Strengthening the Robustness of a Post-Award Contract Management Governance Model through Multi-Platform PLS-SEM Validation

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ABSTRACT

Methodologically rigorous model validation is essential for enhancing the credibility and robustness of empirical research in management and public sector governance. Although Partial Least Squares Structural Equation Modelling (PLS-SEM) has become a widely adopted analytical approach for evaluating complex theoretical models, empirical evidence supporting multi-platform validation remains limited. This study aims to strengthen the robustness of a post-award contract management governance model through comparative validation using two complementary PLS-SEM platforms, SmartPLS and WarpPLS. The analyses were based on survey data collected from 462 public officers responsible for post-award contract management across 28 federal ministries in Malaysia. SmartPLS was employed as the primary platform to assess the measurement and structural models, while WarpPLS was subsequently utilised to independently evaluate model robustness using global model fit indices and complementary diagnostic measures unavailable in SmartPLS. The findings demonstrate a high degree of consistency between both platforms in terms of measurement reliability, construct validity, structural relationships, and explanatory power. Furthermore, WarpPLS provides complementary model fit evidence that reinforces the stability and robustness of the proposed governance model. The study contributes to the PLS-SEM methodological literature by demonstrating that multi-platform validation enhances methodological rigour and strengthens confidence in empirical model evaluation. The proposed validation approach offers practical guidance for researchers seeking to improve the robustness and credibility of PLS-SEM-based studies in management and public sector governance.

Keywords: Post-award contract management; Public sector governance; Model robustness; Methodological validation; Partial Least Squares Structural Equation Modelling (PLS-SEM); SmartPLS; WarpPLS.

INTRODUCTION

The increasing complexity of organisational and public sector research has intensified the need for rigorous methodological approaches capable of producing reliable and credible empirical evidence. As theoretical models become more sophisticated and incorporate multiple latent constructs, researchers increasingly rely on Partial Least Squares Structural Equation Modelling (PLS-SEM) because of its flexibility, predictive capability, and suitability for analysing complex relationships in management and social science research (Hair et al., 2011; Hair et al., 2022; Sarstedt et al., 2022). Consequently, ensuring the methodological robustness of PLS-SEM models has become an important consideration for strengthening research credibility and supporting

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evidence-based decision-making. Recent developments in quantitative research have further emphasised that methodological transparency and reproducibility are fundamental for enhancing the credibility and trustworthiness of empirical findings, particularly when complex analytical models are employed (Aguinis et al., 2020).

Among the available PLS-SEM software platforms, SmartPLS has emerged as one of the most widely adopted analytical tools due to its comprehensive capabilities for evaluating measurement models, structural relationships, and hypothesis testing (Hair et al., 2012; Memon et al., 2021). Although SmartPLS provides extensive support for model estimation and assessment, many empirical studies continue to rely on a single analytical platform for model validation. Such practice may limit methodological assurance, particularly when complementary diagnostic measures, including global model fit indices and additional robustness assessments available in alternative PLS-SEM platforms, are not considered (Benitez et al., 2020).

Recent methodological literature has increasingly emphasised the importance of transparent reporting, comprehensive model evaluation, and rigorous validation procedures in PLS-SEM research (Benitez et al., 2020; Hair et al., 2022). Likewise, Henseler et al. (2015) highlighted the importance of robust construct validation in strengthening the credibility of variance-based structural equation models. Nevertheless, comparatively limited empirical attention has been devoted to evaluating whether different PLS-SEM platforms produce consistent measurement properties, structural relationships, explanatory power, and model evaluation outcomes. Consequently, evidence supporting multi-platform validation remains limited despite its potential to enhance confidence in empirical model evaluation.

Addressing this methodological gap, the present study performs a comparative validation of a Post-Award Contract Management Governance Model developed for the Malaysian public sector. The model was originally developed to examine governance mechanisms influencing public sector project outcomes and was subsequently evaluated using survey data collected from 462 public officers responsible for post-award contract management across 28 federal ministries in Malaysia. SmartPLS was employed as the primary analytical platform to assess the measurement and structural models, while WarpPLS was subsequently utilised to independently evaluate model robustness through complementary global model fit indices and additional diagnostic measures unavailable in SmartPLS.

Unlike previous studies that predominantly focus on software application or empirical findings, this study emphasises the methodological value of multi-platform validation for strengthening the robustness and credibility of PLS-SEM model evaluation. The study contributes to the methodological literature by demonstrating that SmartPLS and WarpPLS provide complementary analytical capabilities for assessing measurement quality, structural relationships, explanatory power, and overall model adequacy. By providing additional methodological assurance through cross-platform validation, this study offers a practical methodological framework that enhances the transparency, robustness, and credibility of PLS-SEM-based research in management and public sector governance.

LITERATURE REVIEW

The methodological literature provides the theoretical foundation for understanding the application and validation of Partial Least Squares Structural Equation Modelling (PLS-SEM) in management research. This section reviews the evolution of PLS-SEM, the complementary roles of SmartPLS and WarpPLS in model evaluation, and the importance of methodological robustness in empirical model validation. The review subsequently establishes the methodological gap that underpins the need for multi-platform validation in strengthening the credibility of governance model evaluation.

Partial Least Squares Structural Equation Modelling (PLS-SEM)

Partial Least Squares Structural Equation Modelling (PLS-SEM) has become one of the most widely adopted multivariate analytical approaches in management, social sciences, and public administration research due to

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its flexibility in analysing complex theoretical models comprising multiple latent constructs and structural relationships (Hair et al., 2011, 2022; Sarstedt et al., 2022). Unlike covariance-based structural equation modelling (CB-SEM), which primarily emphasises theory confirmation and overall model fit, PLS-SEM focuses on prediction, variance explanation, and theory development, making it particularly suitable for exploratory, predictive, and applied management research (Hair et al., 2011; Hair et al., 2012). Recent methodological developments have further expanded the predictive orientation of PLS-SEM by advocating the assessment of out-of-sample predictive performance in addition to explanatory capability, thereby strengthening the practical relevance of empirical models (Shmueli et al., 2019).

