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RISK MANAGEMENT ANALYSIS RELATED TO THE ROLE OF INDEPENDENT QUALITY CONTROL CONSULTANTS (PMI) IN THE TRANSITION OF FUNDING FROM TOLL ROAD BUSINESS ENTITIES (BUJT) TO THE STATE BUDGET (APBN) IN TOLL ROAD INFRASTRUCTURE PROJECTS USING THE SEM-PLS AND ANALYTICAL HIERARCHY PROCESS METHODS

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Abstract

This study analyzes risk management related to the role of Independent Quality Control Consultants during the transition of toll road infrastructure project funding from Toll Road Business Entities (BUJT) to the State Budget (APBN). The funding transition introduces complex regulatory, technical, and coordination challenges that may affect project quality, time performance, and compliance. Therefore, this research aims to examine the influence of competence and risk assessment on the effectiveness of PMI performance, with stakeholder management positioned as an intervening variable. A mixed analytical approach was employed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) and the Analytical Hierarchy Process (AHP). SEM-PLS was applied to test causal relationships among variables, while AHP was used to determine the priority level of factors influencing PMI effectiveness. Data were collected from professionals involved in toll road infrastructure projects, including consultants, contractors, supervisors, and academics. The results show that competence and risk assessment have a significant positive effect on the effectiveness of PMI performance. Furthermore, stakeholder management significantly mediates the relationship between competence and performance, as well as between risk assessment and performance, indicating that effective communication, coordination, and collaboration enhance the impact of technical capabilities and risk control. The AHP analysis reveals that the implementation of government regulatory standards is the most influential factor, followed by professional independence, ethical integrity, and human resource competence in understanding public funding regulations. In conclusion, the effectiveness of PMI during the BUJT-to-APBN funding transition depends on an integrated approach that combines regulatory compliance, professional competence, structured risk assessment, and stakeholder management. These findings provide strategic insights for policymakers and practitioners in strengthening quality control systems within toll road infrastructure projects.

Keywords: Risk Management, Independent Quality Control Consultant (PMI), Funding Transition (BUJT–APBN), Toll Road Infrastructure Projects, Stakeholder Management; SEM-PLS, Analytical Hierarchy Process (AHP)

INTRODUCTION

Infrastructure development in general is one of the main pillars in supporting economic growth and improving public welfare. Well-developed infrastructure not only functions as a means of transportation but also plays a crucial role in enhancing food security, strengthening investment, and reducing regional economic disparities. In this context, various studies indicate that well-planned and integrated infrastructure development can generate significant positive impacts on economic growth and social welfare. First, infrastructure serves as a primary driver of economic growth. In recent years, infrastructure development in Indonesia has increased significantly, largely supported by both public and private sectors. In the toll road sector in particular, the role of Toll Road Business Entities (Badan Usaha Jalan Tol/BUJT) in financing these projects has become increasingly important. BUJT is responsible not only for funding construction but also for ensuring infrastructure quality by employing Independent Quality Control Consultants (Pengendali Mutu Independen/PMI). PMI consultants are tasked with supervising and ensuring the quality of construction financed by BUJT; therefore, they play a vital role in maintaining high-quality standards in toll road projects. However, the government, through the Ministry of Public Works and Housing (PUPR), has recently initiated a change in this financing scheme by transferring the funding of PMI consultants from BUJT to the

State Budget (Anggaran Pendapatan dan Belanja Negara/APBN). This policy was implemented as part of a strategy to enhance accountability and ensure that toll road quality supervision remains aligned with standards expected by the government and the general public. This transition also aims to reduce potential conflicts of interest between BUJT and PMI consultants, with the expectation that funding from the APBN will strengthen consultants' independence and objectivity in performing their duties. Nevertheless, this change introduces new challenges, particularly related to risk management during the funding transition. Under the BUJT funding scheme, budget flexibility was higher and reporting procedures tended to be simpler. In contrast, APBN funding requires PMI consultants to comply with stricter government procedures and regulations and to maintain higher levels of transparency in reporting. In addition, risks related to budget allocation efficiency, potential political intervention, and compliance with national regulations present new challenges for PMI consultants funded through the APBN.

In this context, it is essential to conduct a comprehensive risk management analysis related to the transition of funding from BUJT to the APBN in order to identify key risks and effective mitigation strategies. This analysis is not only important for PMI consultants but also for other stakeholders, such as the Ministry of PUPR and BUJT, who have vested interests in the success and sustainability of national infrastructure projects. This study provides insights into the impact of the funding transition on the effectiveness of independent quality supervision and offers solutions to minimize risks arising from this change. According to Putri and Wisudanto, infrastructure development supported by a sound financing structure can generate positive multiplier effects for the economy (Putri & Wisudanto, 2017). This is consistent with the findings of Mulyani et al., who show that infrastructure contributes to food security, particularly in regions with limited access to resources (Oktalia et al., 2025). Furthermore, Suhendra emphasizes the importance of Public–Private Partnership (PPP/KPBU) schemes in financing infrastructure projects, enabling private sector participation in infrastructure provision (Suhendra, 2017). Research by (Carlsson & Sandström, 2008) demonstrates that risk management in road infrastructure projects is a multifaceted process requiring early planning, systematic methodologies, and effective stakeholder engagement to ensure project success. Early planning is crucial as it allows for the identification and integration of critical risks into project plans, which can then be addressed through appropriate mitigation measures. The transition of toll road project funding from BUJT to the APBN has the potential to create issues such as financial instability, project delays, and stakeholder dissatisfaction, all of which must be systematically identified and managed to ensure project sustainability and effectiveness. According to Salah (2015), structured and effective risk mitigation efforts help prioritize risks based on their likelihood and impact, enabling targeted mitigation strategies to resolve emerging issues.

A study by (Bhatt et al., 2025) employed a combination of Structural Equation Modeling (SEM) and the Analytical Hierarchy Process (AHP) to analyze factors influencing the success of large-scale infrastructure projects, including road infrastructure. SEM helps identify relationships between risk reduction strategies such as feasibility studies, community involvement, and contract selection while AHP enhances the accuracy of predicting interrelationships among factors. The three most influential factors identified in the study were feasibility studies, community involvement, and contract selection, all of which had significant impacts on project success. The responsibilities of Independent Quality Control Consultants (PMI) include reviewing monthly progress reports, assisting in evaluating changes in construction scope, monitoring construction progress, and reporting findings to the Toll Road Regulatory Agency (BPJT). PMI consultants operate independently to uphold quality standards without bearing BUJT's responsibilities, thereby enhancing supervision and accountability in the construction process (Hartono et al., 2018). A comparison between conditions before and after the funding transition from BUJT to the APBN is presented based on ten aspects, including funding sources, infrastructure ownership, investment returns, and development priorities, as shown in Table 1.

