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Analyzing the Effects of Supply Chain Management and Skilled Workforce Competency on Project Schedule Delays and Their Implications for Occupational Accident Prevention: Evidence From PT Daidan Group

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Abstract: Project schedule delays and the high risk of workplace accidents remain major issues in construction project management, particularly those related to ineffective supply management and insufficient expert workforce skills. This study aims to analyze the effect of supply management and expert workforce skills on workplace accident prevention, with schedule delays as a mediating variable at PT Daidan Group. The research design employs a quantitative descriptive approach using a survey method. The population consists of technical workers and experts, with a sample of 157 respondents selected using purposive sampling based on the Slovin formula. Data were collected through structured questionnaires using a Likert scale. The data analysis technique applied is Structural Equation Modeling–Partial Least Squares (SEM-PLS). The results indicate that supply management and expert workforce skills have a positive and significant effect on schedule delays and workplace accident prevention. Schedule delays are also found to have a significant effect on workplace accident prevention and act as a mediating variable between independent and dependent variables. Inventory management and job knowledge dimensions are identified as dominant factors in improving operational effectiveness and workplace safety. These findings suggest that effective supply chain management and enhanced workforce competencies can significantly reduce delays and improve safety performance. The discussion highlights the importance of integrating supply management, human resource development, and project time control in creating a safe and efficient work environment. Therefore, companies are recommended to strengthen inventory control systems, enhance workforce training programs, and optimize project time management to support operational performance and sustainable safety culture.

Keyword: Supply Management, Expert Workforce Skills, Schedule Delays, Workplace Accident Prevention.

INTRODUCTION

PT Daidan Group is a national enterprise that has evolved into an integrated business group operating in the mining and shipping-for-mining sectors. To support the distribution of mining outputs, the company operates a fleet of tugboats and barges that require systematic maintenance and periodic repair. As maritime operations expand and operational complexity increases, shipyard activities—particularly ship repair and docking—have become strategically essential for maintaining fleet reliability and operational continuity. Shipyards function not only as technical repair facilities but also as critical control centers for quality assurance, occupational safety, and cost efficiency in maritime operations.

As an organization that emphasizes innovation, integrity, and operational excellence, PT Daidan Group positions shipyard operations as a key element in sustaining its shipping-for-mining business. Activities such as docking, component replacement, hull maintenance, and safety system upgrades must be managed effectively to prevent schedule delays and cost overruns. Accordingly, strengthening human resource competencies, improving material procurement planning, and enhancing project supervision have become central priorities in maintaining fleet performance and competitiveness within the maritime industry.

A preliminary survey was conducted to examine respondents' perceptions of the effectiveness of supply chain management in supporting project execution and occupational safety. The findings indicate that timely availability of materials that meet required specifications plays a crucial role in ensuring smooth project implementation. Conversely, disruptions in material supply often force workers to accelerate tasks under time pressure, which may compromise safety performance. This finding is consistent with prior studies suggesting that supply chain disruptions significantly affect project performance and increase operational risks. Therefore, strengthening supply chain management systems is essential for improving project outcomes and preventing workplace accidents.

However, the survey results also reveal that a proportion of respondents expressed disagreement regarding the effectiveness of current supply chain practices. The logistics coordination dimension recorded relatively high levels of dissatisfaction, indicating that material delivery has not consistently aligned with project schedules. Inventory management was also perceived as suboptimal, with respondents reporting delays in material availability that affect on-site activities. Furthermore, information sharing across departments remains insufficiently transparent, and supplier partnerships, although generally positive, lack consistency. These findings highlight the need for systematic improvements in supply chain management to mitigate project delays and operational inefficiencies.

In addition to supply chain factors, workforce competency represents a critical determinant of occupational accident prevention in project-based and industrial environments. Skilled workers with adequate training and experience are better equipped to understand standard operating procedures, identify potential hazards, and take preventive actions before risks escalate into accidents. Conversely, insufficient technical skills and safety awareness increase the likelihood of human error, negligence, and procedural violations, which are major contributors to workplace accidents. Thus, enhancing workforce competency through structured training and certification programs constitutes a strategic approach to strengthening occupational safety systems.