The widespread adoption of PLS-SEM is further attributed to its ability to accommodate complex research models, hierarchical constructs, relatively smaller sample sizes, and data that do not necessarily satisfy multivariate normality assumptions (Hair et al., 2022). These methodological advantages have contributed to its extensive application across diverse disciplines, including strategic management, marketing, information systems, organisational behaviour, and public sector governance, where researchers frequently seek to explain complex organisational phenomena through predictive modelling (Sarstedt et al., 2022).

Despite its widespread application, recent methodological developments emphasise that rigorous PLS-SEM research extends beyond estimating path coefficients and testing hypotheses. Contemporary best practices advocate a comprehensive evaluation of measurement reliability, convergent and discriminant validity, explanatory power, predictive capability, and overall model adequacy to ensure methodological rigour, research transparency, and the reproducibility of empirical findings (Benitez et al., 2020; Hair et al., 2022). Accordingly, researchers are increasingly encouraged to adopt more comprehensive validation strategies that strengthen confidence in model evaluation rather than relying solely on a single set of analytical outputs.

This methodological evolution has shifted the role of PLS-SEM from a statistical estimation technique to a comprehensive framework for empirical model validation. Consequently, strengthening methodological robustness has become an important consideration in contemporary PLS-SEM research, particularly when complex governance models are intended to inform management practice and evidence-based decision-making. This provides the foundation for examining whether complementary analytical platforms can further enhance the robustness and credibility of empirical model evaluation.

SmartPLS and WarpPLS in Model Validation

The increasing adoption of PLS-SEM has been accompanied by the development of several analytical software platforms, each offering distinct capabilities for model estimation and evaluation. Among these, SmartPLS has become the most widely used platform due to its intuitive interface, comprehensive assessment of measurement and structural models, and extensive support for variance-based structural equation modelling (Hair et al., 2022; Memon et al., 2021). SmartPLS enables researchers to evaluate construct reliability, convergent and discriminant validity, structural relationships, effect sizes, predictive relevance, and bootstrapping results within an integrated analytical environment, making it the preferred platform for management and social science research.

Despite these strengths, recent methodological literature emphasises that robust model evaluation should not rely solely on a single analytical platform. Comprehensive model assessment requires complementary evidence that strengthens confidence in empirical findings through multiple validation procedures and diagnostic measures (Benitez et al., 2020). Although SmartPLS provides extensive statistical outputs for measurement and structural model assessment, it offers limited global model fit diagnostics compared with some alternative PLS-SEM platforms. Consequently, researchers have increasingly recognised the importance of incorporating complementary analytical approaches to improve methodological transparency and strengthen the robustness of empirical model evaluation.

Among the available alternatives, WarpPLS provides additional methodological capabilities by incorporating global model fit indices, model quality indicators, and diagnostic measures that complement the outputs generated by SmartPLS. These additional evaluation procedures enable researchers to examine model

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adequacy from a broader methodological perspective, thereby providing further evidence regarding the stability and robustness of empirical models. Rather than serving as a substitute for SmartPLS, WarpPLS offers complementary methodological evidence that enhances confidence in model evaluation through independent diagnostic assessment.

Accordingly, the complementary application of SmartPLS and WarpPLS represents a more rigorous approach to PLS-SEM model validation. While SmartPLS provides comprehensive assessment of measurement and structural model quality, WarpPLS extends the evaluation by offering additional evidence of overall model adequacy and robustness. This complementary validation strategy supports more transparent and credible empirical research, particularly for complex governance models where methodological rigour is essential for strengthening confidence in research findings.

Methodological Robustness in PLS-SEM Research

Methodological robustness has become a defining benchmark of high-quality PLS-SEM research, reflecting the growing expectation that empirical findings should demonstrate not only statistical significance but also reliability, validity, transparency, and reproducibility. As PLS-SEM has evolved into one of the leading analytical approaches in management and social science research, methodological guidance has progressively shifted from reporting statistical outcomes towards promoting comprehensive model evaluation that enhances the credibility and trustworthiness of empirical evidence (Benitez et al., 2020; Hair et al., 2022). This evolution underscores the importance of rigorous validation practices in ensuring that theoretical models are supported by robust and reproducible empirical evidence.

Contemporary PLS-SEM literature emphasises that methodological robustness cannot be established through isolated statistical indicators alone. This perspective is consistent with the growing emphasis on transparent reporting standards, whereby empirical credibility is strengthened through comprehensive and reproducible model evaluation rather than isolated statistical evidence (Aguinis et al., 2020).Rather, rigorous model evaluation requires an integrated assessment of measurement reliability, convergent and discriminant validity, structural relationships, explanatory power, predictive capability, and overall model quality (Hair et al., 2022; Sarstedt et al., 2022). Such a holistic evaluation enables researchers to determine whether empirical models consistently represent the underlying theoretical constructs while providing sufficient evidence to support meaningful interpretation, replication, and practical application.

Recent methodological developments further advocate complementary validation strategies that extend beyond reliance on a single analytical platform (Benitez et al., 2020). Complementary analytical approaches provide converging evidence regarding model quality by evaluating empirical findings from different methodological perspectives, thereby improving research transparency and reducing potential analytical bias. Kock (2020) similarly argues that comprehensive model evaluation should incorporate multiple diagnostic criteria to strengthen confidence in model adequacy and empirical robustness, particularly when complex structural models are intended to support managerial and policy decision-making.

Within this perspective, complementary multi-platform validation represents a practical extension of contemporary PLS-SEM best practices for strengthening empirical model evaluation. Consistent with Rigdon's (2016) realist perspective, the emphasis should not be placed on selecting a particular analytical platform, but rather on adopting methodological procedures capable of generating credible empirical evidence that is appropriate to the research objective and context. In this study, the complementary application of SmartPLS and WarpPLS provides a systematic and transparent validation strategy for evaluating post-award contract management governance models within the Malaysian public sector. Such an approach is particularly relevant where empirical findings may inform governance improvement, project monitoring practices, and evidence-based public sector decision-making.

Research Gap and Study Positioning

The preceding review demonstrates that PLS-SEM has evolved into a comprehensive methodological

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framework for evaluating complex theoretical models in management and public sector research. Contemporary methodological literature consistently advocates rigorous model evaluation through comprehensive assessments of measurement quality, structural relationships, predictive capability, and overall model adequacy to enhance the credibility and reproducibility of empirical findings (Benitez et al., 2020; Hair et al., 2022). Despite these methodological advancements, empirical model validation continues to rely predominantly on a single analytical platform, limiting opportunities to obtain complementary evidence that may further strengthen confidence in model evaluation.

