Ilomata International Journal of Management

OPEN ACCESS

RECEIVED 14 March 2026
ACCEPTED 9 June 2026
PUBLISHED 31 July 2026

CITATION
Hadiani NA, Sadikin A, Hidayatullah M (2026). Boosting Risk Management Performance through Human Capital Capacity, Managerial Commitment, and Effective Implementation Processes. Ilomata International Journal of Management. 7 (3), 1150-1160.
doi: 10.61194/ijjm.v7i3.2301

TYPE Original Research
PUBLISHED 31 July 2026
DOI 10.61194/ijjm.v7i3.2301
VOL 7 Issue 3 July 2026

Boosting Risk Management Performance through Human Capital Capacity, Managerial Commitment, and Effective Implementation Processes

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Abstract

Risk management in utility infrastructure depends on two behavioral foundations: technical competence of operational staff and strategic commitment of leaders. This study examines how human capital capacity and managerial commitment are associated with risk management implementation process, risk management effectiveness, and risk management performance at PT PLN (Persero) UIP3B Kalimantan. Prior studies emphasize technical risk frameworks, yet limited attention has been given to how organizational behavior and leadership commitment relate to implementation quality and perceived performance outcomes in state-owned utility settings. Data were collected through a census survey of 170 technical personnel directly involved in risk management activities, complemented by assessments from 12 supervisory performance raters. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to examine the hypothesized structural relationships. Results indicate that managerial commitment shows the strongest association with implementation quality, while human capital capacity shows a smaller but significant association. Implementation process and risk management effectiveness indicate a possible pathway linking behavioral inputs to perceived risk management performance. However, this pathway should be interpreted cautiously because the mediation effects are weak, the explained variance for effectiveness is low, and effectiveness and performance may share overlapping perceptual domains. The study is bounded by a single-organization, cross-sectional design with self-reported and supervisory perception-based measures; therefore, the findings should be generalized cautiously and validated through longitudinal designs and objective operational indicators.

KEYWORDS

human capital; managerial commitment; implementation process; risk management effectiveness; risk management performance.

Introduction

Electricity infrastructure serves as critical infrastructure for national economic growth, requiring governance frameworks that systematically integrate risk awareness, standardized procedures, and continuous monitoring. Recent empirical work emphasizes that operational effectiveness depends on integration of formal processes, operational audits, dynamic risk oversight, and resilience-oriented power-system governance (Ghanbari & Jiang, 2025; Lin & Wu, 2024; Pecina et al., 2022; Sadiq et al., 2024; J. Zhang et al., 2025).

A persistent operational challenge in utility settings involves the disconnect between formal risk governance policies and practical execution. Contemporary research identifies three critical barriers: uncertain environmental dynamics, integration gaps within siloed management systems, and insufficient integration between risk management and decision-making routines

(AL Jarrah et al., 2022; Anton & Nucu, 2020; Crovini et al., 2021; Dvorski Lacković et al., 2022; Khalil-Oliwa & Jonek-Kowalska, 2024). Operational challenges documented in utility infrastructure settings reveal that implementation effectiveness and technical workforce competency represent significant leverage points for performance improvement, patterns consistently reflected in UIP3B Kalimantan's strategic risk governance assessments (AL Jarrah et al., 2022; PT PLN (Persero) UIP3B Kalimantan, 2025; Sadiq et al., 2024). While contemporary risk management literature emphasizes macro-level resilience and financial metrics, limited empirical attention has been directed toward the techno-managerial dynamics linking behavioral inputs to operational reliability outcomes in state-owned utility providers (Brodie-Good, 2022; Wang, 2025).

Current academic discourse has not fully mapped how human capital and managerial commitment jointly shape the implementation pathway that connects risk governance policy to operational performance outcomes, particularly grid reliability indicators such as forced outage reduction. Energy-sector and power-system studies increasingly emphasize resilience, reliability, and risk governance in electricity infrastructure, yet they rarely test the behavioral implementation pathway in a state-owned transmission organization (Lin & Wu, 2024; Migisha et al., 2023; Mohanty et al., 2024; Pecina et al., 2022). This research gap is significant because most existing implementation science frameworks focus on healthcare or public health sectors, leaving utility infrastructure settings under-theorized and under-examined.

Foundational theories propose that organizational performance reflects the quality of internal resources and the strategic orientation of leadership. Prior work on enterprise risk management, human capital, and upper-echelon decision-making identifies internal capability, leadership commitment, and risk governance maturity as primary drivers of strategic execution (Bohnert et al., 2019; Callahan & Soileau, 2017; Florio & Leoni, 2017; Hambrick & Mason, 1984; Horvey & Ankamah, 2020; Saeidi et al., 2019; Syrová & Špička, 2023). Implementation science emphasizes context-driven frameworks for translating policy into organizational practice (Damschroder et al., 2022; J. Zhang et al., 2025). Effectiveness of risk controls is also shaped by organizational dynamics including decision-making integration, implementation structure, and performance-management alignment (Crovini et al., 2021; Dvorski Lacković et al., 2022; Hristov et al., 2024; Zhu et al., 2023). Despite these theoretical foundations, the specific mechanism through which human capital and managerial commitment jointly influence risk management implementation and subsequent performance in utility contexts remains under-researched (Dellana et al., 2022; Rantala et al., 2024; Wahid et al., 2022).

Consequently, this study investigates how human capital capacity and managerial commitment relate to risk management implementation processes and how implementation effectiveness subsequently relates to overall risk management performance in state-owned utility infrastructure. The contribution is contextual and empirical: the study provides evidence from a utility setting on how Resource-Based View and Upper Echelons Theory operate within infrastructure reliability contexts, while offering a strategic framework for similar organizations to strengthen performance through targeted human capital development and sustained leadership engagement.