Within the shipyard industry, workforce competency encompasses technical capabilities such as certified welding, knowledge of ship structures, machinery system installation, and adherence to occupational health and safety (OHS) procedures. According to human capital theory, investments in education and training enhance worker productivity and improve overall work quality. Empirical data within PT Daidan Group indicate an increase in certified skilled workers from 65% in 2022 to 88% in 2025, reflecting the company's commitment to human resource development. This improvement has been accompanied by a reduction in technical errors, from nine cases in 2022 to two cases in 2025, contributing to higher efficiency, reduced

rework, and improved safety outcomes. These findings support previous research highlighting the role of workforce competency in enhancing both operational performance and safety.

Nevertheless, preliminary survey results suggest that workforce competency remains suboptimal in certain aspects. Some respondents reported insufficient mastery of technical procedures and safety standards. The work experience dimension indicates that not all personnel possess adequate experience in similar projects, while coordination among workers is perceived as inconsistent. Additionally, respondents emphasized the need for further technical training to strengthen competencies. These gaps may negatively affect work efficiency and, if unaddressed, increase the risk of project delays and workplace accidents.

Based on the observed conditions in shipyard operations at PT Daidan Group, it is evident that project schedule delays and occupational accident risks are not driven by a single factor but result from the interaction of multiple managerial and operational elements. Supply chain management (X1) plays a crucial role in ensuring timely and accurate material availability, while workforce competency (X2) determines the effectiveness of task execution. Both variables influence schedule delays (Y), which, under certain conditions, can create work pressure and increase the likelihood of unsafe practices, thereby affecting occupational accident prevention (Z). This perspective aligns with project management theory, which identifies schedule performance as a key mediator between operational inputs and safety outcomes

Therefore, the relationships among these variables can be conceptualized more systematically by positioning schedule delay as a mediating variable that links supply chain management and workforce competency to occupational accident prevention. This mediation framework provides a more comprehensive understanding of how operational inefficiencies translate into safety risks and offers a robust theoretical foundation for empirical investigation.

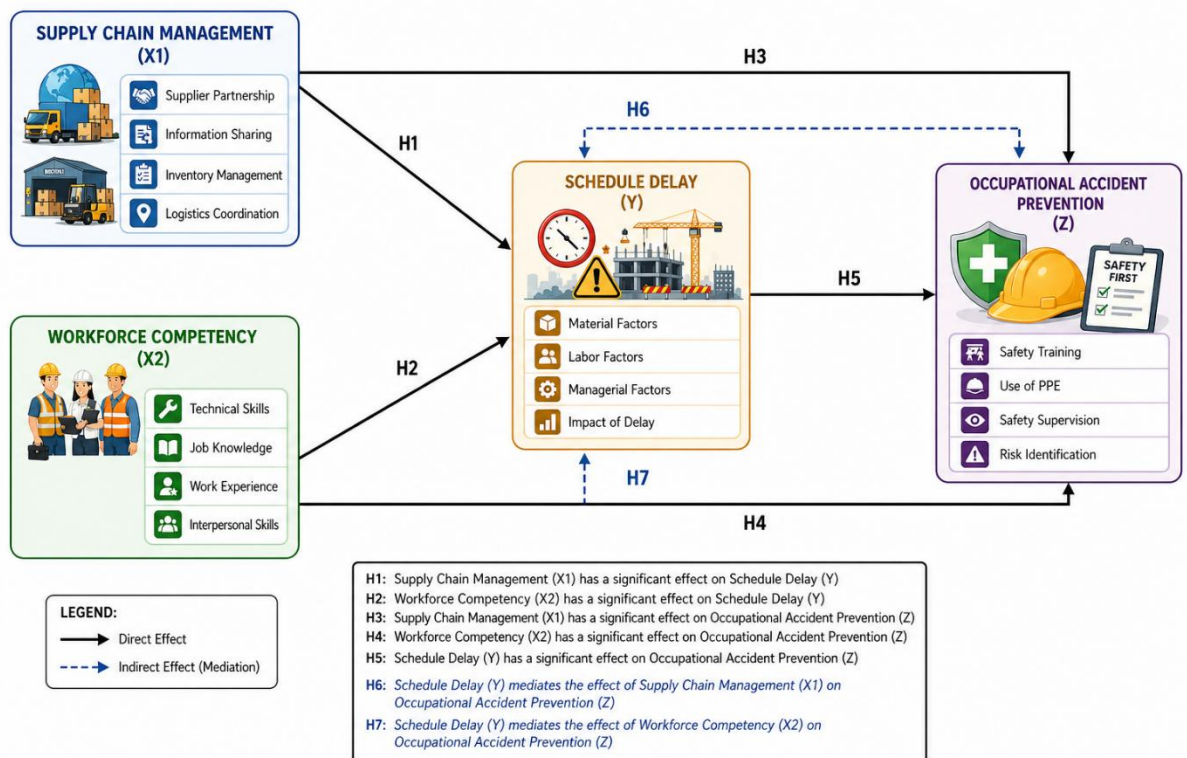


Figure 1. Conceptual Framework

METHOD

The study adopts a quantitative survey-based research design to examine the causal relationships among supply chain management, workforce competency, schedule delays, and

