety Culture, influences Safety Behavior, influences Safety Performance.
f) H6 is Safety Regulations (SMKK and SMK3) can strengthen the positive influence of Safety Leadership for improving performance. Safety Evaluation as part of the elements (SMKK and SMK3) has a positive influence on safety performance.
g) H7 Safety Innovation (i.e., the use of safety digitalization) further strengthens the process of evaluating and improving the safety performance of construction projects.

RESULT AND DISCUSSION

Variables and Indicators

Identification of research variables is carried out based on previous literature studies which ultimately form an existing model of construction project leadership. There are 5 main variables in this study, as follows: Safety Leadership; Safety Motivation; Safety Culture; Safety Knowledge; and Safety Behavior.
Of the five main variables, each has indicators as shown in Table 1 below.

Table 1 Variables and indicators

Variable	Indicator
Safety Leadership	1. Inspiration 2. Demonstration 3. Encouragement 4. Honesty 5. Involvement
Safety motivation	1. Worker's participation 2. Staff rotation 3. *Reward* dan Punishment
Safety culture	1. Commitment of management 2. Company regulation & SOP 3. Prioritizing at accident occurred
Safety knowledge	1. Safety Training 2. Knowledge Transfer
Safety behavior	1. Worker commitment 2. Trust 3. Safety awareness 4. Mutual support among coworkers

(Source: own research, 2025)

As shown in figure 2., the inclusion of 2 (two) mediating variable, Safety Evaluation and Safety Innovation on to the existing models. The indicators of the variable and safety performance as dependent variable is shown in table 2.

Table 2. Mediating variables and indicators

Variable	Indicator
Safety evaluation	1. Management overview 2. Safety audit
Safety innovation	1. Safety performances dashboard 2. Digitally safety process 3. Safety infrastructure
Safety culture	1. Zero accident 2. Quality 3. Time 4. Cost 5. Company reputation 6. Safety control

(Source: own research, 2025)

Descriptive Analysis

Descriptive analysis techniques are carried out to find out a descriptive picture of the spread or distribution of data presented as information. The descriptive analysis of variables is shown in table 3.

Table 3 Descriptive Analysis

	safety leadership (X1)	safety culture (X2)	motivation (X3)	knowledge (X4)	safety behavior (X5)	evaluation (X6)	innovation (X7)	safety performance (Y)
Mean	43.314	17.229	25.114	16.629	35.086	35.343	37.029	56.943
Standard Error	1.218	0.490	0.803	0.570	0.719	0.872	1.324	1.076
Median	44.0	18.0	26.0	17.0	34.0	38.0	37.0	56.000
Mode	50.0	16.0	30.0	20.0	40.0	40.0	45.0	65.000
Standard Deviation	7.206	2.901	4.751	3.370	4.252	5.156	7.835	6.366
Sample Variance	51.928	8.417	22.575	11.358	18.081	26.585	61.382	40.526
Kurtosis	3.856	4.157	4.256	3.229	-0.420	-0.156	3.318	-1.127
Skewness	-1.750	-1.782	-1.740	-1.551	-0.399	-0.897	-1.363	-0.145
Range	32.0	13.0	22.0	15.0	16.0	16.0	36.0	21.000
Minimum	18.0	7.0	8.0	5.0	24.0	24.0	9.0	44.000
Maximum	50.0	20.0	30.0	20.0	40.0	40.0	45.0	65.000
Sum	1516.0	603.0	879.0	582.0	1228.0	1237.0	1296.0	1993.000
Count	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.000
Confidence Level (95.0%)	2.475	0.997	1.632	1.158	1.461	1.771	2.691	2.187

(Source: own research, 2025)

As shown from the table above, the pattern is described as follows:

a) Sample Size: All variables have a consistent sample size of 35.
b) Skewness: A prominent pattern across most variables (X1, X2, X3, X4, X6, X7) is a negative (left) skew, suggesting that scores are generally concentrated towards the higher end of their respective scales. Safety Behavior (X5) and Safety Performance (Y) show less pronounced skewness, with Safety Performance being the closest to a symmetrical distribution.
c) Kurtosis: Most variables exhibit positive kurtosis (leptokurtic), indicating more peaked distributions with heavier tails than a normal distribution. However, Safety Behavior (X5), Evaluation (X6), and Safety Performance (Y) show negative kurtosis (platykurtic), suggesting flatter distributions with lighter tails.
d) Variability: Innovation (X7) has the largest standard deviation and range, indicating the highest variability in scores, while Safety Culture (X2) and Knowledge (X4) show the least variability among the independent variables. Safety Performance (Y) has moderate variability.
e) Confidence Level (95.0%): This row provides the margin of error for the respective means, indicating the precision of the mean estimates. Smaller values suggest more precise estimates.

Overall, the descriptive analysis suggests that the sample generally reports high levels across most safety management aspects, with safety performance also being relatively high. The negative skewness in many variables points towards a concentration of higher scores, while the varying kurtosis values suggest different distributional shapes.

External Measurement Model Evaluation (Outer Models)

Convergent validity

Convergent validity with reflective indicators can be seen from the influence of, among others, indicators with their construct values. Indicators with loading factor values are said to be valid/reliable if they have an influence value above 0.7, however, for early stage research from the development of a measurement scale, a loading value of 0.7 is considered sufficient (Chin, 1998 in Ghozali & Fuad, 2014). However, if the resulting value is not > 0.7, the indicator is declared invalid and the indicator must be removed from the model so that data must be reprocessed.