Table 1. Comparison Before and After the Funding Transition from BUJT to the State Budget (APBN)

Aspect	Before Transition	After Transition
Funding Objective	Primarily focused on the interests of the Toll Road Business Entity (BUJT), which has a direct stake in toll road operational sustainability and toll revenue.	Focused on achieving optimal quality standards and serving the public interest in accordance with government policies.
Independence of PMI Consultants	Limited, due to potential conflicts of interest between BUJT and PMI consultants who are directly funded by the supervised entity.	Greater independence, as funding is sourced from the State Budget (APBN) and supervision is conducted based on government standards for public interest.
Quality of Quality Supervision	The quality of supervision may vary depending on BUJT's commitment to quality standards and cost efficiency.	More structured and consistent quality supervision, regulated by government standards and aligned with APBN requirements.
Accountability and Transparency	Relatively lower, as accountability reports are primarily directed to BUJT with minimal direct public disclosure.	Higher, involving government oversight and mandatory public reporting in accordance with APBN financial transparency standards.
Supervision and Reporting Procedures	Supervision and reporting procedures tend to be simpler and can be adjusted to meet BUJT's needs.	Procedures are stricter and governed by government regulations that must be complied with by PMI consultants, with more transparent and detailed periodic reporting.
Budget Flexibility	More flexible, but often dependent on BUJT's interests, and budget effectiveness may be influenced by profit-oriented objectives.	Generally more rigid, as it is regulated by APBN rules with specific allocations and requires approval for any budget changes.
Risk of External Pressure	High, as consultants may experience pressure to meet BUJT's expectations due to direct funding from BUJT.	Lower, as APBN funding emphasizes public interest, reducing conflicts of interest and direct external pressure.

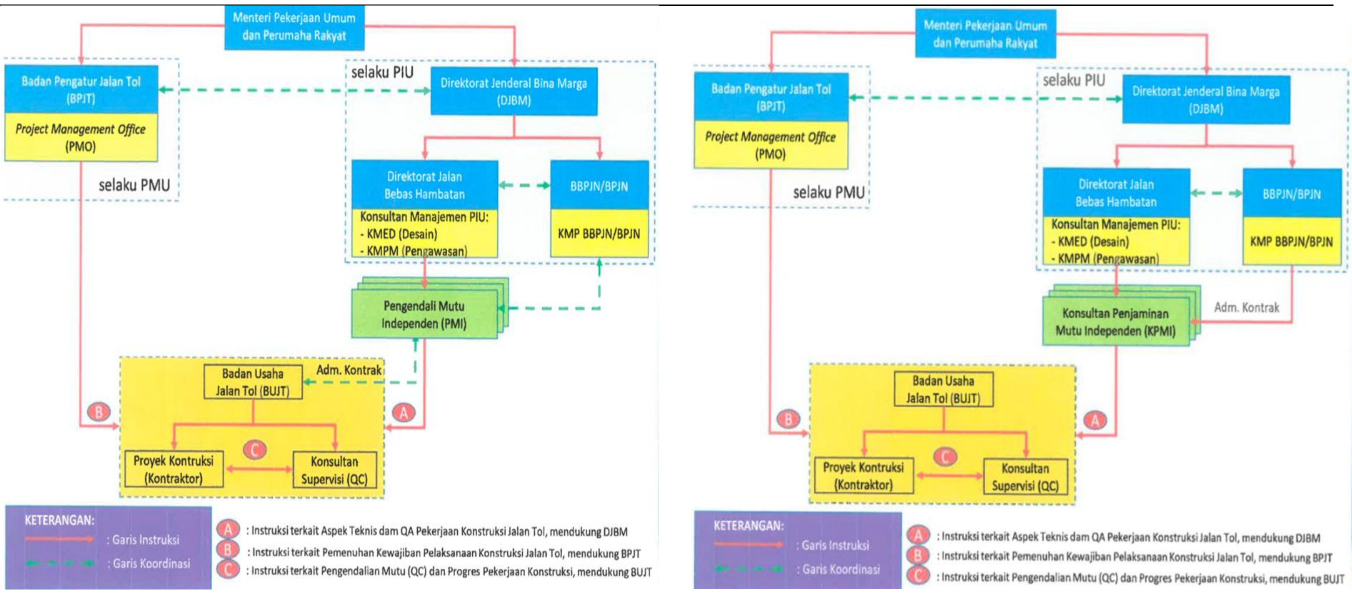

Figure 1.Funding Mechanism of Independent Quality Control Consultants (PMI) under BUJT and the State Budget (APBN)

Figures 1 illustrate the funding mechanisms under BUJT and APBN schemes. In Figure 1.1, the Independent Quality Control Consultant (PMI) supervises construction quality and is directly connected to BPJT and the Directorate General of Highways (DJBM). In Figure 1.2, the PMI position is replaced by the Independent Quality Assurance Consultant (KPMI), whose role is more specifically focused on quality assurance and is directly connected to BUJT through an administrative contract. Figure 1.2 also shows a simplified funding mechanism, eliminating several coordination lines, giving the impression of a more focused relationship between BUJT and the quality assurance entity (KPMI). The Jakarta–Cikampek South Toll Road Project serves as an interesting example of a Public–Private Partnership (PPP/KPBU) project. This toll road is designed as an alternative to the existing Jakarta–Cikampek Toll Road, aiming to reduce congestion and improve connectivity between Jakarta and southern West Java. The project is planned to span 64 kilometers, connecting Jati Asih in Bekasi City to Sadang in Purwakarta Regency. Initially, the project was to be fully financed by BUJT, namely PT Jasa Marga (Persero) Tbk through its subsidiary, PT Jasamarga Japek Selatan.

However, over time, the project faced various challenges, particularly related to financing and land acquisition. The government decided to use APBN funds to support land acquisition through the State Asset Management Agency (LMAN). This measure was taken to accelerate land acquisition by reducing the financial burden on BUJT. LMAN support includes direct payments to landowners whose land is required for the project, thereby expediting the acquisition process and minimizing potential disputes (Prasetyo Adi Sungkono & Fredy Kurniawan, 2019). The Viability Gap Fund (VGF) scheme was also implemented as government support for infrastructure projects that are not fully commercially viable but have strategic value. Through VGF, the government provides subsidies to BUJT to cover funding gaps, reducing financial risks and accelerating toll road development. In addition to land acquisition support, the government also provided State Capital Participation (Penyertaan Modal Negara/PMN) to PT Jasa Marga (Persero) Tbk as the parent company of PT Jasamarga Japek Selatan. This PMN was used to strengthen the company's capital structure, enabling smoother continuation of the project. Presidential Regulation Number 3 of 2016 on the Acceleration of National Strategic Projects serves as the main legal basis for designating projects considered strategic for national development. The Jakarta–Cikampek II South Toll Road is included in the list of projects stipulated under this regulation (Aninditya et al., 2023). The transfer of several toll road projects in West Java and DKI Jakarta from BUJT to APBN funding is included in the National Strategic Program under Minister of Coordinating Economic Affairs Regulation Number 21 of 2022. The author's discussion of PMI in this funding transition is presented in a study analyzes the funding transition of PMI consultants using toll road projects in West Java as case studies. The research is expected to assess the effectiveness of Independent Quality Control Consultants in minimizing construction project issues by analyzing critical influencing factors using an integrated SEM-PLS and AHP approach.

