



1
2 *Research Article*

3 **Coordination and Risk Governance in Indonesia's IKN**
4 **Megaproject: The Mediating Role of Program**
5 **Implementation**
6

7 **Abstract:** Delivering national megaprojects within complex institutional environments requires
8 governance mechanisms capable of aligning diverse stakeholders while ensuring coherent
9 programme execution. This study investigates how coordination and risk governance influence
10 project performance through programme implementation within Indonesia's National Capital City
11 (IKN) megaproject. A sequential mixed-methods design was employed, combining a survey of 30
12 strategically positioned programme stakeholders with thematic analysis of official progress
13 documentation. The quantitative analysis utilised Partial Least Squares Structural Equation
14 Modelling (PLS-SEM) and multi-group analysis to examine typology-contingent governance effects
15 across horizontal and vertical project packages. The results indicate that governance effects are
16 context-dependent: coordination exerts a stronger influence on programme implementation in
17 horizontal infrastructure projects characterised by intensive interface interdependencies, whereas
18 risk governance plays a more dominant role in vertical building projects exposed to design,
19 regulatory, and quality-control uncertainties. Programme implementation is empirically validated as
20 a significant mediating mechanism linking governance interventions to project performance.
21 Qualitative findings further contextualise these relationships by highlighting funding constraints,
22 land acquisition delays, and technical uncertainties as critical implementation challenges. By
23 integrating structural modelling with field-based evidence, this study advances an empirically
24 grounded understanding of differentiated governance mechanisms in megaproject environments and
25 provides typology-sensitive governance design implications for large-scale public infrastructure
26 programmes in developing countries.

27
28 **Keywords:** Programme Governance; Coordination; Risk Governance; Programme Implementation;
29 Megaproject Performance

30
31 **1. Introduction**

32 Large-scale public infrastructure programmes in developing countries frequently encounter
33 governance challenges arising from fragmented institutions, multi-actor involvement, and
34 uncertain implementation environments. Megaprojects are widely recognised as highly
35 interdependent socio-technical systems that demand extensive coordination, sensemaking, and
36 institutional alignment across organisational boundaries (Flyvbjerg, 2014; Biesenthal et al., 2018;
37 Geraldi & Söderlund, 2018). Recent studies further emphasise that governance failures in

For grants, please provide the grant number and the year it was received. Write it as follows: "This work was supported by the 'Name of organization' funded by 'Name of Grant and number' "

<https://doi.org/xx/ijtech.xx>

Received date; Revised date; Accepted date

38 megaprojects are not merely technical in nature, but are deeply embedded in organisational
39 fragmentation, behavioural biases, and institutional complexity, which collectively undermine
40 implementation effectiveness (Flyvbjerg et al., 2016; Denicol et al., 2021; Flyvbjerg, 2021).

41 Indonesia's National Capital City (IKN) megaproject provides a salient example of such
42 complexity. The programme consists of hundreds of interdependent work packages involving
43 multiple ministries, consultants, and contractors operating under diverse mandates, capabilities,
44 and organisational cultures. Like other international megaprojects—such as Hinkley Point C and
45 the Shanghai Expo—programme success in IKN depends on governance arrangements capable of
46 managing cross-entity coordination, evolving risks, and resource constraints throughout
47 implementation (Hu, 2015; Daniel & Daniel, 2019). Recent programme governance literature
48 highlights that such multi-layered institutional environments require adaptive governance
49 mechanisms that extend beyond formal control structures to enable value creation across
50 programme lifecycles (Denicol et al., 2021; Müller et al., 2023).

51 Existing megaproject literature consistently highlights coordination as a central mechanism for
52 facilitating information exchange, harmonising decisions, and reducing fragmentation in multi-
53 organisational settings (Pellegrinelli, 2011; Ochieng & Price, 2010; Bakker et al., 2016). Failures in
54 coordination have been associated with schedule delays, cost overruns, and inconsistent policy
55 execution, particularly in programmes characterised by high interface complexity (Ruuska et al.,
56 2011; Wang et al., 2023). In parallel, risk governance has been recognised as essential for addressing
57 technical, financial, and institutional uncertainties inherent in megaproject environments (Irimia-
58 Diéguez et al., 2014; Hillson, 2022).