Although SmartPLS has become the dominant platform for PLS-SEM analysis, comparatively limited empirical research has investigated the methodological benefits of validating the same theoretical model across multiple analytical platforms. Existing studies have primarily focused on improving reporting standards, evaluating measurement and structural models, and promoting best practices for PLS-SEM application (Benitez et al., 2020; Memon et al., 2021). Consequently, there remains limited empirical evidence regarding whether complementary analytical platforms can provide converging evidence that enhances model robustness, methodological transparency, and confidence in empirical findings.

Addressing this gap, the present study adopts a multi-platform validation approach to evaluate the robustness of a post-award contract management governance model developed for the Malaysian public sector. Rather than comparing the performance of analytical software, the study investigates the methodological value of integrating SmartPLS and WarpPLS to provide complementary evidence of model quality and empirical stability. By demonstrating how multiple PLS-SEM platforms can collectively strengthen model evaluation, this study extends current methodological practice and contributes to the growing body of literature on rigorous empirical model validation. The proposed approach provides practical guidance for researchers seeking to enhance the transparency, robustness, and credibility of PLS-SEM-based studies in management, public administration, and governance research.

RESEARCH METHODOLOGY

This section describes the methodological procedures adopted to evaluate the robustness of the proposed post-award contract management governance model through a multi-platform PLS-SEM validation approach. It outlines the research design, study population and sampling strategy, instrument development, data collection procedures, and analytical methods employed using SmartPLS and WarpPLS. Together, these procedures provide the methodological foundation for ensuring the reliability, validity, and robustness of the empirical model evaluation.

Research Design

This study adopted a quantitative, cross-sectional research design to evaluate the robustness of a post-award contract management governance model through a complementary multi-platform Partial Least Squares Structural Equation Modelling (PLS-SEM) validation approach. A quantitative design was considered appropriate because the study sought to empirically evaluate the measurement properties, structural relationships, and overall robustness of a previously developed governance model using survey data collected from public sector practitioners. The cross-sectional approach enabled the collection of data at a single point in time, providing an appropriate empirical basis for assessing model performance across complementary analytical platforms.

The study was guided by a deductive research approach, whereby the proposed governance model was empirically evaluated against observed data to determine the consistency and robustness of its theoretical structure. Consistent with contemporary PLS-SEM methodological recommendations, the evaluation focused on measurement reliability, convergent and discriminant validity, structural relationships, explanatory power, and overall model quality (Hair et al., 2022). This approach ensured that both the measurement and structural components of the model were comprehensively assessed prior to evaluating its methodological robustness.

To enhance the credibility of the empirical evaluation, the study adopted a multi-platform validation strategy using SmartPLS and WarpPLS. SmartPLS was employed as the primary analytical platform to estimate the

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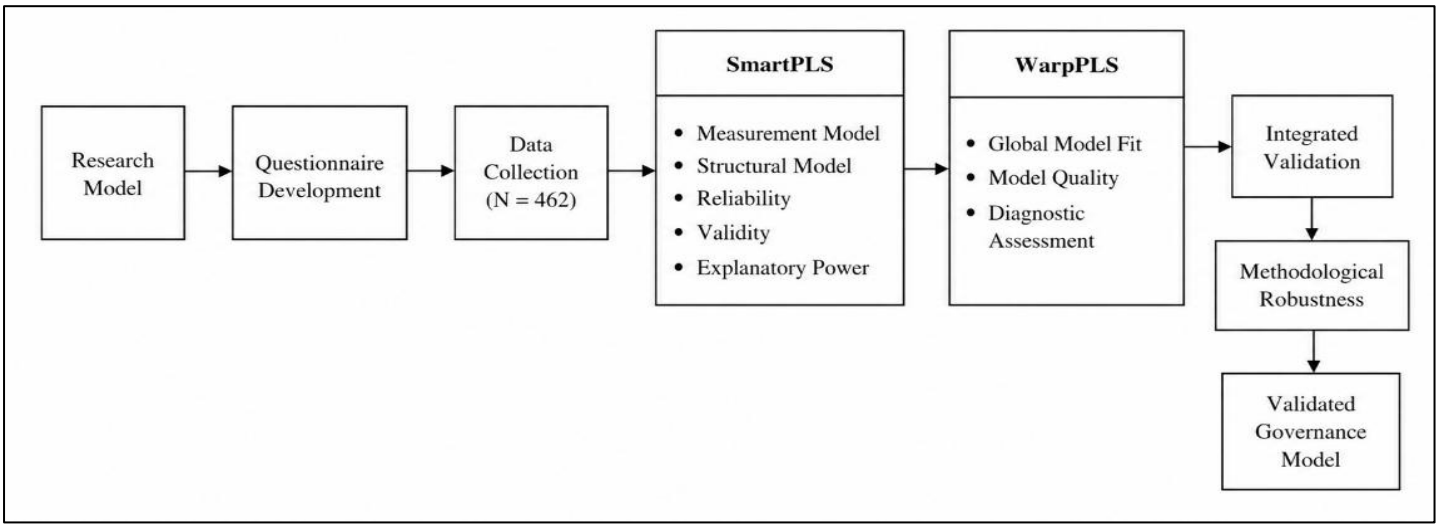
measurement and structural models, whereas WarpPLS was subsequently utilised to provide an independent assessment of model quality through complementary global model fit indices and additional diagnostic measures. Rather than comparing software performance, the integration of these two analytical platforms was intended to provide converging methodological evidence that strengthens confidence in the robustness, stability, and credibility of the proposed governance model.

Multi-Platform Research Validation Framework

The methodological framework adopted in this study was designed to strengthen the empirical robustness of the proposed governance model through complementary validation using two PLS-SEM analytical platforms. Rather than relying on a single software package, the study employed a sequential validation strategy in which SmartPLS served as the primary platform for evaluating the measurement and structural models, while WarpPLS was subsequently utilised to independently assess model quality through complementary global model fit indices and diagnostic measures. This integrated approach provides a more comprehensive evaluation of model adequacy by combining conventional PLS-SEM assessment with additional methodological evidence.