Literature Review

Human Capital As A Strategic Asset in Risk Management

Effective risk governance in utility infrastructure fundamentally depends on the technical competence and analytical capabilities of operational personnel. Human capital encompassing specialized knowledge, technical proficiencies, and cognitive agility has been established as critical for identifying vulnerabilities and executing mitigation protocols. Across multiple empirical contexts, human capital emerges as a measurable predictor of risk management effectiveness (Bruwer et al., 2022; Nikolaenko & Sidorov, 2023; Wahid et al., 2022).

However, the mechanism through which human capital influences outcomes remains contested in the literature. Some studies position human capital as a direct driver of risk effectiveness (Wahid et al., 2022), whereas implementation-oriented studies suggest that competence may operate indirectly through execution fidelity (AL Jarrah et al., 2022; Egila et al., 2025). In utility-specific contexts, limited empirical evidence exists on whether human capital's primary effect is on implementation process quality or on direct risk effectiveness. Internal strategic documents at UIP3B Kalimantan identify competency and maintenance bottlenecks as implementation constraints, suggesting that human capital deficits may constrain execution capacity, yet these documents do not test the sequential pathway from human capital through implementation to final performance outcomes (PT PLN (Persero) UIP3B Kalimantan, 2025). Thus, the specific role of human capital in driving implementation fidelity within utility settings remains empirically under-determined.

Managerial Commitment as the Structural Backbone of Risk Governance

Upper Echelons Theory posits that executive values and strategic orientation directly shape organizational outcomes. Applied to risk governance, this theory suggests that active leadership engagement is essential for embedding risk strategies into organizational systems and performance-management routines (Dvorski Lacković et al., 2022; Hambrick & Mason, 1984; Hristov et al., 2022). Managerial commitment transcends passive endorsement; empirical studies document that it manifests through dedicated resource allocation, strict policy enforcement, and active personnel motivation to adhere to mitigation protocols (Wahid et al., 2022; W. Zhang et al., 2025).

Despite established theoretical importance, empirical studies rarely specify how managerial commitment operationalizes into implementation quality within utility contexts. Governance and upper-echelon perspectives establish that leadership orientation is consequential, but they do not fully specify whether commitment operates primarily through resource mobilization, behavioral modeling, or implementation governance structures (Dvorski Lacković et al., 2022; Hambrick & Mason, 1984; Hristov et al., 2024). At UIP3B Kalimantan, preliminary evidence suggests that visible executive sponsorship acts as a catalyst for the implementation process, yet no published study has empirically tested this pathway within energy transmission settings. This represents a critical gap: the mechanism linking managerial commitment to implementation fidelity in state-owned utilities remains theoretically plausible but empirically unconfirmed.

Implementation Process as the Critical Mediating Mechanism

Global frameworks such as ISO 31000:2018 and COSO ERM provide architectural guidelines for risk assessment and governance. However, true operational effectiveness requires disciplined, localized execution strategy (Egila et al., 2025; Glevitzky et al., 2025). Literature demonstrates that implementation demands rigorous adherence to protocols, continuous monitoring of operational hazards, and adaptive feedback loops.

Recent evidence shows that systematic implementation processes support stronger control over operational disruptions in infrastructure and project-based settings

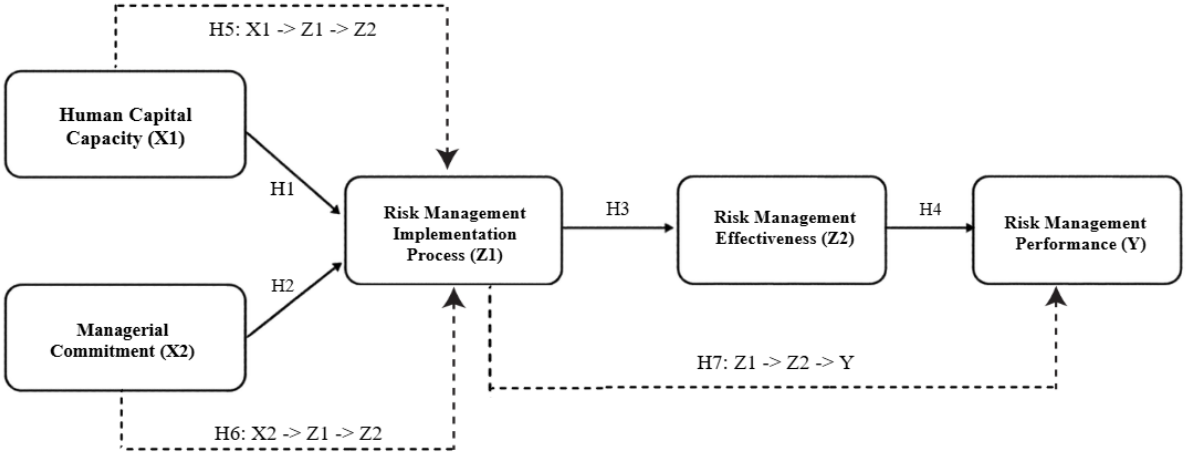

Figure 1. Research Conceptual Framework

(AL Jarrah et al., 2022; Ghanbari & Jiang, 2025; Sadiq et al., 2024). However, existing studies treat implementation as either an outcome variable (driven by human capital and commitment) or as an antecedent to effectiveness, rarely examining it as a mediating mechanism within a sequential chain. The "Implementation-Effectiveness-Outcome" paradigm (Migisha et al., 2023) suggests that structured procedural execution translates into tangible operational metrics such as enhanced grid reliability and reduced forced outage rates. Yet empirical studies in utility infrastructure have not systematically tested whether implementation quality serves as the primary pathway through which human capital and managerial commitment jointly drive risk management performance. This sequential mediation mechanism remains theoretically implied but empirically unvalidated in utility-specific contexts.

The Convergence of Human Capital, Commitment, and Implementation

Despite the established significance of human capital, managerial commitment, and implementation as individual constructs, a distinct empirical gap persists regarding their specific, sequential interactive effects within utility infrastructure settings. Risk management and safety literature suggests that organizational resilience emerges from the interplay between competent personnel, structured processes, and leadership-supported control systems (Gorzeń-Mitka & Wieczorek-Kosmala, 2023; Rantala et al., 2024). However, contemporary risk management research remains predominantly focused on corporate financial metrics, frequently overlooking the behavioral and operational nuances critical to energy infrastructure reliability.