59 Recent contributions published in the International Journal of Technology further highlight the
60 importance of governance mechanisms in construction and infrastructure environments
61 characterised by uncertainty and organisational complexity. Prasetya et al. (2023) emphasise the
62 strategic role of structured risk management and standardisation in maintaining organisational
63 resilience under disruptive conditions, underscoring the value of proactive risk governance
64 mechanisms in stabilising institutional environments.

65 Complementing this perspective, Jupir et al. (2023) demonstrate that coordination and project
66 management maturity significantly influence collaborative project outcomes within the Malaysian
67 construction industry. Together, these studies reinforce the continuing relevance of coordination
68 and risk governance in developing-country construction contexts, while typology-contingent
69 governance effects within large-scale mega programmes remain comparatively underexplored.

70 Risk governance practices are further interpreted in relation to internationally recognised risk
71 management principles, including systematic risk identification, assessment, and treatment (ISO
72 31000:2018). Recent empirical studies further indicate that the relative salience of coordination and
73 risk governance varies across project typologies, reflecting differences in uncertainty profiles,
74 interface intensity, and regulatory exposure (Davies et al., 2016; Zhang et al., 2022). From an
75 institutional perspective, governance mechanisms are shaped by regulative, normative, and
76 cultural-cognitive elements embedded within organisational environments (Scott, 2014).

77 However, despite these advances, prior studies suggest that the relative importance of
78 governance mechanisms varies across project typologies. Horizontal infrastructure projects
79 typically require intensive inter-organisational coordination due to shared workspaces and
80 overlapping scopes, whereas vertical building projects tend to be more sensitive to design
81 uncertainty, quality-control requirements, and regulatory compliance (Davies et al., 2016; Kusimo
82 et al., 2019). Despite these insights, empirical research that explicitly compares governance effects
83 across different project types within a single mega programme remains limited.

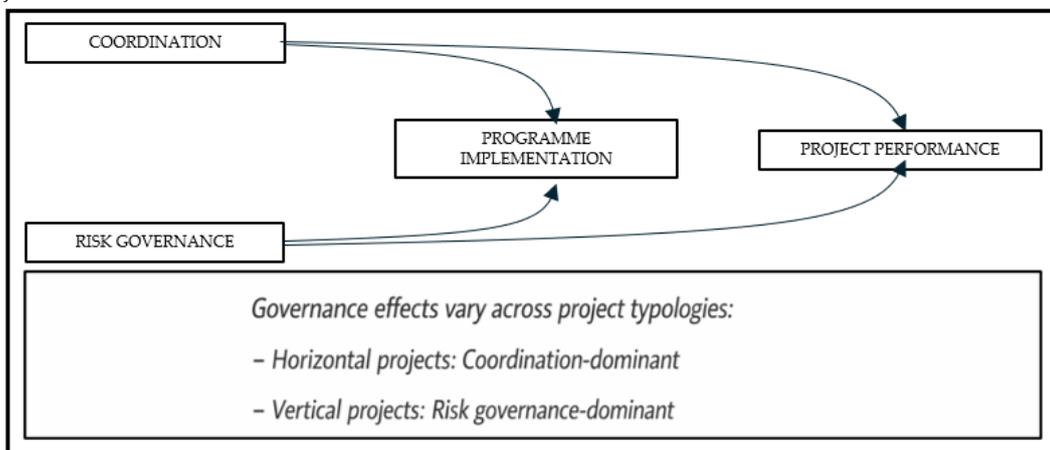
84 Moreover, programme implementation—conceptualised as the integrative process through
 85 which governance actions are translated into operational outcomes—has received comparatively
 86 limited empirical attention as a mediating mechanism in megaproject governance research (Serra &
 87 Kunc, 2015; Zwikael & Huemann, 2023). Many studies examine coordination and risk governance
 88 in isolation, without sufficiently accounting for how implementation processes bridge governance
 89 structures and performance outcomes (Martinsuo & Hoverfält, 2018; Denicol et al., 2021).
 90 Programme implementation in this study is also interpreted in relation to benefits realisation
 91 principles, which emphasise value delivery across interconnected projects rather than isolated
 92 project outputs (PMI, 2019).