Table 4 Outer Model

Path	*Outer loadings*			
	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration
X111 -> X-1	0.372			
X111 -> X-11	0.738	0.641		
X112 -> X-1	0.502			
X112 -> X-11	0.997	0.977	1	1
X121 -> X-1	0.492			
X121 -> X-12	0.773	0.679		
X122 -> X-1	0.633			
X122 -> X-12	0.996	0.999	1	1
X131 -> X-1	0.657			
X131 -> X-13	0.924	0.943	0.943	0.943
X132 -> X-1	0.659			
X132 -> X-13	0.928	0.906	0.907	0.907
X141 -> X-1	0.773	0.799	0.798	0.797
X141 -> X-14	0.889	0.862	0.862	0.861
X142 -> X-1	0.82	0.891	0.89	0.889
X142 -> X-14	0.944	0.961	0.961	0.961
X151 -> X-1	0.769	0.876	0.877	0.878
X151 -> X-15	0.924	0.957	0.957	0.957
X152 -> X-1	0.73	0.755	0.755	0.755
X152 -> X-15	0.876	0.825	0.824	0.824
X211 -> X-2	0.426			
X211 -> X-21	0.981	0.992	0.993	0.993
X212 -> X-2	0.354			
X212 -> X-21	0.812	0.77	0.767	0.764
X221 -> X-2	0.989	0.909	0.902	0.893
X221 -> X-22	0.995	0.909	0.902	0.893
X222 -> X-2	0.813	0.96	0.965	0.97
X222 -> X-22	0.818	0.96	0.965	0.97

Path	*Outer loadings*			
	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration
X311 -> X-3	0.723	0.731	0.731	0.731
X311 -> X-31	0.867	0.88	0.878	0.878
X312 -> X-3	0.802	0.793	0.796	0.796
X312 -> X-31	0.963	0.955	0.956	0.956
X321 -> X-3	0.768	0.735	0.739	0.739
X321 -> X-32	0.81	0.774	0.78	0.78
X322 -> X-3	0.945	0.948	0.948	0.948
X322 -> X-32	0.996	1	0.999	0.999
X331 -> X-3	0.706	0.648		
X331 -> X-33	0.956	0.964	0.966	0.966
X332 -> X-3	0.606			
X332 -> X-33	0.821	0.804	0.799	0.799
X411 -> X-4	0.546			
X411 -> X-41	0.99	0.983	0.983	0.983
X412 -> X-4	0.416			
X412 -> X-41	0.759	0.787	0.788	0.788
X421 -> X-4	0.596			
X421 -> X-42	0.599			
X422 -> X-4	0.997	1	1	1
X422 -> X-42	0.999	1	1	1
X511 -> X-5	0.507			
X511 -> X-51	0.83	0.917	0.937	0.937
X512 -> X-5	0.579	0.53		
X512 -> X-51	0.944	0.87	0.841	0.841
X521 -> X-5	0.96	0.998	1	1
X521 -> X-52	0.987	1	1	1
X522 -> X-5	0.671			
X522 -> X-52	0.685			
X531 -> X-5	0.345			
X531 -> X-53	0.87	0.801	0.775	0.775
X532 -> X-5	0.383			
X532 -> X-53	0.958	0.986	0.992	0.992
X541 -> X-5	0.118	0.293		
X541 -> X-54	-0.886			
X542 -> X-5	0.167			
X542 -> X-54	-0.983			
X611 -> X-6	0.498			
X611 -> X-61	0.745	0.767	0.766	0.765
X612 -> X-6	0.592			
X612 -> X-61	0.886	0.867	0.865	0.861
X613 -> X-6	0.648			
X613 -> X-61	0.97	0.974	0.975	0.976
X621 -> X-6	0.763	0.955	0.96	0.966
X621 -> X-62	0.763	0.955	0.96	0.966
X622 -> X-6	0.621			
X622 -> X-62	0.621			
X623 -> X-6	0.785	0.86	0.85	0.838
X623 -> X-62	0.785	0.86	0.85	0.838
X624 -> X-6	0.282			
X624 -> X-62	0.282			
X625 -> X-6	0.367			
X625 -> X-62	0.367			
X711 -> X-7	0.44			