The closest prior studies addressing related questions do not fully map the proposed indirect pathway structure. Wahid et al. (2022)examine human capital and commitment effects in an electronic risk management setting, but do not test whether implementation process mediates the relationship between behavioral inputs and risk management effectiveness. Al Jarrah et al. (2022) examine project implementation and risk management relationships, but not within state-owned electricity transmission. UIP3B Kalimantan internal documents identify implementation and competency concerns, but do not empirically model how human capital and commitment relate to implementation process and effectiveness (PT PLN (Persero) UIP3B Kalimantan, 2025). No published study has simultaneously aligned human capital capacity, managerial commitment, implementation process, effectiveness, and performance within a state-owned utility infrastructure model. This empirical void forms the foundation for the present study's research questions and conceptual framework, which will be detailed in the subsequent section.

Conceptual Framework and Hypotheses

Human Capital Capacity denotes specialized knowledge and technical competencies of operational personnel in risk management, distinct from general capability (Wahid et al., 2022). Managerial Commitment refers to observable resource allocation and policy enforcement, operationalized through procedural execution and risk governance alignment (Dvorski Lacković et al., 2022; Hristov et al., 2024). Risk Management Implementation Process captures execution fidelity of standardized procedures and is positioned as the mediator between behavioral inputs and risk management effectiveness (Egila et al., 2025). Risk Management Effectiveness measures perceived success in mitigating operational risks and is positioned as the mediator between implementation process and perceived risk management performance (Migisha et al., 2023). Risk Management Performance represents the perceived final outcome related to reduced forced outages and improved grid reliability (Ghanbari & Jiang, 2025; Lin & Wu, 2024). The revised hypothesis structure avoids duplicated mediation claims by separating two implementation-mediated paths to effectiveness and one effectiveness-mediated path to performance.

Based on the structural relationships depicted in the conceptual framework (Figure 1), the following hypotheses are formulated for empirical testing:

- H1: Human capital capacity has a positive and significant association with risk management implementation process.
- H2: Managerial commitment has a positive and significant association with risk management implementation process.
- H3: Risk management implementation process has a positive and significant association with risk management effectiveness.
- H4: Risk management effectiveness has a positive and significant association with risk management performance.
- H5: Risk management implementation process mediates the relationship between human capital capacity and risk management effectiveness.
- H6: Risk management implementation process mediates the relationship between managerial commitment and risk management effectiveness.
- H7: Risk management effectiveness mediates the relationship between risk management implementation process and risk management performance.

Methods

This study employed a cross-sectional explanatory survey design to examine the hypothesized structural relationships among human capital capacity, managerial commitment, risk management implementation process, risk management effectiveness, and risk management performance at PT PLN (Persero) UIP3B Kalimantan. Since the data were collected at one point in time, the findings support prediction-oriented and associational interpretation, not cause-and-effect inference. This design was appropriate for testing structural associations and mediation pathways among latent constructs within a specific organizational setting (Creswell & Creswell, 2023; Hair et al., 2019).

The primary respondents were 170 technical personnel directly involved in risk management activities. The unit of analysis was the individual technical personnel respondent. In addition, 12 managerial staff were involved only as supervisory performance raters, not as primary research respondents. These managerial raters assessed risk management effectiveness and risk management performance based on their supervisory knowledge of the relevant work units. Their ratings were matched with the corresponding technical personnel data based on work-unit and supervisory linkage. Therefore, the PLS-SEM model was estimated using 170 individual-level observations, while the 12 managerial ratings were used only to complement outcome measurement and reduce common method bias.

Data were collected using a structured questionnaire with a 1 to 10 Likert scale. Technical personnel assessed human capital capacity, managerial commitment, and risk management implementation process, while managerial raters assessed risk management effectiveness and risk management performance. All constructs were modeled as reflective constructs, so formative measurement assessment was not conducted. The measurement items were adapted from established risk management and organizational behavior literature (COSO, 2013; Dvorski Lacković et al., 2022; ISO, 2018; Wahid et al., 2022).

Partial Least Squares Structural Equation Modeling, or PLS-SEM, was conducted using SmartPLS 4 because it is suitable for prediction-oriented analysis, latent variable assessment, and testing direct and indirect relationships in a structural model. The measurement model was assessed through outer loadings, Average Variance Extracted, Cronbach's Alpha, Composite Reliability, and Heterotrait-Monotrait ratio. The structural model was assessed through path coefficients, R^2, f^2, Q^2 predictive relevance, and bootstrapping with 5,000 resamples to test direct and indirect effects. Common method bias was reduced by separating predictor and outcome measurements across different sources. However, temporal ambiguity, reverse association, and omitted variable bias cannot be fully ruled out due to the cross-sectional design. Thus, the results should be interpreted as predictive and associational rather than evidence of temporal cause-and-effect (Hair et al., 2019).

Result and Discussion

The research examines UIP3B Kalimantan, a regional transmission operator responsible for electricity transmission infrastructure. This organization provided the empirical context for investigating relationships between human capital capacity, managerial commitment, implementation processes, and risk management outcomes. The organization employs ISO 31000 and COSO ERM frameworks to structure risk governance activities, consistent with the broader use of enterprise risk management systems in electric power companies (ISO, 2018; Pecina et al., 2022).

Respondent Characteristics and Data Quality Considerations

The primary survey respondents comprised 170 technical personnel, while 12 managerial staff served only as supervisory raters for risk management effectiveness and risk management performance. All variables Human Capital Capacity (X1), Managerial Commitment (X2), Risk Management Implementation Process (Z1), Risk Management Effectiveness (Z2), and Risk Management Performance (Y) were assessed on 1-10 Likert scales. Mean scores ranged from 8.29 to 8.45, with standard deviations between 0.87 and 1.12. Human Capital Capacity (X1) scored 8.29 (SD = 0.98), Managerial Commitment (X2) scored 8.35 (SD = 0.95), Implementation Process (Z1) scored 8.34 (SD = 0.97), Effectiveness (Z2) scored 8.35 (SD = 1.12), and Performance (Y) scored 8.45 (SD = 0.87).