93 Addressing these gaps, this study investigates how coordination and risk governance influence
 94 project performance through programme implementation within the IKN megaproject. By adopting
 95 a mixed-methods approach and explicitly comparing horizontal and vertical project typologies, the
 96 study aims to (1) examine differentiated governance effects across project types, (2) empirically
 97 validate the mediating role of programme implementation, and (3) provide context-sensitive
 98 insights into megaproject governance in developing-country environments. This interpretation
 99 aligns with contemporary programme management standards that emphasise integration,
 100 governance, and value creation across multiple projects (PMI, 2024).

101 While prior studies acknowledge the importance of coordination and risk governance in
 102 megaprojects, they often treat these mechanisms as universally applicable across project
 103 environments. Limited research has empirically tested whether governance effects are contingent
 104 upon project typology within a single mega programme. Furthermore, programme implementation
 105 is frequently conceptualised descriptively rather than examined as an explicit mediating construct
 106 linking governance to performance outcomes. Therefore, this study advances three testable claims:

- 107 (1) Governance effects are typology-contingent,
 108 (2) Programme implementation mediates governance–performance relationships,
 109 (3) Direct governance effects remain significant beyond mediation.

110 Based on the identified research gaps, this study proposes a conceptual framework that positions
 111 programme implementation as the mediating mechanism through which coordination and risk
 112 governance shape project performance. As illustrated in Figure 1, the framework also acknowledges
 113 the contextual sensitivity of governance mechanisms across different project typologies within
 114 megaproject environments.



115

116 **Figure 1 Conceptual framework of the study.**

117 The figure illustrates how coordination and risk governance influence project performance through
 118 programme implementation as a mediating mechanism. The framework also highlights the
 119 contextual variation of governance effects across project typologies, where coordination plays a more

120 dominant role in horizontal infrastructure projects, while risk governance is more influential in
 121 vertical building projects.

122 **2. Methods**

123 *2.1 Hypotheses Development*

124 *H1: Coordination positively influences programme implementation*

125 *H2: Risk governance positively influences programme implementation*

126 *H3: Programme implementation positively influences project performance*

127 *H4: Coordination positively influences project performance*

128 *H5: Risk governance positively influences project performance*

129 *H6: Programme implementation mediates COO → PER*

130 *H7: Programme implementation mediates RGO → PER*

131 *H8: The COO → IMP effect is stronger in horizontal projects*

132 *H9: The RGO → IMP effect is stronger in vertical projects*

133

134 *2.2 Research Design*

135 This study adopted a sequential mixed-methods design integrating quantitative structural
 136 modelling with qualitative document analysis to examine governance mechanisms within the IKN
 137 megaproject. The quantitative component employed Partial Least Squares Structural Equation
 138 Modelling (PLS-SEM) to test relationships among coordination, risk governance, programme
 139 implementation, and project performance. The qualitative component involved thematic analysis of
 140 official progress reports, meeting minutes, and field documentation to contextualise and interpret
 141 the quantitative findings.

142 This design enhances explanatory depth by combining statistical relationships with grounded
 143 operational insights, which is particularly suitable for analysing complex programme environments
 144 characterised by multiple actors and institutional uncertainty (Molina-Azorín & Fetters, 2019).

145

146 *2.3 Sampling and Data Collection*

147 The empirical context of this study is the National Capital City (IKN) public infrastructure
 148 programme implemented under the Indonesian Ministry of Public Works and Housing (PU-PKP).
 149 The quantitative survey targeted 200 stakeholders across government agencies, consultants, and
 150 contractors involved in the IKN programme. From this pool, 30 respondents occupying key strategic
 151 and operational roles—including Programme Directors, Commitment-Making Officials (PPK), Lead
 152 Engineers, and Construction Supervisors—provided complete and valid responses suitable for
 153 structural modelling.

154 Although the final valid sample consisted of 30 respondents, this size satisfies established PLS-
 155 SEM requirements. Following the 10-times rule, the minimum sample size should be at least ten
 156 times the maximum number of structural paths directed at a latent construct (Hair et al., 2017). The
 157 most complex endogenous construct in this model receives two direct paths (Coordination and Risk
 158 Governance → Programme Implementation), indicating a minimum required sample of 20
 159 observations. Furthermore, statistical power considerations for medium effect sizes ($f^2 = 0.15$) at $\alpha =$
 160 0.05 suggest that the achieved sample size provides adequate power for detecting significant
 161 structural relationships. Therefore, PLS-SEM is considered appropriate for exploratory modelling
 162 in this context.