Path	*Outer loadings*			
	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration
X711 -> X-71	0.797	0.796	0.796	0.796
X712 -> X-7	0.371			
X712 -> X-71	0.67			
X713 -> X-7	0.526			
X713 -> X-71	0.953	0.97	0.97	0.97
X721 -> X-7	0.53			
X721 -> X-72	0.61			
X722 -> X-7	0.833	1	1	1
X722 -> X-72	0.954	1	1	1
X723 -> X-7	0.503			
X723 -> X-72	0.575			
X731 -> X-7	0.67			
X731 -> X-73	0.937	0.999	1	1
X732 -> X-7	0.653			
X732 -> X-73	0.907	0.68		
X733 -> X-7	0.609			
X733 -> X-73	0.847	0.657		
Y111 <- Y	0.372			
Y111 <- Y-1	0.899	0.895	0.888	0.893
Y112 <- Y	0.467			
Y112 <- Y-1	0.937	0.941	0.946	0.942
Y121 <- Y	0.54			
Y121 <- Y-2	0.81	0.765	0.655	
Y122 <- Y	0.833	0.822	0.824	0.813
Y122 <- Y-2	0.925	0.951	0.955	0.961
Y131 <- Y	0.718	0.753	0.772	0.79
Y131 <- Y-3	0.921	0.924	0.924	0.924
Y132 <- Y	0.691			
Y132 <- Y-3	0.914	0.91	0.911	0.91
Y141 <- Y	0.766	0.795	0.813	0.833
Y141 <- Y-4	0.928	0.924	0.924	0.923
Y142 <- Y	0.738	0.804	0.831	0.862
Y142 <- Y-4	0.922	0.926	0.927	0.928
Y151 <- Y	0.714	0.768	0.778	0.764
Y151 <- Y-5	0.93	0.93	0.931	0.93
Y152 <- Y	0.73	0.782	0.783	0.785
Y152 <- Y-5	0.933	0.933	0.932	0.933
Y161 <- Y	0.704	0.652		
Y161 <- Y-6	0.896	0.895	0.889	0.891
Y162 <- Y	0.692			
Y162 <- Y-6	0.899	0.897	0.897	0.899
Y163 <- Y	0.765	0.728	0.685	
Y163 <- Y-6	0.902	0.905	0.91	0.907

(Source: SEM-PLS data processing, 2025)

As shown in the table above, the outer model values of all variables are declared valid after going through 4 iterations.

Final loading factor of structural model is shown in figure 3.

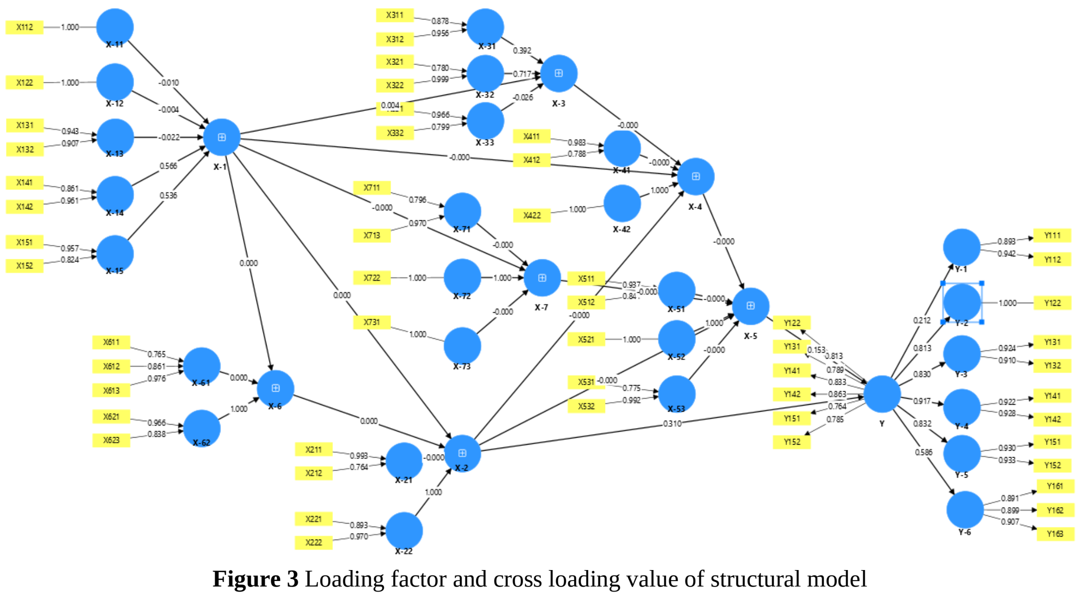

Figure 3 Loading factor and cross loading value of structural model

Discriminant validity test

Discriminant validity test, conducted to test whether the indicators of a construct are not highly correlated with indicators from other constructs. Discriminant validity of the measurement model with reflective indicators is assessed based on the cross loading of the measurement with the construct. If the correlation of the construct with the measurement item is greater than the size of the other construct, it indicates that the latent construct predicts the size of the block better than the size of the other block.

As shown on figure 3 above, that each indicator in the latent variable has a cross loading value from each indicator to its construct and is greater than its cross-loading value. Thus, it can be concluded that some constructs or latent variables already have good discriminant validity.

Construct reliability test

Another method to find discriminant validity is to compare the square root value of the Average Variance Extracted (AVE) of each construct with the correlation value between the construct and other constructs (latent variable correlation). The model has sufficient Discriminant Validity value if the AVE for each construct is greater than the influence between the construct and other constructs. The Construct reliability value is shown in table 5 below.