LITERATURE REVIEW

Competence

Competence is a concept that refers to an individual's ability to perform tasks or job responsibilities effectively and efficiently. It encompasses not only technical skills but also knowledge, attitudes, motivation, and personal characteristics that influence work performance. Therefore, competence is considered a crucial factor in determining individual effectiveness and success in a professional context. (McClelland, 1973) defines competence as an individual's underlying characteristics that are directly related to superior performance at work. He emphasizes that competence goes beyond technical skills and includes motivation, values, and personal traits that drive individuals to achieve high levels of performance. This perspective highlights the importance of internal personal attributes in shaping work outcomes. (McClelland & Boyatzis, 1982) in *The Competent Manager*, describes competence as the underlying characteristics of an individual that are causally related to effective or superior performance in a specific job. He categorizes competence into several dimensions, including technical competence, social competence, and conceptual competence, which collectively support professional effectiveness. Similarly, (Spencer & Spencer, 2008)in *Competence at Work*, define competence as an underlying characteristic of an individual that is related to effective or superior performance in a job or situation. They classify competence into key components such as knowledge, skills, self-concept, personal traits, and motives, all of which interact to influence individual performance. The United Nations Industrial Development Organization (UNIDO) defines competence as a combination of skills, knowledge, and attitudes that enable individuals to perform tasks effectively within a specific context (Canton, 2021). According to UNIDO, competence is developed through education, work experience, and lifelong learning processes(Canton, 2021). Based on these perspectives, competence can be understood as a multidimensional construct consisting of knowledge, skills, attitudes, and personal characteristics that collectively determine an individual's ability to perform tasks effectively and achieve superior performance.

Risk Assessment

Risk assessment is a fundamental component of risk management, focusing on the systematic evaluation of potential risks that may affect the achievement of organizational or project objectives. (Smeeth et al., 2009) in their book *How to Measure Anything in Cybersecurity Risk*, define risk assessment as a quantitative process used to measure risk more accurately. They emphasize the importance of data-driven and analytical approaches in assessing risk, enabling organizations to make informed decisions based on measurable uncertainty. Risk management, as a broader framework, encompasses risk identification, risk mitigation, and risk assessment, with risk assessment serving as a critical stage in understanding the magnitude and priority of identified risks. Experts highlight the importance of a proactive approach to risk assessment by integrating it into strategic planning and governance systems. This comprehensive approach is not only aimed at preventing negative outcomes but also at enhancing organizational resilience and competitive advantage. By systematically evaluating risks, organizations can anticipate potential challenges and develop strategies to manage uncertainty more effectively.

According to ISO 31000, risk is defined as the effect of uncertainty on objectives, and the standard provides a comprehensive framework for risk management practices applicable across different organizational levels (Papamichael et al., 2024). ISO 31000 emphasizes the integration of risk management into overall governance structures and organizational decision-making processes. Risk management is described as a continuous cycle that includes risk identification, risk analysis, risk evaluation, and risk treatment, all aimed at minimizing adverse impacts on organizational objectives (Bazaluk et al., 2024). Within this framework, risk assessment plays a crucial role by systematically analyzing and evaluating potential risks associated with specific activities or projects. This process is essential for informed decision-making, as it enables organizations to prioritize risks based on their likelihood and impact, and to allocate resources effectively for risk mitigation. Consequently, effective risk assessment contributes significantly to organizational sustainability and the successful implementation of complex projects.

Funding

The Independent Quality Control Consultant (Pengendali Mutu Independen/PMI) is a third party appointed to conduct independent quality supervision and control in projects, particularly large-scale construction projects such as toll roads. The presence of PMI aims to ensure that projects are implemented in accordance with established quality standards, thereby producing high-quality outputs that meet user needs. PMI plays a crucial role in safeguarding construction quality, minimizing technical deviations, and ensuring compliance with technical specifications and regulatory requirements. The roles and responsibilities of PMI consultants include the following.

First, PMI acts as an extension of the Toll Road Regulatory Agency (BPJT) in administering quality control for toll road development implemented by Toll Road Business Entities (BUJT). This role involves ensuring that construction quality complies with predefined quality benchmarks outlined in technical specifications, aligns with the Final Engineering Design, and adheres to the planned implementation schedule as indicated in the S-curve. Second, PMI enhances BPJT's capacity for toll road construction supervision through comprehensive documentation, including weekly, monthly, quarterly, special, and engineering reports. Public infrastructure funding in Indonesia involves various financing schemes that include public funding, private funding, and hybrid models. Infrastructure financing sources generally consist of the State Budget (APBN), Toll Road Business Entities (BUJT), and government–private sector partnerships, commonly referred to as Public–Private Partnerships (PPP). In toll road projects, BUJT traditionally plays a dominant role in financing both construction and operational phases, including allocating funds for quality supervision conducted by PMI consultants.However, recent policy changes that transfer PMI funding from BUJT to the APBN represent a paradigm shift in budget management and funding objectives. According to reports from the Ministry of Public Works and Housing (PUPR), this policy aims to enhance the objectivity of PMI consultants and reduce potential conflicts of interest. By utilizing APBN funding, quality supervision is expected to focus more on broader public interests rather than solely on cost efficiency and the financial objectives of BUJT, thereby strengthening independent oversight and governance.

The government has implemented several policies to support this funding transition, including State Capital Participation (Penyertaan Modal Negara/PMN) to strengthen the role of state-owned enterprises (SOEs) in infrastructure development, as well as government guarantees to support APBN-based financing. Large-scale projects such as the Trans-Sumatra Toll Road have been financed through the APBN with the involvement of state-owned construction enterprises to ensure project sustainability and high-quality standards. Case studies from the Trans-Java and Trans-Sumatra toll road projects demonstrate that funding transitions enable the government to exercise greater control over infrastructure quality and the performance of PMI consultants in accordance with national standards. This approach allows for more consistent quality assurance, improved regulatory compliance, and enhanced alignment with public infrastructure development objectives. The concepts of accountability and transparency are fundamental principles in public fund management, particularly in the context of the State Budget (APBN). The literature emphasizes that public funds must be managed based on transparency and must be accountable to the public (Yuniarto, 2020). High levels of accountability in APBN management contribute to increased public trust in infrastructure projects and strengthen the effectiveness of quality supervision mechanisms. Transparent financial reporting and clear governance structures ensure that infrastructure funding is utilized efficiently and in accordance with public interest objectives.