occupational accident prevention. A quantitative approach is appropriate as it enables objective measurement, statistical testing, and generalization of findings through empirical data analysis (Arikunto, 2012; Creswell, 2014; Sugiyono, 2019). The research is grounded in scientific principles—rational, empirical, and systematic—ensuring that the procedures are logically structured, observable, and replicable. Data were collected using a structured questionnaire and analyzed using Structural Equation Modeling with the Partial Least Squares approach (SEM-PLS) using SmartPLS software. The study applies a cross-sectional design, where independent and dependent variables are measured simultaneously at a single point in time, allowing for efficient assessment of relationships among constructs (Hair et al., 2021; Sarstedt et al., 2021).

This research utilizes both primary and secondary data sources to ensure comprehensive analysis. Primary data were obtained through questionnaire distribution to technical workers and skilled experts actively employed at the shipyard of PT Daidan Group in 2025, with a total population of 258 individuals. The sampling technique employed is probability sampling using simple random sampling, ensuring that each member of the population has an equal chance of selection (Sugiyono, 2017). The sample size was determined using the Taro Yamane formula with a 5% margin of error, resulting in 157 respondents (Ridwan & Kuncoro, 2016). The questionnaire was developed based on operationalized indicators of each research variable and measured using a five-point Likert scale to capture respondents' perceptions. Secondary data were collected from official documents, regulations, books, and peer-reviewed journals relevant to the research variables, providing theoretical and contextual support for the study (Umar, 2012; Suryani & Hendryadi, 2015).

Data analysis was conducted using both descriptive and inferential statistical techniques, with SEM-PLS employed as the primary analytical method. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were used to summarize respondent characteristics and variable distributions (Ghozali, 2021; Sekaran & Bougie, 2020). Inferential analysis through SEM-PLS allows simultaneous testing of measurement and structural models, including validity and reliability assessments (convergent validity, discriminant validity, composite reliability, and Cronbach's alpha) as well as hypothesis testing using bootstrapping procedures (Hair et al., 2019; Ghozali, 2017). The structural model evaluation includes R-square, Q-square predictive relevance, and goodness-of-fit indices such as SRMR. Hypothesis testing is conducted at a 5% significance level, where relationships are considered significant if p-values are below 0.05. Furthermore, mediation analysis is performed to assess the indirect effects of supply chain management and workforce competency on occupational accident prevention through schedule delays, providing a comprehensive understanding of both direct and indirect relationships within the proposed model (Sarstedt et al., 2021).

RESULTS AND DISCUSSION

Result

The data in this study were collected from primary sources through structured questionnaires distributed to 157 technical workers and skilled experts at PT Daidan Group's shipyard between March 2 and April 2, 2025. The respondent profile indicates a dominance of male participants (75.2%), with representation across multiple job positions, suggesting a balanced organizational perspective. Most respondents were aged 21–30 years (49.7%) and held a bachelor's degree (64.3%), reflecting a relatively young and educated workforce. These characteristics support the relevance and reliability of the dataset in capturing perceptions related to operational performance and safety practices (Creswell, 2014; Sekaran & Bougie, 2020).