These uniformly elevated means warrant interpretive caution. The narrow response dispersion and ceiling effect (75-80% of responses concentrated in 8-10 range) indicate three interpretive concerns: (1) ceiling effects limiting discriminatory power of measurement scales; (2) positive-response bias potentially reflecting social desirability in organizational self-report settings; (3) limited variance constraining ability to detect relationships across full scale range. High self-reported scores should not be interpreted as definitive evidence of strong real-world implementation quality. Rather, they indicate respondent perceptions within UIP3B Kalimantan. Actual operational effectiveness (forced outage frequency, equipment failure rates) was not independently verified. External validation against objective operational metrics would be necessary to distinguish between genuine organizational strength and biased responding.

PLS-SEM Analysis Results

Partial Least Squares-Structural Equation Modeling (PLS-SEM) was used to examine the hypothesized structural relationships between Human Capital Capacity (X1), Managerial Commitment (X2), Implementation Process (Z1), Risk Management Effectiveness (Z2), and Risk Management Performance (Y). The evaluation process is divided into the measurement model (outer model) to ensure instrument quality and the structural model (inner model) to test the strength of the hypothesized paths.

Assessment of the Measurement Model (Outer Model)

The measurement model was assessed to ensure that all reflective constructs were measured validly and reliably. The evaluation focused on outer loadings, Cronbach's Alpha, Composite Reliability, Average Variance Extracted (AVE), and the Heterotrait-Monotrait Ratio (HTMT) (see Table 1). The criteria used were outer loading > 0.70, Cronbach's Alpha > 0.70, Composite Reliability > 0.70, AVE > 0.50, and HTMT < 0.90.

The results show that all indicators had outer loading values above 0.70, ranging from 0.720 to 0.938. This indicates that all indicators adequately represented their respective latent constructs. Therefore, no indicator was removed from the measurement model. Convergent validity and internal consistency reliability were also supported. AVE values ranged from 0.638 to 0.806, exceeding the 0.50 threshold. Composite Reliability values ranged from 0.898 to 0.953, while Cronbach's Alpha values ranged from 0.858 to 0.936. These results indicate that all constructs met the required reliability and convergent validity criteria. However, the lower AVE values for Risk Management Implementation Process, Risk Management Effectiveness, and Risk Management Performance suggest that some item variance remains unexplained. Therefore, although the constructs meet the minimum validity criteria, the results should still be interpreted cautiously.

Discriminant validity was assessed using Heterotrait-

Table 1. Measurement Model Assessment Results

Construct	Indicator	Outer Loading	Cronbach's Alpha	AVE	Composite Reliability
Human Capital Capacity (X1)	X1.1	0.875	0.936	0.806	0.953
	X1.2	0.851			
	X1.3	0.756			
	X1.4	0.777			
	X1.5	0.842			
	X1.6	0.876			
	X1.7	0.756			
	X1.8	0.858			
	X1.9	0.809			
	X1.10	0.724			
Managerial Commitment (X2)	X2.1	0.900	0.911	0.746	0.936
	X2.2	0.918			
	X2.3	0.833			
	X2.4	0.733			
	X2.5	0.868			
	X2.6	0.798			
	X2.7	0.806			
	X2.8	0.793			
	X2.9	0.72			
	X2.10	0.914			
Risk Management Implementation Process (Z1)	Z1.1	0.886	0.878	0.673	0.911
	Z1.2	0.791			
	Z1.3	0.787			
	Z1.4	0.826			
	Z1.5	0.752			
	Z1.6	0.903			
	Z1.7	0.801			
	Z1.8	0.748			
	Z1.9	0.894			
	Z1.10	0.821			
Risk Management Effectiveness (Z2)	Z2.1	0.938	0.884	0.685	0.916
	Z2.2	0.757			
	Z2.3	0.740			
	Z2.4	0.758			
	Z2.5	0.770			
	Z2.6	0.910			
	Z2.7	0.792			
	Z2.8	0.934			
	Z2.9	0.911			
	Z2.10	0.925			
Risk Management Performance (Y)	Y.1	0.805	0.858	0.638	0.898
	Y.2	0.808			
	Y.3	0.754			
	Y.4	0.815			
	Y.5	0.754			
	Y.6	0.777			
	Y.7	0.827			
	Y.8	0.815			
	Y.9	0.726			
	Y.10	0.730			

Source: Primary Data, processed using SmartPLS 4, 2026.

Monotrait (HTMT) ratio analysis. All HTMT values remained below the 0.90 threshold, meeting conventional discriminant validity criteria. However, relatively higher HTMT ratios between Managerial Commitment and Implementation Process (0.550) and between Human Capital and Managerial Commitment (0.618) suggest these construct pairs share moderate common variance (30-35%), indicating potential overlapping conceptual domains. While discriminant validity criteria are met, these moderate correlations warrant acknowledgment that some constructs may be partly capturing similar organizational phenomena. The measurement model is therefore considered adequate for structural model assessment, although the moderate HTMT values among several governance-related constructs indicate that potential conceptual proximity should still be interpreted cautiously. Cross-loading values are provided in the supplementary appendix to support item-level discriminant validity assessment. The cross-loading results were used to verify whether each indicator loaded more strongly on its intended construct than on other constructs. This additional reporting improves the transparency of the measurement model beyond construct-level reliability, AVE, and HTMT results.

Assessment of the Structural Model (Inner Model)

Table 2. Coefficient of Determination

Endogenous Construct	R^2	Interpretation
Risk Management Implementation Process (Z1)	0.921	High, interpreted cautiously
Risk Management Effectiveness (Z2)	0.02	Very low
Risk Management Performance (Y)	0.946	High, with possible construct overlap

Source: Primary Data, processed using SmartPLS 4, 2026.