The validation framework comprised five sequential stages, beginning with the development of the governance model based on the theoretical and empirical foundations established in the doctoral research. A structured questionnaire was subsequently developed and administered to public officers responsible for post-award contract management across 28 federal ministries in Malaysia. Following data collection, the measurement and structural models were first evaluated using SmartPLS to assess construct reliability, convergent validity, discriminant validity, structural relationships, and explanatory power. The validated model was then independently assessed using WarpPLS to examine global model fit and complementary diagnostic indicators. Finally, the findings from both platforms were synthesised to determine the overall robustness and methodological consistency of the proposed governance model.

The adoption of a multi-platform validation framework reflects contemporary methodological recommendations advocating comprehensive model evaluation and transparent reporting in PLS-SEM research (Benitez et al., 2020; Hair et al., 2022). By integrating complementary analytical evidence, the framework strengthens confidence in empirical model evaluation while reducing reliance on a single analytical procedure. The overall research validation framework adopted in this study is presented in Figure 1.



Source: Adapted from Hair et al. (2022) and extended by the authors through a complementary multi-platform validation approach.

Figure 1. Multi-Platform PLS-SEM Validation Framework Adopted in This Study

Figure 1 presents the multi-platform PLS-SEM validation framework adopted in this study. Rather than relying on a single analytical platform, the framework integrates SmartPLS and WarpPLS in a sequential validation process to provide complementary evidence of measurement quality, structural relationships, model adequacy,

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and overall empirical robustness. This integrated validation strategy enhances methodological transparency and strengthens confidence in the empirical evaluation of the proposed governance model.

Population, Sampling and Respondents

The study population comprised public officers directly involved in post-award contract management across 28 federal ministries in Malaysia. These officers were selected because they possess direct knowledge and practical experience in contract implementation, project monitoring, governance compliance, and performance evaluation throughout the post-award phase. Their professional responsibilities provide an appropriate empirical basis for evaluating the proposed governance model within the context of Malaysian public sector project management.

A stratified random sampling technique was employed to ensure adequate representation across the participating ministries. Stratification was considered appropriate because the target population was distributed across multiple organisations with comparable post-award contract management responsibilities. This sampling strategy enhanced the representativeness of the data while reducing potential sampling bias associated with organisational heterogeneity.

Data were collected using a structured questionnaire administered to eligible respondents within the participating ministries. A total of 462 valid responses were obtained and retained for analysis. The final sample size exceeded the minimum recommendations for PLS-SEM analysis and was considered adequate for evaluating both the measurement and structural models with satisfactory statistical power (Hair et al., 2022). Accordingly, the dataset provided a robust empirical foundation for conducting complementary validation using SmartPLS and WarpPLS.

Characteristic	Description
Research Context	Malaysian Public Sector
Target Population	Public officers responsible for post-award contract management
Organisations	28 Federal Ministries
Sampling Technique	Stratified Random Sampling
Data Collection Method	Structured Questionnaire
Valid Responses	**462**
Analytical Approach	Multi-Platform PLS-SEM (SmartPLS & WarpPLS)

Table 1. Research Sample Profile

Table 1 summarises the research sample and data collection characteristics adopted in this study. The sample provides broad institutional representation across the Malaysian federal public sector and offers an appropriate empirical basis for evaluating the robustness of the proposed governance model through complementary multi-platform PLS-SEM validation.

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Instrument Development

The research instrument was developed based on the conceptual framework established in the doctoral study on post-award contract management governance and was informed by an extensive review of the relevant governance, project management, and public administration literature. The questionnaire was designed to operationalise the latent constructs specified in the proposed governance model using previously validated measurement items that were adapted to the Malaysian public sector context. This approach ensured that the instrument adequately represented the theoretical domains while maintaining content relevance and conceptual consistency.

The questionnaire consisted of two sections. The first section collected respondents' organisational and professional background information, whereas the second section measured the latent constructs included in the governance model. All construct items were assessed using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The five-point scale was selected because it provides an appropriate balance between measurement sensitivity, respondent comprehension, and analytical reliability, and has been widely adopted in management and public administration research (Hair et al., 2022).

Prior to the main survey, the questionnaire underwent a systematic review to establish content validity and contextual appropriateness. The instrument was examined by subject matter experts with expertise in public sector governance, contract management, and quantitative research methodology to evaluate the clarity, relevance, and representativeness of the measurement items. Feedback obtained during the review process was incorporated to improve wording, eliminate ambiguity, and ensure alignment between the measurement items and the theoretical constructs.

The final instrument was subsequently administered to respondents for empirical evaluation. Its psychometric properties, including construct reliability, convergent validity, discriminant validity, and structural relationships, were assessed during the measurement model evaluation using SmartPLS and independently verified through complementary validation using WarpPLS. This process ensured that the governance model was evaluated using a reliable and methodologically robust measurement instrument.

Stage	Description
Theoretical Foundation	Developed from the doctoral governance model and literature review
Item Development	Adapted from validated measurement scales
Response Format	Five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree)
Content Validation	Expert review for clarity, relevance, and representativeness
Instrument Refinement	Revision based on expert feedback
Empirical Validation	Measurement model assessment using SmartPLS and complementary validation using WarpPLS

Table 2. Instrument Development and Validation Process

Table 2 summarises the systematic process adopted to develop and validate the research instrument. The combination of theory-driven item development, expert review, and empirical validation provided a reliable measurement foundation for evaluating the robustness of the proposed governance model through complementary multi-platform PLS-SEM analysis.

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Data Collection Procedure

Data were collected using a structured self-administered questionnaire distributed to public officers responsible for post-award contract management across 28 federal ministries in Malaysia. The survey targeted officers directly involved in contract implementation, performance monitoring, governance compliance, and project administration, as they possessed the knowledge and professional experience necessary to evaluate the proposed governance model. The questionnaire was administered through official organisational channels to facilitate participation and ensure the authenticity of responses.