Measurement Model (Outer Model) Result

The measurement model (outer model) evaluation demonstrates strong construct validity and reliability across all variables. All indicators achieved outer loading values above the acceptable threshold (>0.60), confirming convergent validity, while the Fornell–Larcker criterion and cross-loading results indicate adequate discriminant validity, ensuring that each construct is empirically distinct (Hair et al., 2019; Ghozali, 2017). The highest contributing dimensions include inventory management for supply chain management, job knowledge for workforce competency, labor factors for schedule delay, and safety training for accident prevention. These findings confirm that each construct is well-represented by its indicators and suitable for further structural analysis

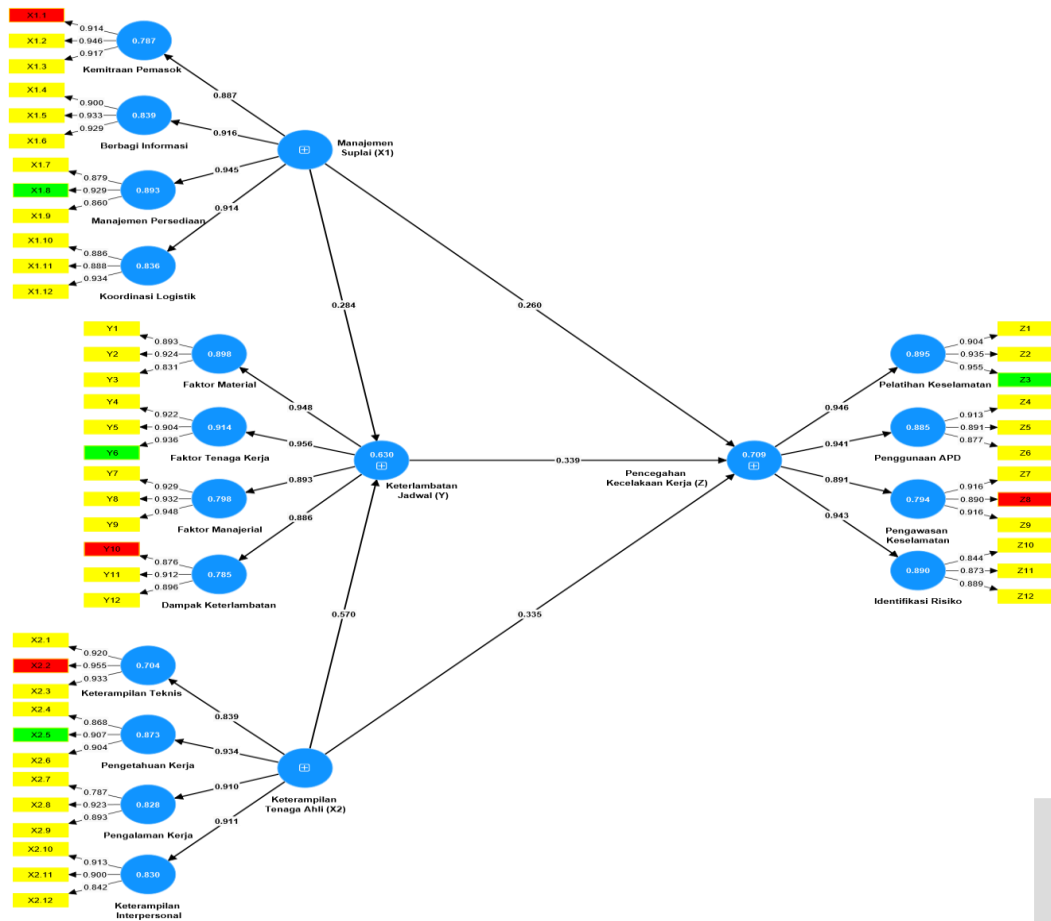


Figure 2. Result Outer Model

Table 1. Construct Reliability Results

Variable	Cronbach’s Alpha	Composite Reliability	Result
Supply Chain Management (X1)	0.959	0.961	Reliable
Workforce Competency (X2)	0.950	0.951	Reliable
Schedule Delay (Y)	0.960	0.962	Reliable
Occupational Accident Prevention (Z)	0.961	0.962	Reliable

The construct reliability results indicate high internal consistency across all variables, with Cronbach’s alpha and composite reliability values exceeding the recommended threshold of 0.70. All constructs fall within the acceptable reliability range, confirming that the measurement instrument consistently captures the intended latent variables (Hair et al., 2019; Hair et al., 2020). The results suggest no redundancy issues, as composite reliability values remain below the upper threshold of 0.95. Therefore, the measurement model is considered

robust and reliable, supporting the validity of subsequent hypothesis testing in the structural model.