Stakeholder Management

Stakeholder management refers to the systematic process of identifying, analyzing, engaging, and managing relationships with individuals or groups that can affect or are affected by the achievement of organizational objectives. Effective stakeholder management is essential for ensuring project success, minimizing conflict, and enhancing organizational sustainability, particularly in complex infrastructure projects involving multiple public and private actors. (Freeman, 2010) in *Strategic Management: A Stakeholder Approach*, defines stakeholders as "any group or individual who can affect or is affected by the achievement of an organization's objectives." This definition broadens the focus of organizational management beyond shareholders to include a wider range of interest groups, such as regulators, contractors, consultants, and the public. Freeman's approach emphasizes the importance of balancing stakeholder interests to achieve long-term organizational success. (Mitchell et al., 1997) in their work *Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts*, conceptualize stakeholders as individuals or groups possessing one or more of three key attributes: power, legitimacy, and urgency. They propose a stakeholder salience model that enables organizations to identify and prioritize stakeholders based on the combination of these attributes. This model is particularly useful in managing complex projects where stakeholder influence varies significantly. (Phillips, 2003) in *Stakeholder Theory and Organizational Ethics*, defines stakeholders as individuals or groups with moral or legal claims that can affect or be affected by organizational actions. Phillips emphasizes fairness, ethical responsibility, and legitimacy in stakeholder relationships, highlighting that organizations have obligations not only to powerful stakeholders but also to those with legitimate claims. (Savage et al., 1991) in their study *Strategies for Assessing and Managing Organizational Stakeholders*, argue that stakeholder management involves analyzing stakeholder power and potential influence, as well as determining appropriate strategies for engagement. They propose categorizing stakeholders based on their potential to support or threaten organizational objectives and tailoring management strategies accordingly. In the context of funding transitions, stakeholder management becomes increasingly critical due to heightened risks associated with regulatory compliance and governance changes. (Wibisono et al., 2024) notes that APBN-based funding requires consultants to adhere to higher accountability standards, including periodic reporting and government audits. These requirements introduce several key risks during the transition phase. First, administrative risk arises from more bureaucratic procedures under APBN funding, which may lead to delays in fund disbursement and operational stagnation. Second, budget allocation risk emerges due to limited APBN resources, potentially resulting in insufficient funding for PMI supervision activities. Third, regulatory risk becomes more prominent, as PMI consultants must comply with stricter government regulations, with non-compliance potentially leading to sanctions or reassessment of contracts. Overall, effective stakeholder management is essential to mitigate these risks by ensuring clear communication, alignment of interests, and compliance with regulatory requirements among all stakeholders involved in the infrastructure funding transition.

METHOD

Research Design

This study adopts a mixed-methods approach, combining quantitative and qualitative descriptive methods to comprehensively analyze risk management related to the role of Independent Quality Control Consultants (PMI) in toll road infrastructure projects experiencing funding transitions from Toll Road Business Entities (BUJT) to the State Budget (APBN). A survey-based quantitative approach is employed to collect stakeholders' perceptions regarding critical success factors in toll road construction projects, while qualitative inputs are used for expert validation and interpretation. The research aims to identify dominant risk management factors and examine their interrelationships in influencing project success, particularly in relation to PMI supervision effectiveness. The analytical framework integrates the Analytical Hierarchy Process (AHP) and Structural Equation Modeling–Partial Least Squares (SEM-PLS).

Research Object

The object of this research is the Bogor–Ciawi–Sukabumi (BOCIMI) Toll Road Construction Project, Section III, which represents a large-scale infrastructure project involving complex funding and stakeholder arrangements.

Research Questions

This study is conducted to address the following research questions:

1. RQ1: What are the critical factors in the risk management approach related to the transition of PMI funding from BUJT to APBN in toll road infrastructure projects?
2. RQ2: How does stakeholder management function as an intervening variable between competence, risk assessment, and funding in influencing the effectiveness of PMI?
3. RQ3: How can a stakeholder management and competence framework be developed to enhance the effectiveness of PMI roles?

Population and Sample

The population consists of stakeholders involved in the Jakarta–Cikampek Selatan Toll Road Project and the Bogor–Ciawi–Sukabumi Section III Project, including project managers, owners, experts, and relevant multi-stakeholders. A purposive sampling technique was applied, selecting respondents based on their direct involvement and experience in toll road infrastructure projects. The sample size was determined using a formula adapted from (Alaghbari et al., 2007), resulting in 87 respondents with a minimum of five years of professional experience and educational backgrounds ranging from bachelor's to doctoral degrees.

Questionnaire Design

The questionnaire was structured into four main sections:
(1) introduction and research objectives;
(2) respondent profile;
(3) instructions for completion; and
(4) assessment items.

A pairwise comparison technique was applied for AHP analysis, with a weighting scale ranging from 1 to 6. Variables and sub-variables were developed based on literature review and expert judgment. A Likert scale (1–6) was used to measure respondents' perceptions, from *strongly disagree* to *strongly agree*.Prior to distribution, the questionnaire underwent expert validation involving professionals with 5–10 years of experience in toll road construction management, followed by a pilot survey to ensure clarity and reliability.

Data Analysis Methods

Data analysis was conducted in two main stages. First, AHP was employed to determine the priority weights of stakeholder management sub-factors, which act as an intervening variable. Second, SEM-PLS was applied to examine causal relationships among latent variables and to identify critical factors influencing PMI effectiveness. The SEM analysis included validity and reliability testing, significance probability assessment, and evaluation of structural relationships between exogenous and endogenous variables. AHP-derived weights were integrated into the SEM-PLS model to enhance analytical robustness.

Data Collection Techniques

Primary data were collected through hardcopy questionnaires distributed directly to selected respondents. The data collection process involved expert validation, pilot testing, large-scale questionnaire distribution, and final expert verification of results. Secondary data were obtained from project documents, reports, and relevant literature.

Research Procedure

The research procedure followed systematic stages: literature review, problem identification, research gap analysis, formulation of research questions and objectives, hypothesis development, data collection, AHP and SEM-PLS analysis, and final interpretation of results. The integration of AHP and SEM-PLS enables the identification of priority risk factors and the development of a structured framework for improving PMI effectiveness in toll road infrastructure projects.

RESULTS AND DISCUSSION

Inner Model Analysis of SEM-PLS (Structural Model)

The structural model evaluation stage aims to assess and predict the relationships among latent constructs within the research model. The results of this testing are used to determine the extent to which empirical data support the relationships formulated in the research hypotheses. In other words, inner model analysis allows researchers to examine whether the assumed relationships among latent variables—both between exogenous and endogenous constructs as well as among exogenous constructs themselves—can be accepted or rejected based on data processing results.

Variance of Endogenous Constructs Based on R-Square Values

The predictive power of the structural model can be assessed through the R-Square (R^2) values of each endogenous construct (Ghozali & Latan, 2015; Henseler et al., 2012). The R^2 value indicates the extent to which exogenous variables explain the variance of endogenous variables. In general, an R^2 value of 0.67 indicates a substantial effect, 0.33 indicates a moderate effect, and 0.19 indicates a weak effect. Therefore, the R^2 value can be used to measure the contribution of exogenous variables to changes in endogenous variables. The R-Square values for each construct are presented in below.

Table 1. Results of R-Square Analysis

Main Factor	R Square	Adjusted R Square
Adaptability	0.778	0.775
Effectiveness of the PMI Consultant Role (Y1)	0.977	0.976
Operational Efficiency After Transition	0.951	0.951
System Elements	0.956	0.956
Long-Term Infrastructure Quality Evaluation	0.928	0.927
Project Safety Program Evaluation	0.960	0.960
Risk Identification	0.948	0.947
Integration and Collaboration Among Stakeholders	0.844	0.842
Technical Capability	0.982	0.982
Stakeholder Needs	0.718	0.715
Clarity of Roles and Responsibilities	0.899	0.897
Risk Assessment Capability	0.943	0.942
Independence in Decision-Making Process	0.847	0.845
Transition Readiness	0.987	0.987
Project Quality Performance After Transition	0.918	0.917
Commitment to Integrity and Objectivity	0.867	0.866
Expert Quality	0.940	0.939
Change Management	0.917	0.916
Stakeholder Management (X4)	0.986	0.985
Internal Policy Updates	0.859	0.857
Funding (X3)	0.877	0.876
Decision Making	0.928	0.927
Stakeholder Knowledge	0.812	0.810