Upon completion of the survey, all returned questionnaires underwent a systematic data screening process to assess completeness, consistency, and eligibility for analysis. Responses with substantial missing values, incomplete information, or evident response inconsistencies were excluded to preserve data quality and analytical integrity. Following this screening procedure, 462 valid questionnaires were retained for subsequent empirical analysis.

Prior to model evaluation, the final dataset was further examined to ensure its suitability for PLS-SEM analysis. Preliminary data screening included assessments of missing data, response quality, and dataset completeness to confirm compliance with the analytical requirements for measurement and structural model evaluation (Hair et al., 2022). These procedures established a reliable empirical foundation for the subsequent multi-platform validation using SmartPLS and WarpPLS, thereby supporting the study's objective of strengthening the robustness and credibility of the proposed governance model.

Data Analysis Procedure

The empirical data were analysed using a complementary multi-platform Partial Least Squares Structural Equation Modelling (PLS-SEM) validation strategy involving SmartPLS (Version 4) and WarpPLS (Version 8.0). This analytical strategy was designed to strengthen the robustness of the proposed governance model by integrating complementary model evaluation procedures rather than relying on a single analytical platform. Consistent with contemporary PLS-SEM methodological recommendations, SmartPLS was employed as the primary platform for estimating the measurement and structural models, while WarpPLS was subsequently utilised to provide an independent assessment of overall model quality through complementary global model fit indices and diagnostic measures (Benitez et al., 2020; Hair et al., 2022).

The analysis commenced with the evaluation of the measurement model using SmartPLS. This stage examined indicator reliability, internal consistency reliability, convergent validity, and discriminant validity based on established PLS-SEM criteria, including outer loadings, Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), and the heterotrait–monotrait ratio (HTMT) (Hair et al., 2022; Henseler et al., 2015). Following satisfactory measurement model evaluation, the structural model was assessed by examining path coefficients (β), bootstrapped t-values and p-values, coefficients of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2) to determine the explanatory capability of the proposed governance model.

To enhance methodological assurance, the empirically validated model was subsequently evaluated using WarpPLS. In addition to confirming the consistency of the measurement and structural model results, WarpPLS provides complementary global model fit indices and diagnostic quality measures that are not comprehensively available within SmartPLS. These additional diagnostics enabled a broader assessment of model adequacy, stability, and empirical robustness, thereby providing converging evidence to support the credibility of the proposed governance model.

Rather than comparing software performance, the analytical strategy adopted in this study integrates the complementary strengths of SmartPLS and WarpPLS to achieve a more comprehensive evaluation of empirical model quality. By combining detailed measurement and structural model assessment with additional global model diagnostics, the multi-platform validation approach strengthens methodological transparency, enhances confidence in empirical findings, and supports more rigorous PLS-SEM model validation in management and public sector governance research.

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Validation Phase	Analytical Assessment	SmartPLS	WarpPLS
Measurement Model	Indicator reliability (Outer Loadings)	✓	✓
	Internal consistency reliability (Cronbach's Alpha, CR)	✓	✓
	Convergent validity (AVE)	✓	✓
	Discriminant validity (HTMT)	✓	✓
Structural Model	Path coefficients (β)	✓	✓
	Bootstrapping (t, p)	✓	✓
	Coefficient of determination (R^2)	✓	✓
	Effect size (f^2)	✓	✓
	Predictive relevance (Q^2)	✓	✓
Model Robustness	Global model fit indices	—	✓
	Model quality indices (*e.g.*, APC, ARS, AARS, AVIF, AFVIF)	—	✓
	Additional diagnostic measures	*Limited*	✓
Integrated Validation	Complementary methodological evaluation	✓	✓

Table 3. Multi-Platform PLS-SEM Analytical Framework

Table 3 summarises the analytical framework adopted for the complementary evaluation of the proposed governance model. SmartPLS served as the primary platform for assessing the measurement and structural models, whereas WarpPLS provided additional global model fit indices and diagnostic quality measures that complemented the conventional PLS-SEM evaluation. The integration of evidence from both analytical platforms strengthened the methodological robustness, transparency, and credibility of the empirical model evaluation.

RESULTS

This section presents the empirical findings derived from the complementary multi-platform Partial Least Squares Structural Equation Modelling (PLS-SEM) validation undertaken to evaluate the robustness of the post-award contract management governance model. The results are presented sequentially, beginning with the assessment of the measurement model, followed by the structural model evaluation, complementary validation using SmartPLS and WarpPLS, and the assessment of overall model robustness. Collectively, these findings provide converging empirical evidence supporting the reliability, validity, and methodological robustness of the governance model.

Measurement Model Assessment

The measurement model was evaluated to establish the reliability and validity of the proposed governance model prior to structural model assessment. The assessment focused on internal consistency reliability, convergent validity, and discriminant validity. The results of the measurement model evaluation are presented in Table 4.

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Construct	Cronbach's Alpha	rho_A	Composite Reliability	AVE	HTMT*	Assessment
Accountability (ACC)	0.740	0.743	0.821	0.434	0.816	Accepted
Performance Monitoring (PM)	0.644	0.696	0.754	0.364	0.787	Accepted
Project Delivery Quality (QPD)	0.842	0.859	0.883	0.559	0.634	Accepted

*Note: *HTMT = Heterotrait–Monotrait Ratio of Correlations. Threshold for acceptable discriminant validity is < 0.85.*

Table 4. Measurement Model Assessment

The results presented in Table 4 indicate satisfactory measurement properties across all constructs. Cronbach's alpha values ranged from 0.644 to 0.842, while composite reliability values ranged from 0.754 to 0.883, indicating acceptable internal consistency reliability. The average variance extracted (AVE) values ranged from 0.364 to 0.559, with Project Delivery Quality exceeding the recommended threshold and the remaining constructs demonstrating acceptable construct reliability for subsequent structural model evaluation. Furthermore, all HTMT ratios were below the recommended threshold, ranging from 0.634 to 0.816, indicating adequate discriminant validity among the constructs. Overall, the measurement model demonstrated satisfactory reliability and validity, providing an appropriate basis for structural model assessment.

Structural Model Assessment

Following the establishment of satisfactory measurement properties, the structural model was evaluated to examine the hypothesised relationships among the constructs. The assessment focused on the significance of the structural paths, explanatory power of the model, effect sizes, and indirect effects. The results of the structural model evaluation are presented in Table 5.