Inner Model Results

Table 2. Structural Model Evaluation Results

Evaluation Metric	Variable / Model	Value	Interpretation
R-Square (R ²)	Schedule Delay (Y)	0.630	Moderate
R-Square (R ²)	Occupational Accident Prevention (Z)	0.709	Strong
Q-Square (Q ²)	Predictive Relevance	0.892	Very Strong
SRMR (Saturated Model)	Model Fit	0.080	Acceptable Fit
SRMR (Estimated Model)	Model Fit	0.085	Acceptable Fit
d_ULS (Saturated Model)	Model Discrepancy	29.899	Requires Bootstrap
d_ULS (Estimated Model)	Model Discrepancy	33.613	Requires Bootstrap

The structural model (inner model) evaluation shows that the explanatory power of the model is adequate to strong. The R-square (R²) value for Schedule Delay (Y) is 0.630, indicating that 63.0% of its variance is explained by Supply Chain Management and Workforce Competency, which falls into the moderate category (Ghozali & Latan, 2021). Meanwhile, the R² value for Occupational Accident Prevention (Z) is 0.709, suggesting strong explanatory power, where 70.9% of the variance is explained by Supply Chain Management, Workforce Competency, and Schedule Delay. These findings confirm that the proposed model captures a substantial proportion of the variance in the endogenous constructs, although some unexplained variance remains attributable to external factors.

The predictive relevance of the model was assessed using the Q-square (Q²) statistic, yielding a value of 0.892, which is greater than zero and close to one. This result indicates that the model has very strong predictive relevance, meaning it is capable of explaining 89.2% of the variability in the endogenous variables (Hair et al., 2019). Such a high Q² value confirms that the model possesses strong out-of-sample predictive capability and is suitable for hypothesis testing. Therefore, the structural model can be considered robust in terms of both explanatory and predictive performance.

The goodness-of-fit (GoF) assessment further supports the adequacy of the model. The SRMR values are 0.080 for the saturated model and 0.085 for the estimated model, both within the acceptable threshold (≤ 0.10), indicating an acceptable model fit (Hair et al., 2019). Although the d_ULS values show some discrepancy between empirical and estimated correlation matrices, this is common in SEM-PLS and typically evaluated through bootstrapping procedures. Overall, the model demonstrates a satisfactory level of fit, suggesting that it is appropriate for further hypothesis testing while acknowledging potential areas for refinement.

Hypothesis Testing Results

The hypothesis testing results indicate that all proposed relationships in the structural model are statistically significant at the 5% significance level. Each hypothesis demonstrates a t-statistic greater than the critical value (1.96) and a p-value below 0.05, confirming empirical support for both direct and indirect effects (Hair et al., 2019; Sarstedt et al., 2021). Workforce Competency (X2) shows the strongest direct effect on Schedule Delay (Y) ($\beta = 0.570$; $t = 7.211$), while Schedule Delay (Y) also significantly influences Occupational Accident Prevention (Z) ($\beta = 0.339$; $t = 2.501$). Additionally, both Supply Chain Management (X1) and Workforce Competency (X2) exhibit significant indirect (mediated) effects on Occupational Accident Prevention through Schedule Delay, confirming the mediating role of Y in the model.