Table 3. Effect Size

Predictor Path	Endogenous Construct	f^2	Effect Interpretation
Human Capital Capacity → Risk Management Implementation Process	Risk Management Implementation Process (Z1)	0.311	Medium
Managerial Commitment → Risk Management Implementation Process	Risk Management Implementation Process (Z1)	1.961	Large
Risk Management Implementation Process → Risk Management Effectiveness	Risk Management Effectiveness (Z2)	0.02	Small
Risk Management Effectiveness → Risk Management Performance	Risk Management Performance (Y)	17.671	Extremely large, interpreted cautiously

Source: Primary Data, processed using SmartPLS 4, 2026.

The structural model evaluation assessed the predictive power of the model and the significance of the hypothesized relationships among latent constructs. This assessment used the coefficient of determination (R^2), effect size (f^2), path coefficient significance, and bootstrapping results. The structural model evaluation assessed the predictive power and significance of the hypothesized relationships using R^2, f^2, Q^2 predictive relevance, path coefficient significance, and bootstrapping results. The Goodness of Fit (GoF) index was not used as the main basis for interpretation because its use in PLS-SEM remains methodologically debated.

The coefficient of determination results show uneven explanatory power across endogenous constructs (see Table 2). Risk Management Implementation Process (R^2 = 0.921) and Risk Management Performance (R^2 = 0.946) show high explained variance, while Risk Management Effectiveness shows very low explained variance (R^2 = 0.020). This uneven pattern warrants cautious interpretation. The very low R^2 for Effectiveness indicates that the implementation process explains only a limited portion of effectiveness variance, while the very high R^2 for Performance may indicate possible construct overlap or model specification sensitivity rather than a purely strong structural relationship. Effect size analysis was then conducted to assess the relative contribution of each predictor path to its corresponding endogenous construct. The f^2 values are presented in Table 3.

The effect size results also require cautious interpretation. Human Capital Capacity shows a medium effect on Risk Management Implementation Process (f^2 = 0.311), while Managerial Commitment shows a large effect on Risk Management Implementation Process (f^2 = 1.961). Risk Management Implementation Process shows a small effect on Risk Management Effectiveness (f^2 = 0.020), which is consistent with the very low R^2 value for Effectiveness. The effect size of Risk Management Effectiveness on Risk Management Performance is extremely large (f^2 = 17.671), suggesting that these two constructs may be empirically close or partially overlapping. Therefore, the structural model results should be interpreted as predictive and associational evidence rather than as definitive proof.

Predictive relevance was assessed through the SmartPLS 4 blindfolding procedure with an omission distance of 7. The cross-validated redundancy Q^2 values were 0.504 for Risk Management Implementation Process, 0.020 for Risk Management Effectiveness, and 0.566 for Risk Management Performance. These results indicate predictive relevance for the endogenous constructs. However, the very low Q^2 value for Risk Management Effectiveness confirms that the implementation-effectiveness pathway remains weak. Therefore, the main interpretation still relies on R^2, f^2, bootstrapping results, path significance, and theoretical plausibility, while the indirect effects should be interpreted cautiously.

Results of Hypothesis Testing

The research hypotheses are tested using a bootstrapping procedure with 5,000 resamples to obtain path coefficients, t-statistics, and p-values (see Table 4). Statistical significance is determined at the 5% level ($p < 0.05$).

All hypotheses (H1-H7) achieved statistical significance at the $p < 0.05$ level, indicating that the structural paths tested in the PLS-SEM model align with the revised hypothesis structure. However, statistical significance should be distinguished from theoretical plausibility and substantive effect magnitude. Managerial Commitment shows the strongest effect on Implementation Process (H2: coefficient = 0.711), while Human Capital Capacity exhibits a smaller but significant effect (H1: coefficient = 0.283). The Implementation Process to Effectiveness pathway is notably weak (H3: coefficient = 0.141, p = 0.032), with minimal variance explained in Effectiveness (R^2 = 0.02). The Effectiveness to Performance relationship is exceptionally large (H4: coefficient = 0.973), suggesting possible construct overlap. The revised mediation hypotheses are interpreted in three specific pathways: H5 tests Human Capital Capacity → Implementation Process → Effectiveness, H6 tests Managerial Commitment → Implementation Process → Effectiveness, and H7 tests Implementation Process → Effectiveness → Performance. These indirect effects are statistically significant but small and close to conventional thresholds, so they should be interpreted cautiously rather than as strong mediation evidence.

Association between Human Capital Capacity and Risk Management Implementation

The cross-sectional findings indicate that human capital capacity is significantly associated with risk management implementation process (H1: β = 0.283, $p < 0.001$). This modest effect size indicates that human capital explains approximately 8% of implementation process variance, consistent with Resource-Based View theory positing that specialized knowledge and technical competencies constitute intangible strategic assets contributing to organizational capabilities. The positive coefficient aligns with foundational work by Wahid et al. (2022) demonstrating human capital's relevance to risk management system effectiveness in utility contexts, and extends recent findings by Bruwer et al. (2022)

Table 4. Results of Direct and Indirect (Mediation) Effects

Hyp	*Structural Path*	*Coefficient*	*t-Stat*	*p-Value*	*Decision*
Direct					
H1	Human Capital Capacity → Risk Management Implementation Process	0.283	6.702	0.000	Accepted
H2	Managerial Commitment → Risk Management Implementation Process	0.711	19.171	0.000	Accepted
H3	Risk Management Implementation Process → Risk Management Effectiveness	0.141	1.854	0.032	Accepted
H4	Risk Management Effectiveness → Risk Management Performance	0.973	163.669	0.000	Accepted
Mediation					
H5	Human Capital Capacity → Risk Management Implementation Process → Risk Management Effectiveness	0.039	1.791	0.037	Accepted
H6	Managerial Commitment → Risk Management Implementation Process → Risk Management Effectiveness	0.097	1.826	0.034	Accepted
H7	Risk Management Implementation Process → Risk Management Effectiveness → Risk Management Performance	0.137	1.851	0.032	Accepted

Source: Primary Data (2026)

and Nikolaenko & Sidorov (2023) showing that technical expertise facilitates adoption of risk management frameworks in infrastructure projects. However, the modest effect size warrants caution against deterministic interpretation.