Table 2. Results of R-Square Analysis

Main Factor	R Square	Adjusted R Square
Risk Assessment (X2)	0.959	0.958
Task Completion	0.930	0.929
Role of Technology in Governance Systems	0.931	0.930
Long-Term Project Stability	0.923	0.922
Stakeholder Management Strategy	0.963	0.962
Stakeholder Satisfaction Level	0.868	0.867
Transparency and Accountability	0.874	0.872
Transparency of Reports and Reporting	0.938	0.937

The testing results presented show that the R^2 value for Project Performance (Z1) is 0.98, which exceeds 0.67 and is categorized as high. This result indicates that 98% of project performance is influenced by operational project risk and project management. Similarly, the second R^2 value for the Effectiveness of the PMI Consultant Role (Y1) is 0.978, which is also greater than 0.67 and classified as high. This result indicates that 97.8% of construction dispute outcomes are influenced by operational project risk and project management.

f-Square Value Results

In this study, the f-square value is used to assess the magnitude of the effect (effect size) of independent variables on dependent variables. According to general guidelines proposed by (Sarstedt et al., 2020) an f-square value of 0.02 indicates a small effect, 0.15 indicates a medium effect, and 0.35 indicates a large effect. The f-square analysis results of this study are presented in Table 3 below.

Table 3. Results of f-Square Analysis

	Effectiveness of PMI Consultant Role (Y1)	Competence (X1)	Stakeholder Management (X4)	Funding (X3)	Risk Assessment (X2)
Effectiveness of PMI Consultant Role (Y1)					
Competence (X1)	0.029		0.055	7.131	23.202
Stakeholder Management (X4)	0.033				
Funding (X3)	0.039		5.274		
Risk Assessment (X2)	0.763		0.079		

Direct Effect Testing

At this hypothesis testing stage, an analysis was conducted to determine whether there is a significant effect of independent variables on dependent variables. Hypothesis testing was carried out through path coefficient analysis, which illustrates parameter magnitude and significance levels based on T-statistic values. The parameter significance values provide information regarding the strength and direction of relationships among variables in the research model. The criteria for hypothesis acceptance or rejection were established based on a significance level of $\alpha = 0.05$ (Haryono, 2020), with the following decision rules:

1. H_0 is rejected if the T-statistic < 1.96 (not significant).
2. H_0 is accepted if the T-statistic ≥ 1.96 (significant).
3. If the P-value > 0.05, H_0 is rejected (not significant).
4. If the P-value ≤ 0.05, H_0 is accepted (significant).

The test results were obtained through the Calculate PLS Bootstrapping procedure in SmartPLS software, which generated T-statistic and P-value outputs. The analysis results are presented in Tables below.

Table 4. Direct Effect Analysis Results (1/3)

Path Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
Effectiveness of PMI Consultant Role (Y1) → Adaptability	0.882	0.882	0.020	43.717	0.000
Effectiveness of PMI Consultant Role (Y1) → Independence in Decision-Making Process	0.920	0.919	0.015	59.376	0.000
Effectiveness of PMI Consultant Role (Y1) → Commitment to Integrity and Objectivity	0.931	0.931	0.013	71.088	0.000
Effectiveness of PMI Consultant Role (Y1) → Internal Policy Renewal	0.927	0.927	0.014	64.323	0.000
Effectiveness of PMI Consultant Role (Y1) → Task Completion	0.964	0.964	0.007	141.699	0.000
Effectiveness of PMI Consultant Role (Y1) → Stakeholder Satisfaction Level	0.932	0.931	0.015	61.003	0.000
Effectiveness of PMI Consultant Role (Y1) → Transparency of Reporting and Disclosure	0.969	0.969	0.006	169.890	0.000

Table 5. Direct Effect Analysis Results (2/3)

Path Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
Competence (X1) → Effectiveness of PMI Consultant Role (Y1)	0.047	0.046	0.096	11.495	0.000
Competence (X1) → Technical Capability	0.991	0.991	0.002	577.091	0.000
Competence (X1) → Quality of Experts	0.970	0.970	0.006	153.367	0.000
Competence (X1) → Stakeholder Management (X4)	0.052	0.051	0.085	0.612	0.541
Competence (X1) → Funding (X3)	0.936	0.936	0.014	66.002	0.000
Competence (X1) → Risk Assessment (X2)	0.979	0.979	0.006	172.924	0.000
Stakeholder Management (X4) → Effectiveness of PMI Consultant Role (Y1)	0.072	0.073	0.141	0.508	0.612
Stakeholder Management (X4) → Long-Term Infrastructure Quality Evaluation	0.963	0.963	0.007	147.408	0.000
Stakeholder Management (X4) → Inter-Stakeholder Integration and Collaboration	0.919	0.917	0.017	54.606	0.000
Stakeholder Management (X4) → Stakeholder Needs	0.847	0.846	0.028	30.524	0.000
Stakeholder Management (X4) → Clarity of Roles and Responsibilities	0.948	0.948	0.011	83.846	0.000
Stakeholder Management (X4) → Decision-Making	0.963	0.963	0.010	99.627	0.000
Stakeholder Management (X4) → Stakeholder Knowledge	0.901	0.903	0.019	46.465	0.000
Stakeholder Management (X4) → Role of Technology in Governance Systems	0.965	0.965	0.007	144.672	0.000
Stakeholder Management (X4) → Stakeholder Management Strategy	0.981	0.981	0.004	249.235	0.000
Stakeholder Management (X4) → Transparency and Accountability	0.935	0.935	0.016	57.751	0.000

Table 6. Direct Effect Analysis Results (3/3)

Path Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
Funding (X3) → Effectiveness of PMI Consultant Role (Y1)	0.213	0.209	0.123	1.728	0.085
Funding (X3) → Operational Efficiency After Transition	0.975	0.976	0.006	175.574	0.000
Funding (X3) → Transition Readiness	0.994	0.994	0.002	617.222	0.000
Funding (X3) → Project Quality Performance After Transition	0.958	0.958	0.009	110.601	0.000
Funding (X3) → Change Management	0.958	0.958	0.009	104.768	0.000
Funding (X3) → Stakeholder Management (X4)	0.789	0.791	0.036	22.104	0.000
Funding (X3) → Long-Term Project Stability	0.961	0.961	0.008	121.503	0.000
Risk Assessment (X2) → Effectiveness of PMI Consultant Role (Y1)	0.675	0.677	0.087	7.782	0.000
Risk Assessment (X2) → System Elements	0.978	0.978	0.005	183.919	0.000
Risk Assessment (X2) → Project Safety Program Evaluation	0.980	0.980	0.004	222.599	0.000
Risk Assessment (X2) → Risk Identification	0.974	0.973	0.006	160.855	0.000
Risk Assessment (X2) → Risk Assessment Capability	0.971	0.971	0.008	128.855	0.000
Risk Assessment (X2) → Stakeholder Management (X4)	0.167	0.166	0.067	2.475	0.014

SEM-PLS Analysis Results

Based on the analysis conducted on 175 dimensions, it was found that ten factors have the greatest influence in determining the impact of the funding transition from BUJT to the State Budget (APBN). These factors are ranked from the most influential to the least influential, as presented in table below.