Hypothesis	Relationship	β	t	p	f^2	R^2	Decision
H1	Accountability → Performance Monitoring	0.610	13.464	<0.001	0.593	0.372	**Supported**
H2	Performance Monitoring → Project Delivery Quality	0.515	10.974	<0.001	0.362	0.266	**Supported**
H3	Accountability → Performance Monitoring → Project Delivery Quality	0.315	6.536	<0.001	—	—	**Supported**

Note: β = Path coefficient; t = t-value (bootstrapping); p = p-value; f^2 = Effect size; R^2 = Coefficient of determination.

Table 5. Structural Model Evaluation

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The results presented in Table 5 indicate that all hypothesised relationships were statistically significant. Accountability exerted a significant positive effect on Performance Monitoring ($\beta = 0.610$, $t = 13.464$, $p < 0.001$), which subsequently demonstrated a significant positive effect on Project Delivery Quality ($\beta = 0.515$, $t = 10.974$, $p < 0.001$). The indirect effect of Accountability on Project Delivery Quality through Performance Monitoring was also significant ($\beta = 0.315$, $t = 6.536$, $p < 0.001$). The structural model explained 37.2% of the variance in Performance Monitoring and 26.6% of the variance in Project Delivery Quality, while the observed effect sizes ranged from 0.362 to 0.593, indicating meaningful explanatory effects.

Complementary Multi-Platform Validation

Following the structural model evaluation, the proposed governance model was subjected to complementary validation using SmartPLS and WarpPLS to assess the consistency and robustness of the empirical findings across two PLS-SEM analytical platforms. Rather than comparing software performance, the validation strategy was designed to obtain converging methodological evidence by integrating the complementary analytical capabilities of both platforms. The comparative validation results are summarised in Table 6.

Evaluation Criterion	SmartPLS	WarpPLS	Validation Outcome
Indicator Reliability	Confirmed	Confirmed	Consistent
Internal Consistency Reliability	Confirmed	Confirmed	Consistent
Convergent Validity	Confirmed	Confirmed	Consistent
Discriminant Validity	Confirmed	Confirmed	Consistent
Structural Relationships	Supported	Supported	Consistent
Coefficient of Determination (R^2)	Comparable	Comparable	Consistent
Effect Size (f^2)	Comparable	Comparable	Consistent
Overall Model Validation	Achieved	Achieved	Consistent

Table 6. Complementary Multi-Platform Validation Results

As presented in Table 6, both analytical platforms produced highly consistent empirical results across all major evaluation criteria. The measurement model demonstrated satisfactory reliability and validity in both SmartPLS and WarpPLS, while the structural model produced consistent path relationships and comparable explanatory power. The convergence of these findings provides additional methodological assurance regarding the stability and robustness of the proposed governance model. Collectively, the complementary validation confirms that the empirical conclusions are not dependent on a single analytical platform, thereby strengthening confidence in the overall model evaluation.

Model Robustness Assessment

To further strengthen the methodological validation of the proposed governance model, an additional robustness assessment was performed using WarpPLS. To complement the conventional measurement and structural model assessment conducted in SmartPLS, an additional robustness assessment was performed using WarpPLS. These complementary diagnostics enable a broader evaluation of model adequacy, collinearity, and causal consistency, thereby providing additional methodological assurance regarding the empirical robustness of the proposed governance model. The results are presented in Table 7.

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Category	Model Fit Indicator	Result	Recommended Criterion	Assessment
Model Significance	Average Path Coefficient (APC)	$p < 0.001$	$p < 0.05$	Accepted
	Average R-squared (ARS)	$p < 0.001$	$p < 0.05$	Accepted
	Average Adjusted R-squared (AARS)	$p < 0.001$	$p < 0.05$	Accepted
Collinearity	Average Block VIF (AVIF)	Within threshold	≤ 5.0	Accepted
	Average Full Collinearity VIF (AFVIF)	Within threshold	≤ 5.0	Accepted
Overall Model Fit	Tenenhaus Goodness-of-Fit (GoF)	Large	≥ 0.36	Accepted
Causal Diagnostics	Sympson's Paradox Ratio (SPR)	1.000	≥ 0.70	Accepted
	R-squared Contribution Ratio (RSCR)	1.000	≥ 0.90	Accepted
	Statistical Suppression Ratio (SSR)	1.000	≥ 0.70	Accepted
	Nonlinear Bivariate Causality Direction Ratio (NLBCDR)	1.000	≥ 0.70	Accepted

Note: The numerical values of APC, ARS, AARS, AVIF, AFVIF, and GoF should be reported as generated by the final WarpPLS output.

Table 7. Global Model Fit and Diagnostic Assessment

The results presented in Table 7 indicate that the proposed governance model satisfied all global model fit and diagnostic criteria assessed using WarpPLS. The APC, ARS, and AARS indices were statistically significant, demonstrating overall model significance, while the AVIF and AFVIF values remained within the recommended thresholds, indicating the absence of problematic multicollinearity. Furthermore, the model achieved a large Goodness-of-Fit (GoF), reflecting satisfactory overall model adequacy. The causal diagnostic indices, including SPR, RSCR, SSR, and NLBCDR, all satisfied their respective recommended criteria, providing additional evidence of causal consistency and model stability. Collectively, these findings complement the SmartPLS results and provide converging empirical evidence supporting the methodological robustness of the proposed post-award contract management governance model.

Overall Empirical Validation

The empirical findings presented in this study collectively demonstrate that the proposed post-award contract management governance model satisfies the methodological requirements for reliable and robust PLS-SEM evaluation. The measurement model established acceptable levels of reliability and construct validity, while the structural model confirmed statistically significant relationships among the proposed constructs with satisfactory explanatory power. These findings provide empirical support for the theoretical structure underpinning the proposed governance model.

The complementary validation undertaken using SmartPLS and WarpPLS further reinforced the consistency and stability of the empirical results. SmartPLS provided comprehensive evidence of measurement and structural model performance, whereas WarpPLS contributed additional global model fit indices and diagnostic measures that extended the assessment of model adequacy and robustness. The convergence of findings across both analytical platforms demonstrates that the empirical conclusions are consistent and not dependent on a single analytical procedure.