The weak-to-moderate association suggests that human capital alone is insufficient to ensure implementation quality. Alternative organizational factors substantially influence implementation fidelity alongside technical competence. Anh and Huong (2022) similarly found that human resource management effectiveness depends on organizational routines, incentive structures, and reporting culture factors beyond individual skill. Utility-oriented ERM literature also indicates that expertise must be embedded in structured governance, implementation routines, and operational decision-making systems to generate reliable performance outcomes (Dvorski Lacković et al., 2022; Pecina et al., 2022). The HTMT analysis revealing moderate construct overlap between human capital and managerial commitment (0.618) suggests these factors may reflect common underlying organizational capacity rather than independent predictors. Additionally, reverse causation is plausible in cross-sectional designs: well-implemented procedures may enhance perceived human capital among respondents rather than skilled personnel driving implementation. This bidirectional ambiguity should be tested through longitudinal research.

From a practical standpoint, the findings suggest that technical training investments require complementary organizational structures to translate competencies into consistent implementation. Mubarok & Safarini (2022) found that career development and work motivation together influence employee performance, implying that human capital development alone without motivational structures yields limited returns. At UIP3B Kalimantan, strengthening human capital through specialized risk training should be coupled with organizational routines, clear accountability structures, and incentive systems that reward rigorous implementation. The modest effect size indicates that investing in training alone, without attending to organizational context, will yield limited improvements in implementation process quality.

Association between Managerial Commitment and Risk Management Implementation

Managerial commitment demonstrates the strongest direct association with implementation process (H2: $\beta = 0.711$, $p < 0.001$), substantially larger than human capital's association (0.283). This finding aligns with Upper Echelons Theory, which proposes that organizational processes reflect leadership values and priorities (Hambrick & Mason, 1984). The large effect size suggests that visible leadership engagement manifested through resource allocation, policy enforcement, and risk evaluation participation substantially strengthens implementation fidelity. Risk governance and performance-management literature also emphasizes the importance of leadership-supported alignment, strategic direction, and accountability structures in shaping organizational control systems (Dvorski Lacković et al., 2022; Hristov et al., 2024; Zhu et al., 2023).

However, the statistical prominence of this coefficient should be carefully distinguished from substantive dominance, and several alternative explanations merit consideration. The large coefficient may partly reflect perceptual overlap between managerial commitment and implementation process measures: both constructs were assessed through similar survey mechanisms potentially measuring related organizational phenomena. The HTMT analysis indicating moderate construct overlap (0.550) warrants acknowledgment that shared measurement variance may inflate the apparent relationship. Additionally, in cross-sectional designs, reverse causation is equally plausible: well-implemented procedures may reinforce respondent perceptions of commitment rather than commitment driving implementation. The generalizability of this finding to utilities with different governance structures particularly private utilities with different incentive systems or external regulatory pressures remains uncertain. The dominance effect may be context-specific to state-owned providers where hierarchical authority structures amplify leadership influence.

From a practical perspective, the findings suggest that leadership visibility and commitment are important for strengthening implementation processes. Executives should actively participate in risk evaluations, enforce accountability structures, and allocate dedicated resources to risk governance activities. However, leadership mandate alone is insufficient; Putra and Hendri (2022) found that leadership motivation must be coupled with clear organizational processes and staff development to translate intent into sustained performance. At UIP3B Kalimantan, strengthening managerial commitment through visible executive engagement should be accompanied by procedural clarity, resource provision, and mechanisms ensuring that commitment translates into systematic risk governance rather than remaining aspirational.

Association between Implementation Process and Risk Management Effectiveness

Implementation process demonstrates a statistically significant but very small direct effect on risk management effectiveness (H3: $\beta = 0.141$, $p = 0.032$; $R^2 = 0.02$). This weak association requires critical interpretation: the minimal variance explained in effectiveness (2%) indicates that implementation process adherence alone accounts for minimal effectiveness variation. The low effect size contradicts theoretical expectations that procedural rigor should substantially influence control quality. Wadesango et al. (2018) similarly noted that while risk management processes are vital, their ultimate effectiveness "relies heavily on the accuracy of data and actual follow through," suggesting that procedure quality does not automatically generate control effectiveness. Khalil-Oliwa and Jonek-Kowalska (2024) found that implementation frameworks like ISO 31000 are necessary but insufficient without accurate risk data and genuine mitigation action quality. This evidence suggests that implementation procedures represent only one component of a much larger effectiveness system.

The weak pathway suggests substantial unmeasured factors determining risk management effectiveness. Potential omitted variables include accuracy and completeness of risk assessment data, quality of risk identification methodologies, actual effectiveness of implemented mitigation actions, technological systems supporting real-time risk detection, and external environmental factors affecting operational risk exposure. Occupational risk assessment research indicates that documented risk processes do not automatically guarantee genuine risk reduction because actual outcomes depend on identification accuracy, assessment quality, and follow-up actions (Glevitzky et al., 2025; Rantala et al., 2024). This weak implementation-effectiveness association limits confidence in a strong indirect pathway; therefore, the mediation evidence should be treated as statistically significant but substantively weak.

The practical implication is that strengthening risk management effectiveness requires attention beyond procedural compliance. Organizations must ensure that risk identification processes capture actual operational vulnerabilities, that assessed risks are accurately characterized, and that mitigation actions actually address identified risks rather than merely following procedure. At UIP3B Kalimantan, investment in digitized risk registers (as suggested in the original discussion) should be coupled with validation mechanisms ensuring that the system captures real operational risks and that mitigation actions genuinely reduce risk exposure rather than simply documenting compliance with procedures. The low effect size indicates that improvements in procedural adherence alone will yield limited effectiveness gains without complementary improvements in risk data quality and mitigation action effectiveness.