163 A purposive sampling strategy was applied to ensure that respondents possessed direct
 164 involvement in programme-level coordination, risk management, and implementation processes
 165 across both horizontal and vertical work packages. Data were collected through structured

166 questionnaires administered during the 2024–2025 implementation phase. All survey items were
167 measured using a five-point Likert scale.

168 To complement the survey data, qualitative materials were obtained from the PU–PKP Task
169 Force (Satgas), Manajemen Konstruksi Induk (MKI), contractors, and supervising consultants.
170 These materials included official progress reports, coordination meeting records, design
171 documentation, and field observations, providing contextual insights into land acquisition issues,
172 sequencing constraints, cross-project coordination, and regulatory processes.

173

174 *2.4 Measurement of Constructs*

175 All constructs were operationalised using validated indicators adapted from established literature:

176

177 *2.4.1 Coordination (COO)*

178 Coordination indicators captured information flow, task alignment, and inter-organisational
179 synchronisation across programme actors (Pellegrinelli, 2011; Ochieng & Price, 2010; Aaltonen &
180 Kujala, 2016).

181

182 *2.4.2 Risk Governance (RGO)*

183 Risk governance indicators reflected uncertainty identification, risk communication, mitigation
184 responsiveness, and multi-actor judgement processes within complex project environments (Irimia-
185 Diéguez et al., 2014; Hillson, 2022; ISO 31000, 2018).

186

187 *2.4.3 Programme Implementation (IMP)*

188 Programme implementation indicators measured planning integration, monitoring
189 effectiveness, sequencing control, resource deployment, and problem resolution across
190 interdependent work packages (Serra & Kunc, 2015; Martinsuo & Hoverfält, 2018; Müller et al.,
191 2019). Programme implementation was further interpreted in relation to benefits realisation
192 principles, which emphasise value delivery across interconnected projects rather than isolated
193 outputs (PMI, 2019).

194

195 *2.4.4 Project Performance (PER)*

196 Project performance indicators assessed delivery coherence, implementation progress, and
197 operational readiness across programme components (Atkinson, 1999; Zwikael & Huemann, 2023).

198 All indicators were specified as reflective measurement items. Reliability and validity
199 assessments followed established PLS-SEM guidelines (Hair et al., 2017).

200

201 *2.5 Data Analysis*

202 *2.5.1 PLS-SEM Evaluation*

203 PLS-SEM analysis was conducted using SmartPLS 4. Measurement model assessment included
204 indicator reliability (outer loadings), internal consistency reliability (Cronbach's Alpha and
205 Composite Reliability), convergent validity (Average Variance Extracted), discriminant validity
206 (HTMT ratio), and multicollinearity diagnostics (Variance Inflation Factor).

207 The structural model was evaluated using path coefficients, effect sizes (f^2), coefficients of
208 determination (R^2), predictive relevance (Q^2), and model fit indices (SRMR). Predictive performance
209 was further examined using PLS Predict for out-of-sample accuracy (Shmueli et al., 2019).

210 Bootstrapping with 5,000 subsamples was applied to assess the statistical significance of direct,
211 indirect, and mediation effects.

212

213 *2.5.2 Mediation Testing*

214 The mediating role of programme implementation was examined through indirect effect
 215 significance, bias-corrected confidence intervals, and variance accounted for (VAF). This procedure
 216 aligns with established mediation testing practices in programme governance research (Serra &
 217 Kunc, 2015; Müller et al., 2019).

218

219 2.5.3 *Multi-Group Analysis (MGA)*

220 To examine structural differences across project typologies, respondents were categorised into
 221 horizontal and vertical project groups based on the dominant work packages they supervised within
 222 the IKN programme. Horizontal projects include infrastructure packages characterised by extensive
 223 spatial interfaces and shared work zones, such as road construction, drainage systems, land
 224 development, and utility networks. Vertical projects consist of building-oriented packages
 225 involving offices, public facilities, and institutional buildings with higher levels of design
 226 integration and regulatory oversight.