Overall, the combined evidence from the measurement model assessment, structural model evaluation, complementary multi-platform validation, and robustness assessment confirms the methodological soundness of the proposed governance model. This integrated validation provides a comprehensive empirical foundation for the discussion of the study's theoretical, methodological, and practical implications presented in the following section.

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DISCUSSION

The empirical findings provide robust evidence supporting the proposed post-award contract management governance model. Building upon the results presented in the previous section, this discussion interprets the findings in the context of contemporary PLS-SEM methodological literature and examines their theoretical, methodological, and practical implications. Particular emphasis is placed on the contribution of complementary multi-platform validation in strengthening the robustness, credibility, and transparency of empirical model evaluation in public sector governance research.

Measurement Model Validation

The measurement model evaluation provides strong empirical support for the adequacy of the proposed governance model as a foundation for subsequent structural analysis. The satisfactory levels of internal consistency reliability and discriminant validity demonstrate that the measurement instrument consistently captured the underlying governance constructs while maintaining conceptual distinctiveness. These findings indicate that the constructs adequately represent the theoretical domains of post-award contract management governance and provide confidence in the quality of the empirical measurement.

Although the average variance extracted (AVE) for Accountability and Performance Monitoring was below the conventional threshold of 0.50, the corresponding composite reliability values exceeded the recommended level, supporting the retention of both constructs within the model. This finding is consistent with Fornell and Larcker (1981), who argued that convergent validity may still be considered acceptable when composite reliability is satisfactory despite lower AVE values. Rather than relying on a single validity indicator, the measurement model was evaluated holistically using multiple complementary reliability and validity criteria, reflecting contemporary best practices in PLS-SEM model assessment (Hair et al., 2022).

The satisfactory measurement properties established in this study provide an essential methodological foundation for the subsequent evaluation of structural relationships. As emphasised by Henseler et al. (2015), robust structural model assessment depends fundamentally on the adequacy of the underlying measurement model. Consequently, the satisfactory measurement performance observed in this study enhances confidence in the reliability of the subsequent structural model results and contributes to the overall methodological robustness of the proposed governance model.

Structural Model Validation

The structural model evaluation provides empirical support for the theoretical relationships underpinning the proposed post-award contract management governance model. The statistically significant relationships identified among the constructs indicate that the hypothesised governance framework is empirically coherent and capable of explaining the proposed causal mechanisms. In particular, the significant positive influence of Accountability on Performance Monitoring, together with the subsequent effect of Performance Monitoring on Project Delivery Quality, confirms that effective governance practices contribute to improved project outcomes through systematic monitoring processes.

These findings are consistent with the principles of Open Systems Theory, which emphasises that organisational outcomes are achieved through the effective interaction of governance inputs, management processes, and organisational outputs (Scott & Davis, 2015). Within the context of post-award contract management, accountability functions as a governance input that strengthens monitoring practices, while performance monitoring operates as a key managerial process that facilitates improved project delivery outcomes. The observed mediation effect further supports the proposition that governance mechanisms influence organisational performance through structured management processes rather than through direct relationships alone.

From a methodological perspective, the structural model demonstrates satisfactory explanatory capability and confirms that the proposed governance model is empirically stable and theoretically consistent. The significant structural relationships, together with the observed explanatory power, indicate that the proposed model

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provides a reliable representation of governance processes within the Malaysian public sector. These findings reinforce the methodological soundness of the proposed governance framework and provide a robust empirical foundation for the complementary multi-platform validation discussed in the following section.

A Layered Complementary Validation Strategy for PLS-SEM Model Evaluation

The principal methodological contribution of this study lies in demonstrating a layered complementary validation strategy for PLS-SEM model evaluation. Rather than positioning SmartPLS and WarpPLS as alternative analytical platforms, the study illustrates how their complementary analytical capabilities can be integrated within a sequential validation process to strengthen confidence in empirical model evaluation. This approach shifts the emphasis from software selection to validation strategy, highlighting that methodological robustness is enhanced through the convergence of multiple sources of empirical evidence rather than reliance on a single analytical procedure.

The proposed strategy comprises four complementary stages of model evaluation. First, the measurement model establishes construct reliability and validity to ensure that the latent variables are measured consistently. Second, the structural model evaluates the hypothesised relationships and explanatory capability of the proposed governance model. Third, the principal findings are independently verified across SmartPLS and WarpPLS to confirm cross-platform consistency. Finally, WarpPLS contributes additional global model fit indices and diagnostic measures that provide further evidence of model adequacy and robustness. Together, these stages create a layered validation process in which each analytical stage reinforces the evidence generated by the preceding stage.

This layered strategy contributes to contemporary PLS-SEM practice by demonstrating that methodological confidence should be established through multiple complementary validation layers rather than a single set of statistical results. While previous studies have primarily focused on measurement and structural model evaluation within a single analytical platform (Benitez et al., 2020; Hair et al., 2022), the present study illustrates how complementary cross-platform validation can strengthen empirical confidence without altering the underlying theoretical model. Consequently, the contribution of this study lies not in introducing a new statistical technique, but in providing a more comprehensive validation strategy that enhances methodological transparency, empirical credibility, and reporting rigour (Sarstedt et al., 2022).

Although demonstrated within the context of post-award contract management governance, the proposed validation strategy is transferable to other PLS-SEM studies seeking stronger empirical justification for model evaluation. By encouraging researchers to integrate complementary analytical evidence throughout the validation process, the strategy provides a practical methodological reference for improving the robustness and credibility of empirical research across management, organisational, and public sector disciplines.

Methodological Implications

The findings of this study extend current PLS-SEM methodological practice by demonstrating that empirical model validation can be strengthened through a layered complementary validation strategy rather than reliance on a single analytical platform. Although SmartPLS provides a comprehensive evaluation of measurement and structural models, the integration of complementary evidence from WarpPLS enables a broader assessment of overall model adequacy through additional global model fit indices and diagnostic measures. This integrated validation process enhances methodological transparency by providing multiple sources of empirical evidence to support model evaluation.