Table 7. Highest Indirect Effect Analysis (1/2)

No.	Factor Description	Code	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
1	Consultant's ability to maintain professional independence and reject interventions that violate ethical and regulatory standards	Z1.5	0.992	0.992	0.004	250.229	0.000
2	Consultant flexibility in adapting quality control to regulatory dynamics and project policies	Y1.8	0.988	0.988	0.004	273.948	0.000
3	Consultant human resource competence in understanding and ensuring compliance with government regulations and project funding policies	Z1.4	0.981	0.980	0.011	92.755	0.000
4	Control and adaptation to dynamic stakeholder interests throughout the project life cycle	Z1.6	0.980	0.978	0.013	76.994	0.000
5	Ability to reject requests or interventions contrary to professional or ethical standards	Y1.2	0.979	0.978	0.006	173.247	0.000
6	Implementation of government regulatory standards	Z1.29	0.971	0.971	0.006	158.625	0.000

Table 8. Highest Indirect Effect Analysis (2/2)

No.	Factor Description	Code	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
1	Human resource skills in understanding and complying with government funding regulations	Y1.17	0.970	0.969	0.015	65.725	0.000
2	Occupational safety performance as an indicator of effective project risk management	X2.15	0.962	0.962	0.007	136.297	0.000
3	Evaluation and implementation of adaptive alternative solutions during the project transition process	Z1.20	0.961	0.961	0.015	63.949	0.000
4	Frequency of technical training and expert competency development in supporting project effectiveness	X3.24	0.958	0.957	0.009	103.064	0.000

Interpretation of the Ten Influential Factors Using AHP Analysis

Based on the results of the Structural Equation Modeling–Partial Least Squares (SEM-PLS) analysis, ten factors with the highest path coefficients and T-statistics were identified as having a significant influence on the Effectiveness of PMI Consultant Performance in Toll Road Infrastructure Projects. These factors represent key indicators of latent variables related to adaptive management, technical capability, risk assessment, stakeholder management, and the effectiveness of the independent quality assurance consultant (PMI).

Table 9. Ten Dominant Factors (1/2)

No	Dominant Factor	Code	T-Statistics	Brief Interpretation
1	Consultant flexibility in adapting quality control to regulatory and policy dynamics	Y1.8	273.948	Indicates the consultant's ability to adapt to regulatory changes without disrupting project schedules.
2	Consultant's ability to maintain professional independence and reject unethical or non-compliant interventions	Z1.5	250.229	Reflects the importance of understanding stakeholder boundaries to prevent conflicts of interest.
3	Ability to reject requests or interventions that violate professional or ethical standards	Y1.2	173.247	Illustrates professional integrity in maintaining quality standards despite external pressure.
4	Implementation of government regulatory standards	Z1.29	158.625	Indicates compliance with national regulations ensuring alignment with government funding and technical policies.
5	Occupational safety performance as an indicator of effective project risk management	X2.15	136.297	Shows that safety performance directly affects project schedule continuity.
6	Frequency of technical training and competency development	X3.24	103.064	Continuous competency improvement accelerates adaptation to on-site challenges.
7	Consultant HR competence in ensuring compliance with government funding regulations	Z1.4	92.755	Highlights the importance of effective coordination and regulatory understanding among stakeholders.

Table 10. Ten Dominant Factors (2/2)

No	Dominant Factor	Code	T-Statistics	Brief Interpretation
8	Control and adaptation to dynamic stakeholder interests during project implementation	Z1.6	76.994	Describes the project team's ability to balance evolving interests without disrupting schedules.
9	Evaluation and implementation of adaptive alternative solutions during project transition	Z1.20	63.949	Highlights the role of technical and administrative evaluation in selecting efficient solutions during policy or design changes.
10	HR skills in understanding and complying with government funding regulations	Y1.17	65.725	Indicates that regulatory understanding accelerates administrative processes and reduces bureaucratic delays.

Determination of Priority Factors Using AHP

After identifying ten influential factors through SEM-PLS, the next stage involved prioritizing these factors using the Analytical Hierarchy Process (AHP). This step aimed to determine the relative importance (priority weights) of each factor influencing the effectiveness of the PMI consultant role based on expert judgment. The integration of SEM-PLS and AHP provides a comprehensive analytical approach in construction project management research. SEM-PLS identifies causal relationships and validates latent variable interactions using empirical data, while AHP determines factor priorities through expert-based pairwise comparisons. According to (Hair & Alamer, 2022) SEM-PLS is well-suited for complex models with multiple latent variables and non-normal data distributions commonly found in construction field studies. Meanwhile, (Saaty, 2008) explains that AHP effectively evaluates relative importance through structured decision hierarchies and expert judgment. Studies such as (Cheng & Li, 2002) demonstrate that combining SEM-PLS and AHP yields more robust results by integrating quantitative empirical analysis with qualitative expert evaluation. This approach not only assesses statistical relationships but also provides deeper insights into factor prioritization affecting project effectiveness.

Development of the Decision Hierarchy Structure

At this stage, a decision hierarchy was developed as the foundation for applying the AHP method. The hierarchy simplifies complex problems into structured decision levels:

AHP Hierarchy Levels:

1. Level 1 (Main Objective)
   Determining priority factors influencing toll road project time performance based on SEM-PLS results.
2. Level 2 (Criteria/Main Factors)
   Ten significant factors identified from SEM-PLS.
3. Level 3 (Sub-Criteria/Alternatives)
   Not applied in this study, as the focus is on main factor weighting.

Hierarchy Structure of This Study
Main Objective
Determining dominant priority factors affecting toll road project time performance to enhance the effectiveness of the PMI consultant role.
Criteria (Level 2):

1. Technical Capability
2. Risk Assessment
3. Funding
4. Stakeholder Management
5. Material Quality
6. Field Supervision
7. Time Management
8. Contractor Experience
9. Occupational Health and Safety Compliance
10. Inter-Stakeholder Coordination

Expert Judgment and Pairwise Comparison Matrix

This stage constitutes a crucial phase in the application of the Analytical Hierarchy Process (AHP), as it focuses on the systematic collection of expert judgments to assess the relative importance of influential factors through a pairwise comparison matrix. The credibility and robustness of the AHP results largely depend on the quality and relevance of the experts involved in this evaluation process. Experts were selected based on clearly defined criteria to ensure both academic rigor and practical relevance. In terms of academic qualifications, selected experts were required to hold at least a Master's degree in disciplines closely related to the research scope, such as Civil Engineering, Project Management, Public Finance, Risk Management, or other relevant fields. Preference was given to experts with doctoral (PhD) qualifications, particularly those with a research focus on infrastructure development, risk management, or construction project governance.

From a professional standpoint, experts were required to possess a minimum of five to ten years of practical experience in toll road infrastructure projects and/or in funding transition schemes involving private concessionaires (BUJT) and government funding mechanisms (APBN). This experience ensured that the experts had firsthand knowledge of the technical, financial, and managerial challenges associated with project implementation and funding transitions. In addition, experts were selected based on their professional roles and direct involvement in infrastructure projects. These roles included independent quality assurance consultants (PMI), project managers, contractors, field supervisors, commitment-making officials (PPK), and representatives from public or private financing institutions. To strengthen the multidisciplinary perspective of the analysis, the expert panel comprised four main groups: Independent Quality Assurance Consultants (PMI), contractors, field supervisors, and academics specializing in civil engineering. This diverse composition of experts provided balanced insights from technical, managerial, regulatory, and academic viewpoints, thereby enhancing the validity and reliability of the AHP-based priority assessment.