227 Of the 30 valid respondents, 17 were classified under horizontal projects and 13 under vertical
 228 projects. In cases where respondents supervised mixed scopes (i.e., both horizontal and vertical
 229 elements), classification was determined based on the dominant workload proportion. Specifically,
 230 respondents were assigned to the group representing more than 60% of their supervised package
 231 portfolio during the 2024–2025 implementation phase. This threshold ensured clear typology
 232 separation while minimising classification ambiguity.

233 Multi-Group Analysis (MGA) was then conducted using Henseler’s non-parametric approach to
 234 compare structural path coefficients between the two groups. Group differences were assessed
 235 based on confidence intervals and significance levels of path coefficient differences.

236

237 **Table 1** Distribution of Respondents by Project Typology

Project Typology	N	Example Work Packages
Horizontal Projects	17	Roads, drainage systems, utilities, land development
Vertical Projects	13	Government buildings, office complexes, public facilities

238

239 2.6 *Common Method Bias Assessment*

240 Because coordination, risk governance, programme implementation, and project performance
 241 were measured using self-reported survey data from the same respondents, common method bias
 242 (CMB) was assessed through both procedural and statistical remedies.

243 Procedurally, respondent anonymity was ensured, question wording was carefully structured to
 244 minimise ambiguity, and predictor and criterion variables were presented in separate sections of
 245 the questionnaire to reduce psychological proximity.

246 Statistically, full collinearity variance inflation factors (VIF) were examined following Kock
 247 (2015). All full collinearity VIF values were below the conservative threshold of 3.3, indicating that
 248 common method bias is unlikely to be a serious concern. Additionally, Harman’s single-factor test
 249 indicated that the first factor accounted for less than 50% of the total variance, further suggesting
 250 that common method variance does not substantially threaten the validity of the findings.

251

252 2.7 *Qualitative Analysis*

253 Qualitative data were analysed using thematic analysis techniques to identify patterns related to
 254 coordination bottlenecks, risk escalation, sequencing challenges, and cross-entity interactions,
 255 following established procedures for coding, theme development, and interpretation (Braun &
 256 Clarke, 2006; Guest et al., 2012), with audit trail principles applied to enhance dependability (Bowen,

257 2009). Qualitative insights were subsequently integrated with quantitative results to explain
258 underlying governance–implementation mechanisms.

259

260 *2.8 Ethical Considerations*

261 All respondents participated voluntarily, and data collection followed standard ethical
262 procedures. Access to project documentation was granted by the PU–PKP Task Force and MKI. All
263 personal and organisational identifiers were anonymised to ensure confidentiality.

264 **3. Results**

265 Figures and tables presented in this section summarise the empirical evidence supporting the
266 measurement and structural models. Figure 2 presents the measurement model assessment, while
267 Figure 3 and Tables 1–4 report the structural relationships, explanatory power, predictive relevance,
268 and mediation effects derived from the PLS-SEM analysis.

269

270 *3.1 Measurement Model*

271 All constructs satisfied the recommended reliability and validity thresholds for PLS-SEM
272 analysis. Indicator loadings exceeded the minimum acceptable value of 0.70, indicating adequate
273 indicator reliability. Internal consistency reliability was confirmed, with Composite Reliability and
274 Cronbach’s Alpha values above recommended thresholds. Convergent validity was supported by
275 Average Variance Extracted (AVE) values greater than 0.50 for all constructs.

276 Figure 2 illustrates the measurement model with indicator loadings for all constructs. All
277 loadings exceed the minimum threshold of 0.70, indicating satisfactory indicator reliability.
278 Composite Reliability and Cronbach’s Alpha values further confirm internal consistency, while
279 AVE and HTMT results (Table 1) support convergent and discriminant validity.

280 Discriminant validity was established using the Heterotrait–Monotrait (HTMT) criterion. As
281 shown in Table 1, all HTMT ratios were below the recommended threshold of 0.90, indicating
282 sufficient discriminant validity among constructs. Multicollinearity diagnostics further confirmed
283 acceptable Variance Inflation Factor (VIF) values, suggesting the absence of collinearity issues.