Table 5 Construct reliability values

Notation	Variable	*Average variance extracted* (AVE)	Cronbach's alpha	*Composite reliability* (rho_a)	*Composite reliability* (rho_c)
Y	Safety performance	0.654	0.894	0.895	0.919
Y-1	Zero accident	0.843	0.817	0.867	0.915
Y-3	Time	0.841	0.812	0.815	0.914
Y-4	Cost	0.856	0.832	0.833	0.922
Y-5	Company reputation	0.868	0.848	0.848	0.929
Y-6	Safety control	0.808	0.882	0.888	0.927

(Source: SEM-PLS data processing, 2025)

In table 5 above, it can be shown that:

1. The value of Average Variance Extracted (AVE) has a value on the Y variable of 0.654, on Y1 of 0.843, and on Y3 to Y6 respectively of 0.841; 0.856; 0.868; and 0.808. So, the value in this study has met the research criteria, which is greater than 0.50. The *AVE* produced by each construct is above 0.50. This shows that each construct is able to explain the variance of its indicators very well, indicating strong convergent validity.
2. Cronbach's Alpha is the most commonly used measure of internal consistency. Higher values (closer to 1) indicate better reliability. Generally, values above 0.7 are considered good, and values above 0.9 are often considered very good. Based on table 4.11 above, all Cronbach's Alpha values are very high, ranging from 0.812 (for the time aspect) to 0.894 (for Safety Performance). This indicates that all indicators or question items in each construct have very good internal consistency.
3. Composite Reliability (rho-a) can be used to measure internal consistency. Higher values indicate better reliability, with a threshold similar to Cronbach's Alpha (i.e., > 0.7). Based on table 4.11 above, the Composite Reliability (rho-a) value is also very high and almost identical to the Cronbach's Alpha value for each construct, ranging from 0.815 (for the time aspect) to 0.895 (for Safety Performance). This strengthens the finding that internal consistency is very strong.
4. Composite Reliability (rho-c) is also used in measuring construct reliability in SEM-PLS. In some contexts (especially PLS-SEM), it is often considered more accurate than Cronbach's Alpha because it takes into account the different factor loadings of each indicator. Values above 0.7 are generally considered good, and above 0.8 are often considered very good. Based on table 4.11 above, all Composite Reliability (*rho-c*) values are very high, ranging from 0.919 (for the time aspect) to 0.929 (for corporate reputation). This shows that these constructs are very reliable in measuring what they should be measured, with a minimal error rate.

Based on all the reliability metrics presented, namely Cronbach's Alpha, Composite Reliability (*rho-a*), Composite Reliability (*rho-c*) and convergent validity metrics (*AVE*), it can be concluded that all constructs/dimensions tested in this table have very high and very good levels of reliability and convergent validity. This means that the measurement instruments used for these variables are internally consistent, stable, and able to measure the intended concept accurately.

Internal Measurement Model Evaluation

R-square and R-square adjusted

R-square is a statistical measure that shows the proportion of variance in a dependent variable that can be explained by the independent variables (or regression model). Its value ranges from 0 to 1. The closer it is to 1, the better the model's ability to explain the variation in the dependent variable. While R-square Adjusted is a version of R-square that has been adjusted for the number of predictors (independent variables) in the model and the number of observations.

Table 6 R-square and R-square adjusted

Notation	Variable	R-square	R-square adjusted
X-1	Safety leadership	0.995	0.995
X-2	Safety culture	1	1
X-3	Motivation	0.99	0.99
X-4	Knowledge	1	1
X-5	Safety behavior	1	1
X-6	Evaluation	1	1
X-7	Innovation	1	1
Y	Safety performance	0.131	0.113
Y-1	Zero accident	0.045	0.035
Y-2	Quality	0.661	0.657
Y-3	Time	0.688	0.685
Y-4	Cost	0.84	0.838

Jurnal Komposit: Jurnal Ilmu-ilmu Teknik Sipil
Vol. 9 No. 2 (2025) pp. 311 - 326
DOI: http://dx.doi.org/10.32832/komposit.v9i2.20134 ISSN: 2615-3513
e-ISSN: 2655-934X

Notation	Variable	R-square	R-square adjusted
Y-5	Company reputation	0.692	0.688
Y-6	Safety control	0.343	0.337

(Source: SEM-PLS data processing, 2025)

Based on table above, it can be shown that the values of this Table show two groups of variables with very different R^2 characteristics:

1. Group 1: Variables with very high R^2 (approaching 1). Variables such as "Safety leadership", "Safety culture", "Safety motivation", "Safety knowledge", "Safety behavior", "Evaluation", and "Safety innovation" have very high R^2 and R^2-adjusted values, namely 0.995, 0.999, or even 1.000. An R^2 value = 1.000 indicates that the model perfectly explains the variation in these variables. In practice, very high R^2 values like this (especially 1.000) on independent variables often indicate that these variables may be formative constructs (not reflective) or have very strong and direct causal relationships with other constructs not presented here, or it could also be an indicator of multicollinearity problems or even over-fitting the model.
2. Group 2: Variables with varying R^2 Several models (Y-2, Y-3, Y-4, Y-5) have fairly good to very good R^2 and R^2-adjusted, indicating that their independent variables are able to explain most of the variance in the dependent variable. Meanwhile, models Y and Y-1 show very low explanatory power, indicating that the independent variables used may be irrelevant or there are other factors that more dominantly influence the dependent variable.

Path coefficient

Path coefficients are values that are useful in showing the direction of the relationship between variables, whether a hypothesis has a positive or negative direction. The path coefficient values for each independent variable (exogenous) against the dependent variable (endogenous) in the study, which can be seen in table 7, as follows.