Table 11. Expert Data

No	Expert Name	Education	Position / Role	Experience (Years)	Relevant Experience
1	Mr. AB	PhD Infrastructure Risk Management	Senior Risk Analyst – National Infrastructure Consultant	12	Toll project risk, PMI consulting, APBN–BUJT mixed funding
2	Ms. YS	MSc Civil Engineering (Transportation)	Project Manager – BUJT	10	Toll planning & monitoring, VGF schemes, stakeholder coordination
3	Mr. YY	PhD Public Finance	Infrastructure Financing Analyst – Ministry of Finance	15	PPP structuring, toll project guarantees
4	Ms. SA	MSc Project Management	Quality Control Consultant (PMI)	11	Toll quality audits, national PMI projects
5	Mr. BA	PhD Infrastructure Engineering	Lecturer & Researcher	8	Toll risk research, technical consultant
6	Ms. DK	MSc Civil Engineering (Geotechnics)	Senior Field Supervisor – Ministry of Public Works	10	Toll supervision (Cisumdawu, Cibitung–Cilincing)
7	Mr. AR	MSc Risk Management	Senior Risk Consultant – Financing Institution	9	PPP risk assessment, financial risk analysis
8	Ms. BP	MSc Construction Project Management	Commitment-Making Official – Ministry of Public Works	10	Government contracts, stakeholder coordination
9	Mr. AA	MSc Transport Engineering	Head of Engineering Division – Contractor	11	Toll construction, technical risk management
10	Mr. RA	PhD Infrastructure Economics	Infrastructure Economist – Bappenas	14	Toll funding policy, BUJT–APBN transition analysis

Assessment Instrument

The assessment instrument was developed in the form of an AHP questionnaire, in which each expert was asked to compare two factors at a time (pairwise comparison) based on their relative importance to the main objective, namely improving the time performance of toll road projects through the implementation of effective management practices. The scale used in this study refers to the Saaty Fundamental Scale (1980), which is widely applied in the Analytical Hierarchy Process (AHP). This scale allows experts to express their judgments regarding the relative importance of one factor over another using a numerical scale ranging from 1 to 9, including intermediate values. In this scale, a value of 1 indicates that two factors are equally important, while a value of 9 represents absolute dominance of one factor over another. Intermediate values (2, 4, 6, and 8) are used to represent compromise judgments between two adjacent levels of importance.

Pairwise Comparison Matrix

The Pairwise Comparison Matrix was employed to evaluate the relative importance among the criteria identified in the study. Each criterion was systematically compared with every other criterion using the Saaty scale (1–9). A value of 1 indicates equal importance between two criteria, whereas a value of 9 indicates that one criterion is extremely more important than the other. The resulting matrix is a square matrix (n × n), where *n* represents the number of criteria evaluated. The elements on the main diagonal of the matrix are always equal to 1, as each criterion is compared with itself. The reciprocal property applies, meaning that if criterion *i* is assigned a value *a(i,j)* relative to criterion *j*, then the inverse relationship holds:

$$a(j,i) = \frac{1}{a(i,j)}$$

In this study, the pairwise comparison matrix reflects the judgments of experts for ten research criteria, which represent the most influential factors identified from the SEM-PLS analysis.

Priority Matrix (Eigenvector Calculation)

The eigenvalue (or eigenvector) represents the characteristic root of the matrix and serves as the priority weight of each criterion. These priority values indicate the relative importance of each factor in achieving the research objective. To obtain the priority weights, each element in the pairwise comparison matrix was divided by the total value of its respective column, resulting in a normalized matrix. The average value of each row in this normalized matrix was then calculated to determine the final priority weight for each criterion.

Eigenvalue Results and Interpretation

Based on the results of the AHP data processing for the ten factors evaluated by the experts, the normalized pairwise comparison matrix produced the eigenvalues (priority weights) for each criterion. The results indicate that factor Z1.29 has the highest eigenvalue (0.20091), making it the top priority factor in the overall assessment. This finding suggests that experts perceive this factor as the most influential and deserving of the greatest attention within the context of this study. The next most influential factors are Z1.4 (0.1396) and Y1.2 (0.14237), both of which demonstrate substantial contributions to decision-making and project performance outcomes. In contrast, the factors with the lowest priority weights are X2.15 (0.03683) and Z1.20 (0.04909), indicating that these factors are perceived to have relatively lower influence compared to the others. Overall, the total priority weight of all criteria is 0.84643, reflecting a consistent normalization process and a valid eigenvector calculation. These results form the basis for determining factor priorities and serve as a foundation for developing strategic recommendations aimed at enhancing the effectiveness of PMI consultants and improving toll road project performance.

Consistency Index and Matrix Consistency

The consistency index represents a threshold for measuring the perceptions provided by respondents. By determining the consistency index, inconsistencies in respondents' judgments can be minimized. The consistency ratio is the comparison value between the consistency index and the random index. The random index represents the average consistency of pairwise comparison matrices with sizes ranging from 1 to 10, obtained from experiments conducted by Oak Ridge National Laboratory and later continued by the Wharton School (Johnson & Schaffer, 1994). The measurement of matrix consistency is based on the maximum eigenvalue. By using the maximum eigenvalue, inconsistencies commonly generated in pairwise comparison matrices can be minimized. The maximum eigenvalue is then used to calculate the consistency index and consistency ratio.

Table 12. Priority Index

Criteria	Pair-Wise Value	Priority (%)	λ Max
Z1.5	10.711	15.46%	1.65592601
Y1.8	15.342	4.87%	0.74703896
Z1.4	11.469	12.71%	1.45764226
Z1.6	6.528	6.44%	0.42071483
Y1.2	6.052	14.82%	0.89683322
Z1.29	5.825	22.34%	1.30150272
Y1.17	14.426	8.05%	1.16131436
X2.15	16.921	3.68%	0.62326427
Z1.20	13.436	4.91%	0.65949961
X3.24	23.120	6.74%	1.55837422
Total		**100.00%**	**10.4821104**
Consistency Index (CI)			**0.05356783**
Consistency Ratio (CR)			**0.04058169**

The AHP analysis stage is complemented by testing the consistency of the pairwise comparison matrix constructed by experts. This test is essential to ensure that preferences among criteria exhibit logical, stable, and methodologically justifiable judgment patterns. Consistency in the AHP method is evaluated using two parameters: the Consistency Index (CI) and the Consistency Ratio (CR). Based on the calculation results of the pairwise comparison matrix involving ten criteria (Z1.5, Y1.8, Z1.4, Z1.6, Y1.2, Z1.29, Y1.17, X2.15, Z1.20, and X3.24), the maximum eigenvalue (λ max) was obtained at 10.482, with a CI value of 0.0536 and a CR value of 0.0406. This CR value was then compared to Saaty's consistency tolerance threshold, namely $CR \leq 0.10$ (10%). Since $CR = 0.0406 < 0.10$, the pairwise comparison matrix is declared consistent.