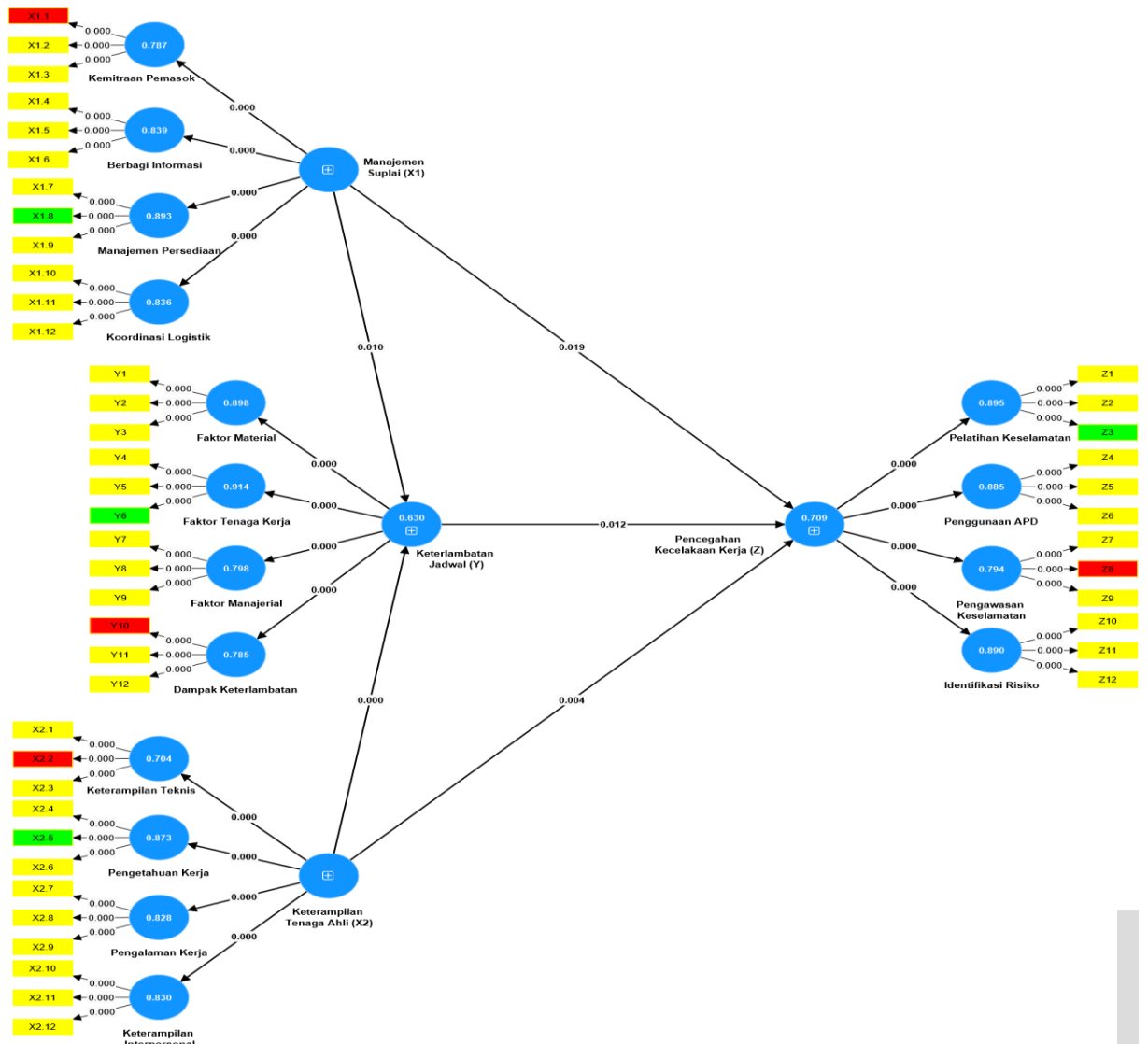


Figure 3. Model Bootstrapping (Inner Model)

Table 3. Hypothesis Testing Results (SEM-PLS)

Hypothesis	Relationship	Path Coefficient (β)	T-Statistic	P-Value	Result
H1	Supply Chain Management (X1) → Schedule Delay (Y)	0.284	2.569	0.010	Supported
H2	Workforce Competency (X2) → Schedule Delay (Y)	0.570	7.211	0.000	Supported
H3	Supply Chain Management (X1) → Occupational Accident Prevention (Z)	0.260	2.337	0.019	Supported
H4	Workforce Competency (X2) → Occupational Accident Prevention (Z)	0.335	2.882	0.004	Supported
H5	Schedule Delay (Y) → Occupational Accident Prevention (Z)	0.339	2.501	0.012	Supported
H6	Supply Chain Management (X1) → Schedule Delay (Y) → Accident Prevention (Z)	0.316	2.878	0.004	Supported
H7	Workforce Competency (X2) → Schedule Delay (Y) → Accident Prevention (Z)	0.193	2.339	0.019	Supported

Discussion

H1. The Effect of Supply Chain Management on Schedule Delay

The results indicate that supply chain management has a significant effect on schedule delay ($t = 2.569$; $p = 0.010$), suggesting that improved supply chain practices can effectively reduce project delays. Effective supply chain management involves material requirement planning, distribution control, and coordination among stakeholders within the supply network. Inefficiencies in these aspects often lead to delays in material delivery, which directly disrupt project timelines. Therefore, supply chain management plays a crucial role in ensuring timely project execution, and the first hypothesis is empirically supported.