Table 7 Path coefficient

Variable Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Safety leadership (X1) -> safety motivation (X3)	**0.004**	**0.008**	**0.015**	**0.291**	**0.0428**
Safety leadership (X1) -> evaluation (X6)	**0**	**0**	**0**	**0.001**	**0.0500**
Demonstration (X11) -> safety leadership (X1)	-0.01	-0.008	0.012	0.813	0.0416
Motivation (X12) -> safety leadership (X1)	-0.004	-0.003	0.009	0.47	0.0438
Inspirational (X13) -> safety leadership (X1)	-0.022	-0.015	0.025	0.888	0.0375
Honesty (X14) -> safety leadership (X1)	0.566	0.543	0.21	2.688	0.0070
Leader’s participation (X15) -> safety leadership (X1)	0.536	0.539	0.209	2.57	0.0100
Safety culture (X2) -> safety performance (Y)	**0.31**	**0.317**	**0.153**	**2.023**	**0.0430**
SOP (X22) -> Safety culture (X2)	1	1	0	5713147.025	0
Participation (X31) -> motivation (X3)	0.392	0.373	0.263	1.491	0.0136
Reward & punishment (X32) -> motivation (X3)	0.717	0.696	0.244	2.944	0.0003
Rotation (X33) -> motivation (X3)	-0.026	-0.017	0.028	0.93	0.0353
Knowledge transfer (X42) -> Safety knowledge (X4)	1	1	0	n/a	n/a
Safety behavior (X5) -> safety performance (Y)	**0.153**	**0.157**	**0.108**	**1.413**	**0.0158**
Commitment (X52) -> Safety behavior (X5)	1	1	0	n/a	n/a
managements over view (X62) -> evaluation (X6)	0	0	0	0	0.05
Safety audit (X62) -> evaluation (X6)	1	1	0	45672.8	0
Digital process (X72) -> Safety innovation (X7)	1	1	0	n/a	n/a
safety performance (Y)--> Zero accident (Y1)	0.212	0.228	0.096	2.21	0.0027
safety performance (Y)--> Quality (Y2)	0.813	0.815	0.046	17.568	0.0000
safety performance (Y)--> Time (Y3)	0.83	0.831	0.04	20.664	0.0000
safety performance (Y) --> Cost (Y4)	0.917	0.916	0.023	39.795	0.0000
safety performance (Y) --> Company reputation (Y5)	0.832	0.83	0.066	12.631	0.0000
safety performance (Y) --> Safety control (Y6)	0.586	0.586	0.09	6.501	0.0000

(Source: SEM-PLS data processing, 2025)

On the Table 7. above shows that the path description column shows the hypothesized causal relationship between two variables. The arrow (->) indicates the direction of influence. For example: "safety leadership (X1) --> Safety culture (X2)" means that safety leadership (independent variable) influences Safety culture (dependent variable). Table 7 can be divided into several thematic sections, representing different aspects of the larger model:

1. Upper Section (starting with “Safety leadership -> safety motivation”): Focuses on the impact of “Safety leadership” and related concepts (Demonstration, Motivation, Inspiration, Honesty, Involvement) on various outcomes such as “safety motivation” and “safety evaluation”. Many of these paths show significant relationships.
2. “Safety culture -> performance”: This is the summarized path with a statistically significant coefficient (Original Sample = 0.31, p-value = 0.0430).
3. “SOP implementation -> safety participation culture”: This path has a fixed value of 1, indicating a direct or assumed relationship, so no statistical test was performed.
4. Section on “Participation”, “Reward & punishment”, “Job rotation”, “Knowledge transfer”: These variables are shown to influence “safety motivation” and “safety knowledge”, with most of the relationships showing statistical significance.
5. “Safety behavior -> safety performance”: This is another summary path, showing a significant positive relationship (Original Sample = 0.153, p-value = 0.0158).
6. "Management review -> evaluation" and "Safety audit -> evaluation": These paths also show direct or assumed relationships with a fixed value of 1.

7. "Safety innovation -> Safety performance (Y1)": Other direct or assumed relationships with a fixed value of 1.
8. Section on "Safety performance (Y1) -> Zero accident (Y1)" and other "Safety performance (Y)" variables: This section investigates the relationships between the various dimensions of "Safety performance" (Y1 to Y5) and specific outcomes such as "Zero accident", "Quality of work", "Time aspect", "Cost aspect", and "Company reputation". Almost all of these paths show a highly statistically significant positive relationship (p value = 0.0000), indicating a strong positive impact of safety performance on these aspects.

Based on the analysis presented in Table 7 above, the strength and statistical significance of the hypothesized relationships between various safety-related factors and performance outcomes in the studied model can be proven.

Indirect Path Effect

In Structural Equation Modeling - Partial Least Squares (SEM-PLS), the indirect effect path refers to the influence of an exogenous (independent) variable on an endogenous (dependent) variable through one or more mediator variables or an exogenous variable does not directly affect the endogenous variable, through another variable in the middle. The indirect effect path is shown in table 4.8 below.