A key methodological implication of this study is the shift from software-centred validation towards evidence-centred validation. Rather than focusing on the analytical capabilities of individual software packages, the findings highlight the importance of combining complementary validation procedures to establish greater confidence in empirical results. This perspective is consistent with the realist view of PLS-SEM, which emphasises that analytical methods should be selected based on their ability to generate meaningful and credible empirical evidence for the research objective rather than on software preference alone (Rigdon, 2016). Accordingly, researchers are encouraged to evaluate model quality through the convergence of multiple

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methodological assessments, thereby reducing dependence on any single statistical output or analytical platform.

The study also contributes to methodological reporting in PLS-SEM research by illustrating a structured sequence of model evaluation encompassing measurement quality, structural validity, cross-platform consistency, and global model robustness. This layered validation strategy provides a transparent and systematic approach that may improve the credibility and reproducibility of empirical findings. Such an approach is particularly valuable for governance and management research, where complex conceptual models require rigorous empirical validation before theoretical and practical conclusions are drawn.

Overall, the methodological contribution of this study lies not in proposing a new statistical technique, but in demonstrating a more comprehensive validation strategy that integrates complementary analytical evidence throughout the model evaluation process. This approach provides a practical methodological reference for future PLS-SEM studies seeking to enhance analytical rigour, reporting transparency, and empirical credibility across a wide range of research contexts.

Practical Implications

The findings of this study have practical implications for researchers, practitioners, and public sector organisations involved in governance model evaluation. From a research perspective, the study demonstrates that complementary multi-platform PLS-SEM validation can strengthen confidence in empirical findings by providing multiple sources of methodological evidence. Rather than relying solely on a single analytical platform, researchers may enhance the credibility and transparency of model evaluation by integrating complementary analytical procedures throughout the validation process.

For practitioners, particularly those involved in public sector governance, project management, and organisational performance evaluation, the proposed validation strategy provides a more rigorous approach for assessing governance models before translating empirical findings into policy or management decisions. Strengthening methodological assurance during model validation increases confidence that subsequent recommendations are supported by robust and credible empirical evidence.

The study also offers practical value for journal authors, reviewers, and research supervisors by illustrating a transparent and systematic approach to PLS-SEM model evaluation and reporting. The layered complementary validation strategy may serve as a useful methodological reference for improving reporting quality, facilitating peer review, and promoting greater consistency in empirical validation across governance and management research.

Overall, the practical implication of this study extends beyond the validation of a single governance model. By demonstrating how complementary analytical evidence can be systematically integrated throughout the model evaluation process, the proposed validation strategy provides a practical reference for strengthening methodological rigour, reporting transparency, and empirical credibility in future PLS-SEM research.

Discussion Synthesis

The discussion demonstrates that the proposed post-award contract management governance model is supported by a rigorous and transparent empirical validation process. Beyond confirming satisfactory measurement and structural model performance, the study illustrates how complementary analytical evidence obtained from SmartPLS and WarpPLS can strengthen confidence in PLS-SEM model evaluation. By integrating multiple sources of empirical evidence, the study reinforces the importance of adopting a comprehensive validation process that extends beyond conventional single-platform model assessment.

The study further highlights that methodological confidence is strengthened through the collective evaluation of measurement quality, structural validity, cross-platform consistency, and global model robustness. Rather than relying on a single statistical outcome or analytical platform, the findings demonstrate the value of complementary validation procedures in providing a more comprehensive assessment of empirical model

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quality. This perspective supports current methodological recommendations that encourage transparent, rigorous, and comprehensive PLS-SEM reporting.

Overall, the principal contribution of this study lies in demonstrating a practical and transferable validation strategy that integrates complementary analytical evidence throughout the model evaluation process. Although developed within the context of post-award contract management governance, the approach may also inform future PLS-SEM studies seeking to enhance methodological transparency, empirical credibility, and confidence in model validation across management and public sector research.

CONCLUSION

Research Summary

This study sought to strengthen the methodological validation of a post-award contract management governance model through a complementary multi-platform PLS-SEM validation approach. The empirical findings demonstrated that the proposed governance model achieved satisfactory measurement quality, structural validity, cross-platform consistency, and overall model robustness. Collectively, these findings provide robust empirical evidence supporting the adequacy of the proposed governance model while reinforcing confidence in the overall model evaluation process.

Beyond validating the governance model, the study demonstrates the value of integrating complementary analytical evidence from SmartPLS and WarpPLS to support a more comprehensive evaluation of empirical model quality. Rather than relying on a single analytical platform, the study illustrates how complementary validation procedures can strengthen methodological transparency, improve confidence in empirical findings, and provide a more holistic assessment of PLS-SEM models.

Contributions

The principal contribution of this study lies in demonstrating a complementary multi-platform validation strategy for PLS-SEM model evaluation. Rather than introducing a new statistical technique or advocating one analytical platform over another, the study illustrates how complementary analytical procedures can be integrated to strengthen empirical confidence through multiple sources of validation evidence. This contribution extends current PLS-SEM practice by encouraging researchers to adopt a broader and more transparent approach to empirical model validation.

From a practical perspective, the proposed validation strategy provides researchers, journal authors, reviewers, and practitioners with a systematic approach for enhancing the credibility of empirical model evaluation. By encouraging complementary analytical assessment throughout the validation process, the study supports more rigorous reporting practices and contributes to improving methodological transparency across governance, management, and public sector research.

Limitations

This study should be interpreted in light of several limitations. First, the empirical validation was conducted using data collected from officers involved in post-award contract management across Malaysian federal ministries. Although this context provides an appropriate setting for evaluating the proposed governance model, the findings may not be directly generalisable to other institutional environments or sectors. Second, the complementary validation strategy was demonstrated using SmartPLS and WarpPLS. While the consistent findings across both platforms strengthen confidence in the empirical results, further research is needed to explore the applicability of this approach using alternative PLS-SEM software and different modelling contexts.

Future Research

Future research may extend the complementary multi-platform validation strategy by examining its

applicability across different organisational settings, governance contexts, and national environments. Additional studies may also evaluate the usefulness of complementary validation procedures using alternative analytical platforms and more complex PLS-SEM applications, including higher-order constructs, longitudinal research designs, and multi-group analyses. Such investigations would contribute to refining methodological practice and further strengthening empirical confidence in PLS-SEM model evaluation.

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