Table 13. Results of the Top 10 Influential Factors Based on AHP Assessment

Rank	Code	Dimension	AHP Score Percentage
1	Z1.29	Implementation of Government Regulatory Standards	22.34%
2	Z1.5	Consultant's ability to maintain professional independence and reject interventions that violate ethical and regulatory standards	15.46%
3	Y1.2	Ability to reject requests or interventions that conflict with professional or ethical standards	14.82%
4	Z1.4	Consultant human resource competence in understanding and ensuring compliance with regulations and government project funding policies	12.71%
5	Y1.17	Human resource skills in understanding and complying with government funding regulations	8.05%
6	X3.24	Frequency of technical training and enhancement of expert competencies to support project effectiveness	6.74%
7	Z1.6	Control and adaptation to stakeholder interest dynamics throughout the project implementation cycle	6.44%
8	Z1.20	Evaluation and implementation of adaptive alternative solutions during project transition processes	4.91%
9	Y1.8	Consultant flexibility in adjusting quality supervision to regulatory and project policy dynamics	4.87%
10	X2.15	Occupational safety performance as an indicator of project risk management effectiveness	3.68%

Research Hypothesis Findings

This subsection discusses the main findings of the study concerning the effectiveness of the performance of PMI Consultants during the transition of project financing from Toll Road Business Entities (BUJT) to the State Budget (APBN), with Stakeholder Management acting as an intervening variable.

H1: "Improvement in competence has a significant effect on the effectiveness of PMI Consultant performance in meeting established standards."

Based on the results of the SEM-PLS analysis, **Hypothesis H1 is accepted**. This is evidenced by a positive and significant path coefficient, as well as a t-statistic value exceeding the critical value of 1.96 at a 5% significance level. These findings indicate that the higher the technical capabilities possessed by PMI Consultants, the more effective their performance in carrying out quality control functions in accordance with project standards.

Table 14. Path Relationship for Hypothesis (1)

Path Relationship	T-Statistic	P-Value
Competence Improvement (X1) → Effectiveness of PMI Consultant Performance (Y1)	11.495	0.000

Substantively, these results are consistent with **Competency Theory** (Spencer & Spencer, 1993), which emphasizes that technical expertise and managerial capabilities constitute the primary foundation for enhancing professional performance in the context of construction supervision.

H2: "Risk assessment has a significant effect on enhancing the effectiveness of the PMI Consultant's role."

Hypothesis H2 is also accepted. The test results show that the risk assessment variable has a significant influence on the effectiveness of the PMI Consultant's role. This indicates that the more accurate and comprehensive the processes of risk identification, analysis, and evaluation, the more optimal the effectiveness of quality control that can be achieved.

Table 15. Path Relationship for Hypothesis (2)

Path Relationship	T-Statistic	P-Value
Risk Assessment (X2) → Effectiveness of PMI Consultant Performance (Y1)	7.780	0.000

Effective risk assessment enables PMI Consultants to make preventive decisions, formulate mitigation strategies, and promptly direct corrective actions in response to potential quality deviations in the field. This finding reinforces the principles of ISO 31000:2018, which emphasize that risk management is a crucial mechanism for minimizing construction quality failures.

H3: "Stakeholder management as an intervening variable strengthens the relationship between competence and the effectiveness of the PMI Consultant's role."

Hypothesis H3 is accepted based on the results of the mediation (indirect effect) test using SEM-PLS. The indirect effect is significant and strengthens the relationship between technical and managerial competence and the effectiveness of the PMI Consultant's role.

This implies that strong competence produces a greater impact on performance effectiveness when PMI Consultants are able to manage stakeholders effectively, including contractors, field supervisors, project owners, and regulatory authorities.

Table 16. Path Relationship for Hypothesis (3)

Path Relationship	T-Statistic	P-Value
Competence (X1) → Stakeholder Management (Z1) → Effectiveness of PMI Consultant Performance (Y1)	9.224	0.000

These findings demonstrate that stakeholder management is not merely an administrative function but plays a strategic role in ensuring support, communication, and coordination among parties, thereby enabling optimal quality control implementation.

H4: "Stakeholder management as an intervening variable strengthens the relationship between risk assessment and the effectiveness of the PMI Consultant's role."

Hypothesis H4 is accepted. The analysis indicates that stakeholder management exerts a significant mediating effect on the relationship between risk assessment and the effectiveness of the PMI Consultant's role.

Table 17. Path Relationship for Hypothesis (4)

Path Relationship	**T-Statistic**	**P-Value**
Risk Assessment (X2) → Stakeholder Management (Z1) → Effectiveness of PMI Consultant Performance (Y1)	20.499	0.000

Well-executed risk assessment becomes substantially more effective when accompanied by the PMI Consultant’s ability to communicate risks to stakeholders, reach consensus on mitigation plans, and ensure commitment to their implementation. Practically, these findings confirm that the success of risk control in construction projects is strongly influenced by the quality of stakeholder relationship management.

CONCLUSION

Based on the results and discussion this study concludes that the effectiveness of Independent Quality Control Consultants (PMI) during the transition of toll road project funding from Toll Road Business Entities (BUJT) to the State Budget (APBN) is strongly influenced by regulatory compliance, professional competence, risk management, and stakeholder management. Using a combined approach of Structural Equation Modeling–Partial Least Squares (SEM-PLS) and the Analytical Hierarchy Process (AHP), the research provides both empirical and prioritization-based insights into the key determinants of PMI performance in infrastructure projects. The AHP analysis demonstrates that the implementation of government regulatory standards is the most influential factor affecting PMI effectiveness, indicating that strict adherence to public-sector regulations is essential in ensuring quality control during funding transitions. Professional independence and the ability to reject interventions that violate ethical and professional standards also emerge as critical factors, emphasizing the importance of integrity and objectivity in maintaining the credibility of quality supervision. In addition, human resource competence—particularly in understanding and complying with government funding regulations—plays a significant role in supporting effective quality control. Although factors such as technical training frequency, adaptability to stakeholder dynamics, and the application of adaptive solutions carry relatively lower priority weights, they remain important in reinforcing operational flexibility and project resilience.

The SEM-PLS results confirm that competence has a significant and positive effect on the effectiveness of PMI performance. Higher levels of technical and managerial capability enable consultants to implement quality standards more consistently and to make sound technical decisions throughout the project lifecycle. Similarly, risk assessment is proven to significantly enhance PMI effectiveness, as systematic identification, analysis, and evaluation of risks allow consultants to prevent quality deviations and manage uncertainties more effectively in toll road infrastructure projects. Furthermore, stakeholder management is found to play a crucial mediating role in strengthening the relationships between both competence and risk assessment with PMI effectiveness. Competence yields greater impact when PMI consultants are able to manage stakeholder relationships through effective communication, coordination, and collaboration among contractors, supervisors, project owners, and regulators. Likewise, risk assessment becomes more effective when risks are clearly communicated, jointly understood, and collectively mitigated by all relevant stakeholders. These findings indicate that quality control and risk management in infrastructure projects are not solely technical processes but are also highly dependent on social and organizational dynamics. Overall, this study highlights that the successful performance of PMI consultants during the BUJT-to-APBN funding transition requires an integrated approach that combines regulatory compliance, professional competence, structured risk assessment, and effective stakeholder management. These findings provide a strong empirical basis for improving quality control practices and for developing policies and standards that enhance the accountability and effectiveness of PMI services in toll road infrastructure projects.

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