Table 8 Indirect Path Effect

Notation	Indirect Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P
X1 -> X2 -> X4	Safety leadership -> safety culture -> safety knowledge	0.121	0.13	0.107	1.131	0.015
X1 -> X2 -> X4 -> X5	Safety leadership -> safety culture -> safety knowledge -> behavior	0.014	0.014	0.019	0.708	0.024
X1 -> X2 -> X4 -> X5 -> Y	Safety leadership -> safety culture -> safety knowledge -> safety behavior -> safety performance	0	0	0.003	0.002	0.049
X1 -> X2 -> X5	Safety leadership -> safety culture -> safety behavior -> safety performance	0.068	0.07	0.041	1.68	0.005
X1 -> X2 -> X5 -> Y	Safety leadership -> safety culture -> safety behavior	0	0.002	0.009	0.003	0.049
X1 -> X2 -> Y	Safety leadership -> safety culture -> safety performance	0.273	0.277	0.117	2.324	0.001
X1 -> X3 -> X5	Safety leadership -> motivation -> safety behavior	0.039	0.036	0.042	0.915	0.018
X1 -> X3 -> X5 -> Y	Safety leadership -> motivation -> safety behavior -> safety performance	0.034	0.034	0.037	0.925	0.018
X1 -> X4 -> X5	Safety leadership -> knowledge -> safety behavior	0.014	0.014	0.037	0.825	0.018
X1 -> X4 -> X5 -> Y	Safety leadership -> knowledge -> safety behavior -> safety performance	0	0.001	0.006	0.002	0.049
X1 -> X6 -> X5	Safety leadership -> innovation -> safety behavior	-0.092	-0.087	0.072	1.274	0.010
X1 -> X6 -> X5 -> Y	Safety leadership -> innovation -> safety behavior -> safety performance	0	0.001	0.011	0.003	0.049
X1 -> X7 -> X2	Safety leadership -> evaluation -> safety culture	0.005	0.008	0.014	0.35	0.036
X1 -> X7 -> X2 -> X4	Safety leadership -> evaluation -> safety culture -> safety knowledge	0.001	0.001	0.003	0.231	0.041
X1 -> X7 -> X2 -> X4 -> X5	Safety leadership -> evaluation -> safety culture -> safety knowledge -> safety behavior	0	0	0	0.184	0.043
X1 -> X7 -> X2 -> X4 -> X5 -> Y	Safety leadership -> evaluation -> safety culture -> safety knowledge -> safety behavior -> safety performance	0	0	0	0.001	0.050
X1 -> X7 -> X2 -> X5	Safety leadership -> evaluation -> safety culture -> safety behavior	0	0.001	0.001	0.294	0.038
X1 -> X7 -> X2 -> X5 -> Y	Safety leadership -> evaluation -> safety culture -> safety behavior -> safety performance	0	0	0	0.001	0.050
X1 -> X7 -> X2 -> Y	Safety leadership -> evaluation -> safety culture -> safety performance	0.2	0.3	0.05	0.349	0.036
X2 -> X4 -> X5	safety culture -> safety knowledge -> behavior	0.018	0.018	0.025	0.734	0.023
X2 -> X4 -> X5 -> Y	safety culture -> safety knowledge -> behavior -> safety performance	0	0.001	0.004	0.002	0.049
X2 -> X5 -> Y	safety culture -> safety behavior -> safety performance	0	-0.003	0.012	0.003	0.049
X3 -> X5 -> Y	Motivation -> safety behavior -> safety performance	0	-0.001	0.014	0.003	0.049
X4 -> X5 -> Y	knowledge -> safety behavior -> safety performance	0	0.003	0.016	0.003	0.049
X6 -> X5 -> Y	innovation -> safety behavior -> safety performance	0.1	0.15	0.084	0.004	0.049

Jurnal Komposit: Jurnal Ilmu-ilmu Teknik Sipil ISSN: 2615-3513
Vol. 9 No. 2 (2025) pp. 311 - 326 e-ISSN: 2655-934X
DOI: http://dx.doi.org/10.32832/komposit.v9i2.20134

Notation	Indirect Path	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P
X7 -> X2 -> X4	evaluation -> safety behavior -> safety performance	0.007	0.002	0.018	0.384	0.035
X7 -> X2 -> X4 -> X5	evaluation -> safety culture -> safety knowledge -> safety behavior	0.001	0	0.002	0.322	0.037
X7 -> X2 -> X4 -> X5 -> Y	evaluation -> safety culture -> safety knowledge -> safety behavior -> safety performance	0	0	0	0.001	0.050
X7 -> X2 -> X5	evaluation -> safety culture -> safety behavior	0.004	0.003	0.009	0.441	0.033
X7 -> X2 -> X5 -> Y	evaluation -> safety culture -> safety behavior -> safety performance	0	0	0.001	0.001	0.050
X7 -> X2 -> Y	evaluation -> safety culture -> safety performance	0.16	0.12	0.03	0.521	0.040

(Source: SEM-PLS data processing, 2025)

Based on table above, it can be shown that the safety leadership variable has an indirect effect on safety performance. Increasing the role of safety leadership will improve the company's safety performance, through the path X1 → X2 → Y (Safety leadership → safety culture → safety performance), with a positive and very significant effect (O = 0.273, P = 0.001). This is one of the strongest indirect effects, indicating that safety leadership significantly improves safety performance through safety culture. In addition, increasing the role of safety leadership will also affect safety performance through the path involving X1 → X3 → Y (Safety leadership → safety motivation → safety performance), with a significant effect (P = 0.049), although the coefficient is very small (O = 0). The effect of safety culture on performance can be seen in the path X2 → X4 → Y (safety culture → safety knowledge → safety performance), with a positive and significant effect (O = 0.018, P = 0.023). This indicates that safety culture affects safety performance through safety knowledge.