Association between Risk Management Effectiveness and Organizational Performance

The extremely large coefficient linking effectiveness to performance (H4: $\beta = 0.973$, $t = 163.669$, $f^2 = 17.671$, $p < 0.001$) warrants critical examination rather than affirmation of a strong structural pathway. Although the HTMT result supports discriminant validity at the construct level, the near-perfect path coefficient and extremely large f^2 indicate possible predictive redundancy, shared perceptual domains, or model-specification sensitivity. Abu Afifa & Saleh (2021) and Ittner & Keusch (2015) both note that in organizational studies, conceptually adjacent constructs may show high statistical association because of measurement overlap rather than fully distinct empirical relationships. Therefore, the effectiveness-performance relationship should be interpreted as an unusually strong associational pattern, not as evidence that effectiveness independently predicts performance beyond possible measurement overlap.

Several alternative explanations warrant serious consideration. First, common rater effects may be present because effectiveness and performance were manager-rated using similar perceptual scales; common rater bias and halo effects could inflate the apparent relationship. Second, construct redundancy may exist if effectiveness measures internal control quality in reducing risks while performance measures perceived operational reliability; in this case, the two constructs may not be sufficiently distinct. Third, effectiveness and performance measures reflect managerial perceptions rather than observed engineering performance metrics such as actual forced outage frequency, equipment failure rates, or system reliability indices. Conclusions about real-world operational change cannot be drawn from perceptual survey data without independent verification against objective operational metrics. Passalacqua et al. (2025) and Koeswahyono (2024) both emphasize that organizational performance research must distinguish between perceived and measured operational outcomes.

The practical implication is that organizations should not assume survey-based performance assessments reflect actual operational outcomes without external validation. At UIP3B Kalimantan, perceived effectiveness improvements should be validated against objective grid reliability metrics: actual forced outage frequency, System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), and equipment failure rates. Relying on manager perceptions alone particularly when perception measures show suspiciously high correlations risks overestimating actual performance improvements. The organizational focus should remain on ensuring that implemented risk controls genuinely reduce operational failures, not simply that managers perceive controls as effective. Independent technical audits and objective performance measurement should complement perceptual assessments to ground performance claims in observable operational reality.

Mediating Role of Implementation Process in the Human Capital Capacity-Effectiveness Path

The mediation result indicates that Risk Management Implementation Process mediates the relationship between Human Capital Capacity and Risk Management Effectiveness (H5: indirect coefficient = 0.039, $t = 1.791$, $p = 0.037$). This finding suggests that technical competence is associated with perceived risk management effectiveness when it is translated into structured implementation practices. The theoretical rationale draws from the Ability-Motivation-Opportunity (AMO) framework: technically competent personnel (ability) require structured organizational processes (opportunity) to translate competencies into consistent risk identification and mitigation routines. Dadd & Hinton (2023) and Wright & Ulrich (2023) emphasize that returns on human capital investments are maximized when capabilities are mobilized within governed organizational environments. Thus, the positive indirect pathway suggests that human capital capacity relates to effectiveness through implementation process quality.

However, this mediation claim requires careful qualification and alternative interpretation. In cross-sectional structural equation modeling, mediation estimates indicate a plausible indirect association estimated by the model rather than proof of a temporal process. The small mediation coefficient (0.039) combined with the weak direct implementation-effectiveness pathway ($\beta = 0.141$) suggests limited practical significance. Alternative temporal orderings are equally plausible: implementation processes might shape human capital development through organizational learning, or both human capital and implementation may reflect underlying organizational culture. This caution is consistent with

prediction-oriented PLS-SEM reporting principles and cross-sectional research design limitations (Creswell & Creswell, 2023; Hair et al., 2019).

Practically, organizations should design standard operating procedures that enable skilled personnel to exercise technical judgment during complex risk assessments rather than constraining expertise through rigid procedures. At UIP3B Kalimantan, the implication is that human capital development needs to be supported by clear implementation routines, accountability structures, and reliable risk documentation. The mediation pathway represents one plausible association between human capital capacity and risk management effectiveness, but it should not be presented as an established causal mechanism without longitudinal evidence.

Mediating Role of Implementation Process in the Managerial Commitment-Effectiveness Path

The mediation result indicates that Risk Management Implementation Process mediates the relationship between Managerial Commitment and Risk Management Effectiveness (H6: indirect coefficient = 0.097, t = 1.826, p = 0.034). This finding suggests that leadership commitment is associated with perceived risk management effectiveness when strategic support is translated into implementation routines. The theoretical grounding is consistent with Social Exchange Theory because leadership resource provision and strategic directives can activate organizational processes that foster compliance culture and control effectiveness. This result indicates that managerial commitment alone is not enough; it needs to be operationalized through clear procedures, monitoring routines, and accountability mechanisms.

This interpretation is consistent with previous enterprise risk management studies showing that leadership support affects risk outcomes only when it is embedded in formal governance and implementation structures. Dvorski Lacković et al. (2022) found that ERM implementation depends on the interaction of governance, organizational culture, and process integration, while Hristov et al. (2024) emphasized that risk management contributes to performance when it is integrated into decision-making and performance-management systems. Wahid et al. (2022) also showed that commitment and human capital are relevant to electronic risk management effectiveness, although their study did not isolate implementation as the indirect channel. Thus, the H6 result extends prior research by positioning implementation process as the mechanism through which managerial commitment is associated with perceived risk management effectiveness in a state-owned utility setting.

The mediation interpretation warrants substantial caution and alternative explanation consideration. The small mediation coefficient (0.097) combined with the weak implementation-effectiveness pathway (β = 0.141) suggests limited practical significance. Alternative explanations include common antecedents, reverse ordering, and context-specific effects in state-owned utilities. Both managerial commitment and implementation process may reflect broader governance maturity rather than a strict sequential pathway. Therefore, the H6 mediation result should be interpreted as a statistically significant but cautious indirect association.