These findings further reveal that schedule delays are not solely caused by technical issues in the field but are also significantly influenced by suboptimal supply chain systems. Poor coordination among suppliers, distributors, and project teams, along with inaccurate logistics planning and weak risk anticipation, exacerbates delays. This highlights the importance of integrating information systems within supply chain management to enhance transparency and distribution accuracy. Previous studies support this finding, as Gunasekera, Cain, and Smith (2015) emphasize that system-based supply chain management reduces operational risks, while Rashid (2020) and Messah (n.d.) identify material and supply factors as primary causes of delays. Similarly, Czajkowska (2025) and Sari (2024) confirm that effective supply chain risk and logistics management significantly reduce project disruptions.

H2. The Effect of Workforce Competency on Schedule Delay

The findings show that workforce competency has a significant and strong effect on schedule delay ($t = 7.211$; $p = 0.000$), indicating that employee skills, experience, and competence are key determinants of timely project completion. Highly skilled workers can perform tasks more efficiently, accurately, and with fewer errors, thereby accelerating project progress. In contrast, less skilled workers tend to repeat mistakes, resulting in inefficiencies and delays. Thus, the second hypothesis is strongly supported.

Furthermore, the results suggest that human resources are a primary determinant in controlling project delays. Workforce competency influences not only work speed but also the quality of output, which directly affects time efficiency. Lack of training, limited experience, and insufficient technical skills are major contributors to delays. These findings are consistent with prior studies, where Hussain (2020) highlights that skilled labor enhances productivity, while Rahayu and Sawitri (2025) and Saleh and Othman (2022) emphasize the role of training and competence in improving project performance. Additionally, Sari (2024) and related studies (2023) confirm that workforce quality is a critical factor in project time management.

H3. The Effect of Supply Chain Management on Occupational Accident Prevention

The results demonstrate that supply chain management significantly influences occupational accident prevention ($t = 2.337$; $p = 0.019$). Effective supply chain management ensures the availability of personal protective equipment (PPE), safety tools, and standardized materials required for safe operations. Delays or inconsistencies in providing these resources can increase workplace hazards and accident risks. Therefore, supply chain management plays a vital role in supporting occupational safety, and the third hypothesis is accepted.

These findings indicate that workplace safety depends not only on individual behavior but also on supporting systems such as supply chain management. Timely and adequate provision of safety equipment is essential for preventing accidents, while poor procurement planning and weak monitoring increase risk exposure. Prior research supports this conclusion, as Gunasekera, Cain, and Smith (2015) highlight the role of supply systems in risk control, Zhang et al. (2024) link supply chain pressure to safety behavior, and Winahyu and Paramarta (2025) identify logistics failures as contributors to unsafe conditions. EU-OSHA (n.d.) further emphasizes that well-managed supply chains improve occupational safety standards.

H4. The Effect of Workforce Competency on Occupational Accident Prevention

The results show that workforce competency has a significant effect on occupational accident prevention ($t = 2.882$; $p = 0.004$), indicating that higher skill levels enhance safety performance. Skilled workers possess better understanding of safety procedures and are more capable of identifying and mitigating risks in the workplace. Additionally, higher competency reduces human error, which is a major cause of accidents. Therefore, workforce competency is a key factor in creating a safe working environment, and the fourth hypothesis is supported.

The findings further reveal that human resource factors play a strategic role in occupational safety systems. Lack of training and experience increases accident risks, as unskilled workers are more likely to ignore safety procedures and engage in unsafe practices. These results are consistent with prior studies, where Rahayu and Sawitri (2025) and Saleh and Othman (2022) identify competency as a critical determinant of safety performance. Hussain (2020) and Firdaus (2023) also emphasize that skilled workers contribute to both safety and productivity, reinforcing the importance of workforce development programs.

H5. The Effect of Schedule Delay on Occupational Accident Prevention

The findings indicate that schedule delay significantly affects occupational accident prevention ($t = 2.501$; $p = 0.012$). Delays often create time pressure, forcing workers to accelerate tasks and potentially neglect safety procedures. This situation increases the likelihood of errors and unsafe practices, thereby elevating accident risks. Consequently, the fifth hypothesis is supported.

The results also show that time management is closely related to workplace safety. Schedule delays not only affect project performance but also increase accident risks due to rushed work and reduced caution. Poor project scheduling and ineffective time management further exacerbate unsafe conditions. Previous studies support this finding, as Rashid (2020) and Messah (n.d.) highlight the link between delays and work pressure, while Saleh and Othman (2022) and Sari (2024) confirm that poor project management increases safety risks. Studies (2023) also identify time pressure as a major cause of workplace accidents.