Due to the diverse mediation roles, this table clearly shows that there are many significant indirect paths in the model. This underlines the importance of mediator variables (such as safety culture, safety motivation, safety knowledge, safety behavior, safety evaluation, and safety innovation) in explaining how the initial exogenous variable (e.g., Safety Leadership) ultimately affects the final endogenous variable (e.g., Safety Performance).
From the analysis that has been done, it can be concluded that Safety Leadership as a Key Predictor. Safety Leadership (X1) emerged as an important predictor that affects many safety outcomes through various mediation paths. Its indirect effect on safety performance through safety culture (X1 → X2 → Y) is very prominent.

Standardized Root Mean Square Residual (SRMR) test

Standardized Root Mean Square Residual (SRMR) is one of the fit indices commonly used in Structural Equation Modelling (SEM), both covariance-based (CB-SEM) and variance/component-based (PLS-SEM). SRMR measures the average difference between the observed correlation matrix (from actual data) and the correlation matrix predicted by the model. The results of the SRMR test on the construction safety leadership model are shown in table 4.15 below.

Table 9 *SRMR* test result

	Saturated model	Estimated model
SRMR	0,065	0,065
d_ULS	2,701	2,701
d_G	2,828	2,828
Chi-square	980,218	980,218
NFI	0,661	0,661

(Source: SEM-PLS data processing, 2025)

Based on the table above, it can be seen that the SRMR value in this model is 0.065 (below 0.08). Thus, it can be concluded that the model is considered to have a good fit. In the d-ULS and d_G tests, each of the test results obtained a value greater than the Original Sample, so for d-ULS and d_G it can be categorized as a model that has a good residual distribution.

Hypothesis test

The influence of safety leadership on safety motivation, behavior, and performance

Hypothesis testing H1 on the influence of the safety leadership variable (X1) on safety motivation (X3), safety behavior (X5) and safety performance (Y), is shown in table 4.14. The original sample value (O) is 0.034 units, the sample mean value (M) is 0.034, the standard deviation value (STDEV) is 0.037, the T-statistic value is 0.925 and the probability value (P-value) is 0.018, less than the general significance level used (α=0.05). Thus, the indirect effect of "Safety leadership" on "safety performance" through "safety motivation" and "safety behavior" is statistically significant. The positive indirect effect coefficient (0.034) indicates that there is a positive relationship. Increasing "Safety leadership" tends to lead to increasing "safety performance" indirectly through increasing "safety motivation" and then "safety behavior". So, it can be concluded that the hypothesis H01 is rejected and Ha1 (hypothesis is accepted). This is in line with the research results of Skeepers & Mbohwa, (2015) and Li et al., (2020)

The influence of safety leadership on safety culture and safety performance

Hypothesis testing H2 on the influence of safety leadership variable (X1) on safety culture (X2) and safety performance (Y) is shown in table 4.14. The original sample value (O) is 0.273, the sample mean value (M) is 0.277, the standard deviation value (STDEV) is 0.177, the T-statistic value is 2.324 and the probability value (P-value) is 0.001, less than the general significance level used (α=0.05). So, it can be concluded that the hypothesis H02 is rejected and Ha2 (hypothesis is accepted).

This is one of the most important and significant indirect paths in the statistical model. Safety leadership significantly and positively affects safety performance, and this influence is largely mediated by safety culture. This means that good leadership builds a strong safety culture, which in turn improves safety performance. This is a key finding for practical implications. This is in line with the research results of Magalhaes' study (Magalhães et al., 2022).

Discussion of indirect path effect of safety leadership through longer path (H3 – H5)

For every path described on H3 to H5, safety leadership pass through different variable, so that the effect of increasement of safety leadership value is diminished. As shown on table 9, even the p-value is less than 0.05 (statistically significant), the value of O and M is almost 0. Which means in the context of real world or managerial decision making, the case with very long mediation paths, where the influence weakens as it passes through many variables.

The effect of innovation and safety evaluation variables on improving safety performance

1. Path X7 -> X2 -> Y (Evaluation -> safety culture -> safety performance): Original Sample (O): 0.16, Sample Mean (M): 0.12, Standard Deviation (STDEV): 0.03, T statistics (|O/STDEV|): 0.521, and P values: 0.04. With a p-value of 0.04, which is less than 0.05, this indirect influence path is statistically significant. This means that this effect is most likely not a coincidence and there is empirical evidence to support the existence of this mediation. The value of "Original Sample (O)" is 0.16, indicating a positive effect. This means that "Safety evaluation" indirectly improves "safety performance" through "safety culture". In a practical context, this can be interpreted that effective safety evaluation (e.g., constructive and systematic evaluation) can help build a stronger safety culture, which in turn will improve overall safety performance. The effect of 0.16 can be considered as a moderate and significant effect.
2. Path X6 -> X5 -> Y (Innovation -> safety behavior -> safety performance): Original Sample (O) value: 0.1, Sample Mean (M) 0.09, Standard Deviation (STDEV) 0.084, T statistics 0.004, and P values: 0.049. With a p-value of 0.049, which is right on the threshold of 0.05, this indirect influence path is statistically significant (although marginal). This indicates that there is statistical support for this mediation path. The value of "Original Sample (O)" is 0.1, indicating a positive effect. This means that "Innovation" can indirectly improve "safety performance" through "safety behavior". Practically, this can be interpreted that innovation (e.g., in safety processes or technologies) can encourage better safety behavior among workers, which then contributes to improved safety performance. An effect of 0.1 is a relatively small effect but statistically significant.