Practically, organizations should ensure that every strategic risk directive is accompanied by clear execution roadmaps and specific accountability measures. At UIP3B Kalimantan, leadership should continuously monitor whether implementation structures actually produce control improvements. The mediation pathway should be treated as one plausible association requiring further validation through longitudinal data and objective operational indicators.

Mediating Role of Risk Management Effectiveness in the Implementation Process-Performance Path

The mediation result indicates that Risk Management Effectiveness mediates the relationship between Risk Management Implementation Process and Risk Management Performance (H7: indirect coefficient = 0.137, t = 1.851, p = 0.032). This finding suggests that implementation process may relate to perceived performance through effectiveness, although the weak implementation-effectiveness pathway requires cautious interpretation. This pathway reflects the logic that administrative compliance should first be reflected in functional control effectiveness before being associated with perceived performance outcomes.

This finding is also aligned with previous research indicating that implementation quality becomes meaningful only when it improves risk-control effectiveness and operational reliability. AL Jarrah et al. (2022) reported that integration between project management processes and risk management supports successful project implementation, while Migisha et al. (2023) emphasized that electricity reliability depends on the translation of operational controls into measurable service outcomes. Power-system resilience studies similarly link structured risk governance and reliability-oriented controls to infrastructure performance (Ghanbari & Jiang, 2025; Lin & Wu, 2024; Pecina et al., 2022). Therefore, the H7 result contributes by specifying effectiveness as the immediate bridge between implementation process and perceived risk management performance, although the weak intermediate pathway and possible overlap between effectiveness and performance require cautious interpretation.

However, the H7 mediation claim must be presented cautiously as one plausible pathway rather than as a demonstrated temporal mechanism. The empirically unusual R^2 pattern, namely minimal variance explained at the effectiveness stage (0.02) followed by very high variance at the performance stage (0.946), contradicts the expected pattern of a strong mediation mechanism. The extremely large final effect (β = 0.973) combined with the weak intermediate pathway suggests that effectiveness and performance may measure overlapping perceptual domains rather than clearly distinct outcomes. In cross-sectional designs, temporal precedence cannot be established.

Practically, the H7 mediation pathway offers a useful organizational heuristic: administrative procedures should be validated against functional effectiveness and operational outcomes rather than valued for compliance alone. However, the unusual statistical pattern and weak intermediate pathway suggest that this mediation should not be treated as a validated performance mechanism. Each stage of the risk value chain requires independent attention and validation.

Limitations and Future Research

This study is subject to several important methodological constraints. The cross-sectional design precludes temporal ordering and cause-and-effect inference; all variables were measured simultaneously, limiting ability to establish whether behavioral inputs precede outcomes. The reliance on self-reported data for human capital, commitment, and implementation process introduces potential common method bias and social desirability bias, despite multi-source design separating predictor and outcome sources. The narrow institutional setting (single state-owned utility operator, UIP3B Kalimantan) limits generalizability; findings may not transfer to utility providers with different organizational structures, regulatory environments, or risk governance maturity levels. The unusually high model fit statistics (R^2 = 0.946 for risk management performance) warrant interpretive caution; such high explained variance may reflect measurement overlap between constructs or sample-specific relationships rather than generalizable pathways. The manager-rated outcome

constructs (effectiveness and performance) represent supervisor perceptions rather than objective operational metrics (actual forced outage frequency, equipment failure rates), introducing additional measurement limitation.

Future research should address these constraints through complementary methodological approaches. Longitudinal designs with repeated measures would establish temporal precedence and permit examination of how human capital investments and commitment initiatives produce changes in implementation quality and subsequent performance outcomes over time. Multi-site comparative studies across utility providers in different regions and regulatory contexts would test whether the observed relationships generalize beyond UIP3B Kalimantan. Integration of objective operational metrics alongside survey measures would validate whether self-reported performance improvements correspond to measurable grid reliability improvements. Mixed-method approaches incorporating qualitative interviews and process observations would illuminate the mechanisms through which behavioral and structural factors jointly influence implementation effectiveness. These extensions would progressively address the inferential limitations of the present cross-sectional, single-site, survey-based design.

Conclusion

This study provides empirical evidence that human capital capacity and managerial commitment are associated with risk management implementation process, and that implementation process is associated with risk management effectiveness. Risk management effectiveness is also associated with perceived risk management performance. The findings indicate that managerial commitment has a stronger association with implementation process than human capital capacity, while the mediation evidence remains weak and requires cautious interpretation. Therefore, the results should not be interpreted as definitive proof, but as predictive and associational evidence within the context of UIP3B Kalimantan. The contribution of this study is contextual and empirical because it explains how behavioral and managerial factors relate to risk management implementation in a state-owned utility setting.

The findings should be generalized cautiously because the study is limited to UIP3B Kalimantan and uses a cross-sectional survey design. The weak mediation evidence, low explained variance for effectiveness, and possible overlap between effectiveness and performance indicate that the proposed indirect pathways should be interpreted carefully. Implementation process quality may serve as a potential operational pathway, but stronger longitudinal evidence and objective operational indicators are needed before it can be treated as a confirmed lever for improving risk management performance. Future studies should use longitudinal designs, mixed-method approaches, and objective operational metrics such as forced outage frequency, equipment failure rates, and reliability indicators to strengthen inferential robustness and deepen understanding of risk management performance in utility infrastructure.

Author contributions

Nor Aprina Hadiani conceived the research, developed the theoretical framework, conducted the analysis, interpreted the findings, and led the manuscript writing. Abdurrahman Sadikin collected data from the target organization, conducted initial statistical screening, and contributed to manuscript drafting. Mahdi Hidayatullah designed the risk management assessment instruments, supported validation of the findings, and performed technical editing. All authors reviewed and approved the final version of the manuscript.

Acknowledgements

The authors would like to thank all those who provided support in the research and publication process, but did not meet the criteria for authorship.

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