H6. The Indirect Effect of Supply Chain Management on Occupational Accident Prevention through Schedule Delay

The results confirm that supply chain management has a significant indirect effect on occupational accident prevention through schedule delay ($t = 2.878$; $p = 0.004$), indicating a mediating role of schedule delay. Effective supply chain management reduces delays, which in turn lowers time pressure and enhances safety performance. Conversely, supply disruptions increase delays and subsequently elevate accident risks. Therefore, the sixth hypothesis is accepted.

These findings highlight the importance of schedule delay as a mediating variable linking supply chain management and safety outcomes. Poorly managed delays increase work pressure, reduce compliance with safety procedures, and create unsafe conditions. Prior research supports this mechanism, as Gunasekera, Cain, and Smith (2015) and Czajkowska (2025) emphasize the role of supply chain risk management, while Rashid (2020) and EU-OSHA (n.d.) highlight the relationship between delays and safety risks. Studies (2023) further confirm that time pressure is a major contributor to workplace accidents.

H7. The Indirect Effect of Workforce Competency on Occupational Accident Prevention through Schedule Delay

The findings show that workforce competency significantly affects occupational accident prevention through schedule delay ($t = 2.339$; $p = 0.019$), confirming the mediating role of schedule delay. Skilled workers are able to complete tasks efficiently, reducing delays and

associated time pressure, which ultimately enhances safety performance. In contrast, low competency leads to inefficiencies and increased accident risks. Thus, the seventh hypothesis is supported.

The results also indicate that workforce competency influences safety both directly and indirectly through time management mechanisms. Competent workers can maintain schedule adherence, thereby reducing stress and operational risks. Previous studies support this relationship, as Hussain (2020) and Rahayu and Sawitri (2025) highlight the role of skills in efficiency and safety, while Sari (2024) and Saleh and Othman (2022) link workforce limitations to delays and accidents. Additional studies (2023) confirm that human resource quality significantly affects project time performance and safety outcomes.

CONCLUSION

The findings indicate that supply chain management and workforce competency have positive and significant effects on schedule delay. Supply chain management, particularly the inventory management dimension (loading = 0.945), emerges as the most dominant factor, emphasizing the importance of material availability, stock control, and distribution accuracy in minimizing delays. This is further supported by indicator X1.8 (loading = 0.929), which highlights the critical role of effective inventory control. The hypothesis testing results ($t = 2.569$; $p = 0.010$) confirm that improved supply chain practices significantly reduce schedule delays. Similarly, workforce competency demonstrates a stronger effect ($t = 7.211$; $p = 0.000$), with the job knowledge dimension (loading = 0.934) and indicator X2.5 (loading = 0.907) indicating that technical understanding and procedural knowledge are essential in enhancing time efficiency. These results suggest that both operational systems and human capital are key drivers in ensuring project timeliness.

Furthermore, both supply chain management and workforce competency significantly influence occupational accident prevention. The inventory management dimension (loading = 0.945) again plays a crucial role, indicating that the availability of safety equipment and materials directly supports workplace safety. This is validated by the significant effect of supply chain management ($t = 2.337$; $p = 0.019$). Workforce competency also shows a significant contribution ($t = 2.882$; $p = 0.004$), with job knowledge (loading = 0.934) being the dominant factor in ensuring adherence to safety procedures and risk awareness. In addition, schedule delay significantly affects occupational accident prevention ($t = 2.501$; $p = 0.012$), where the labor factor dimension (loading = 0.956) and indicator Y6 (loading = 0.936) reveal that reduced productivity and time pressure contribute to unsafe working conditions. These findings confirm that operational efficiency and workforce capability are closely linked to safety performance.

Finally, the results confirm that schedule delay plays a significant mediating role in the relationship between both independent variables and occupational accident prevention. Supply chain management indirectly affects safety through schedule delay ($t = 2.878$; $p = 0.004$), indicating that effective material management reduces delays, which in turn enhances safety outcomes. Similarly, workforce competency shows a significant indirect effect ($t = 2.339$; $p = 0.019$), where higher skill levels improve time efficiency and reduce work pressure, ultimately lowering accident risks. The dominance of the inventory management (0.945) and job knowledge (0.934) dimensions further reinforces the importance of both system efficiency and human competence in achieving optimal safety performance. Thus, schedule delay serves as a critical mediating variable that strengthens the relationship between operational management, workforce capability, and occupational safety.

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