Based on table 8, two statistically significant indirect influence paths are shown, Safety evaluation indirectly improves safety performance through safety culture. This is an important finding that shows that good evaluation mechanisms can strengthen safety culture, which in turn improves performance.

General Discussion

Discussion based on key finding:

1. Factors forming Safety leadership: Honesty (P=0.0070) and Involvement (P=0.0100) aspects have a positive and very significant influence on Safety Leadership. This shows that to build effective safety leadership, honesty and involvement aspects of leaders in implementing safety performance are very crucial. Demonstration (P=0.0416) also has a significant effect. However, Motivation (P=0.638) and Inspiration (P=0.375) do not directly affect Safety Leadership in this model.
2. Without ignoring other forming variables, important mediator variables that need to be considered in developing construction safety performance are:
   a. Safety culture → performance: Significant (O=0.31, P=0.0430). This is an important finding, indicating that safety culture directly contributes to performance. This supports the central role of culture in achieving results.
   b. Participation → safety motivation: Significant (O=0.392, P=0.0136). Employee participation in safety issues is very motivating for them.
   c. Reward & punishment → safety motivation: Very significant (O=0.717, P=0.0003). This is one of the strongest direct effects in the model, indicating that the reward and punishment system has a very large impact on safety motivation.
   d. Safety behavior → safety performance: Significant (O=0.153, P=0.0158). Employee safety behavior directly affects safety performance. This suggests that encouraging safe behavior is key.
   e. Job rotation → safety motivation: Negatively significant (O=-0.026, P=0.0353). This is an unusual finding. Job rotation actually slightly decreases safety motivation. This could be due to several factors, such as uncertainty or reluctance to adapt to a new work environment that potentially has different risks.
3. Impact of “Safety performance (Y)” on Broader Business Outcomes. All paths from the various dimensions of “Safety performance” (Y1-Y5) to specific construction business outcomes (Zero accident, Quality of work, Time aspect, Cost aspect, Company reputation) are highly significant and positive (all P=0.0000). The coefficients are also high (e.g., 0.813 for Safety performance (Y2) → Job quality (Y2)). This is the most dominant and consistent finding in the modelling. It shows that improving safety performance is not only limited to reducing accidents, but also fundamentally improving job quality, time efficiency, cost management, and corporate reputation. This underscores the strategic value of investing in safety.
4. Integration and Overall Conclusions from Both Tables:

a. Long Paths Are Less Practically Relevant: Although one very long indirect path (Safety leadership → safety culture → safety knowledge → safety behavior → safety performance) is statistically significant, its coefficient is zero indicating no practical impact. This suggests that to influence safety performance, the focus should be on more direct paths or stronger mediations.
b. The Crucial Role of Culture and Behavior: Safety culture and safety behavior emerge as significant direct predictors of safety performance. This suggests that initiatives that strengthen safety culture and encourage safe behavior will have a clear impact on performance.
c. Motivation Is Key, Driven by Incentives and Participation: Safety motivation is strongly influenced by reward & punishment systems and participation. These are effective levers to drive motivation.
d. Safety Leadership is Shaped by Personal Characteristics: The model suggests that safety leadership is more a result of traits such as honesty, involvement, and demonstration, rather than directly influencing motivation or evaluation. This may mean that safety leadership operates through more complex or indirect pathways to these factors.
e. Safety Performance is a Strategic Investment: The strongest finding is that safety performance directly and significantly improves a range of desired business outcomes (quality, time, cost, reputation, zero accidents). This strengthens the argument that safety is not just a cost or liability, but a fundamental driver of business value.

Overall, the model has identified several key mechanisms through which safety-related factors interact to influence organizational performance. While some of the long pathways may not be of practical relevance, the model highlights important variables such as safety culture, safety behaviour, motivation (driven by incentives and participation), and the significant impact of safety performance on broader business outcomes.

CONCLUSSION

Based on the results of the calculations that have been carried out, it can be concluded that:

1. Safety leadership has a significant indirect influence on improving safety performance. Strengthening the leadership aspect has the greatest influence on improving work safety culture, which then affects improving aspects of construction safety performance. Although all alternative hypotheses are accepted, it should be noted that this long mediation path does not effectively transfer the influence from safety leadership to safety performance through other mediators.
2. Effective safety evaluation (e.g., constructive and systematic evaluation) can help build a stronger safety culture, which in turn will improve overall safety performance. In addition, the application of innovation in the construction process or safety technology can encourage better safety behaviour among workers, which then contributes to improving safety performance.

Suggestion

As recommendations, although some long paths may not be practically relevant, the model highlights important variables such as safety culture, safety behaviour, motivation (driven by incentives and participation), and the significant impact of safety performance on broader business outcomes. Model development is still very possible.

Based on the conclusions that have been presented, the researcher will provide several suggestions that may be useful in implementing the construction safety leadership model, as follows:

a. Honesty, giving examples and active leadership involvement can build motivation for employees in implementing construction safety.
b. Given that safety culture directly contributes to safety performance, it is necessary to get used to implementing SMKK, participation from all levels and providing rewards & punishments can increase worker motivation in cultivating safety in the work environment.
c. Improving safety performance is not only limited to reducing accidents, but also fundamentally improving the quality of work, time efficiency, cost management, and company reputation. This strengthens the argument that safety is not just a cost or obligation, but is a form of investment and a fundamental driver of business value.

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