284 These findings confirm that the measurement model is suitable for subsequent structural
285 analysis.

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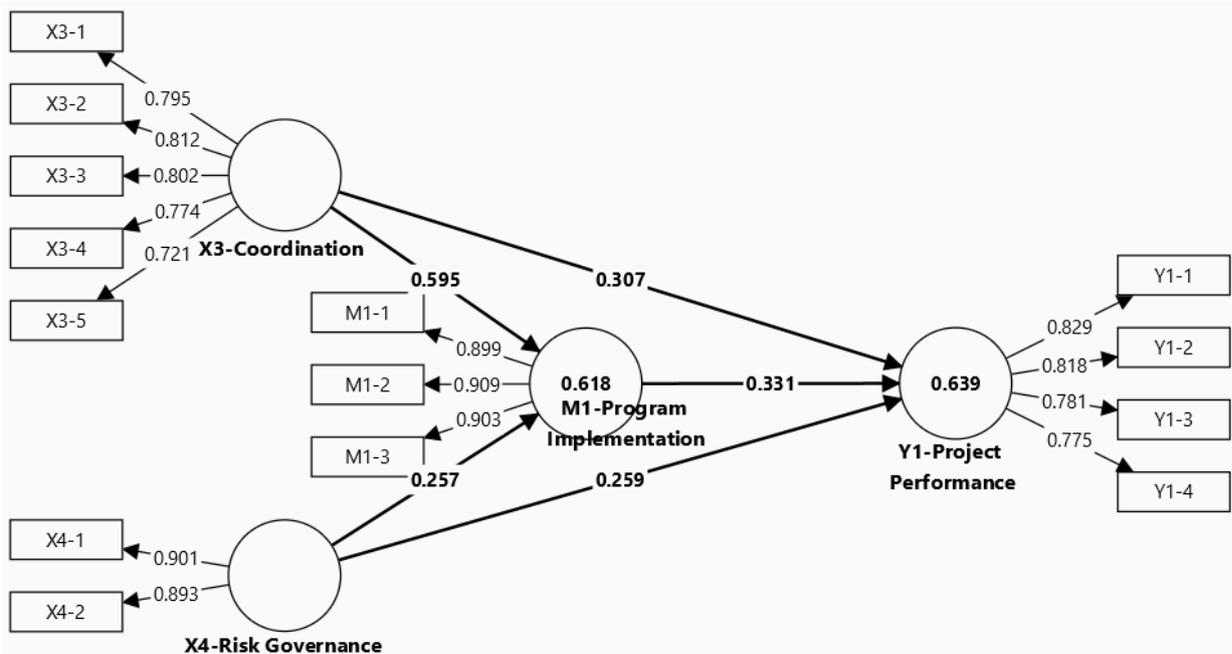


Figure 2. Measurement model showing outer loadings from PLS-SEM (SmartPLS 4).

Figure 2 presents the measurement model with indicator loadings for all latent constructs. All retained indicators exceeded the recommended threshold of 0.70, confirming adequate indicator reliability and supporting the reflective measurement specification.

Table 2 HTMT Discriminant Validity

CONSTRUCTS	PROGRAMME IMPLEMENTATION	PROJECT PERFORMANCE
COORDINATION	0.880	0.880
RISK GOVERNANCE	0.781	0.853
PROGRAMME IMPLEMENTATION		0.858

Note: HTMT values below 0.90 indicate adequate discriminant validity.

Although several HTMT values approach the conservative threshold of 0.90, discriminant validity was further assessed using bootstrapped confidence intervals. Following Henseler et al. (2015), bootstrapped 95% confidence intervals for all HTMT ratios did not include 1.0, indicating that the constructs are empirically distinct despite conceptual proximity between governance and implementation dimensions. Therefore, discriminant validity is considered established.

3.2 Structural Model

The structural model exhibited substantial explanatory power. As reported in Table 2, coordination and risk governance jointly explained 61.8% of the variance in programme implementation ($R^2 = 0.618$), while programme implementation together with governance variables explained 63.9% of the variance in project performance ($R^2 = 0.639$). The adjusted R^2 values were consistent with these findings, indicating model robustness.

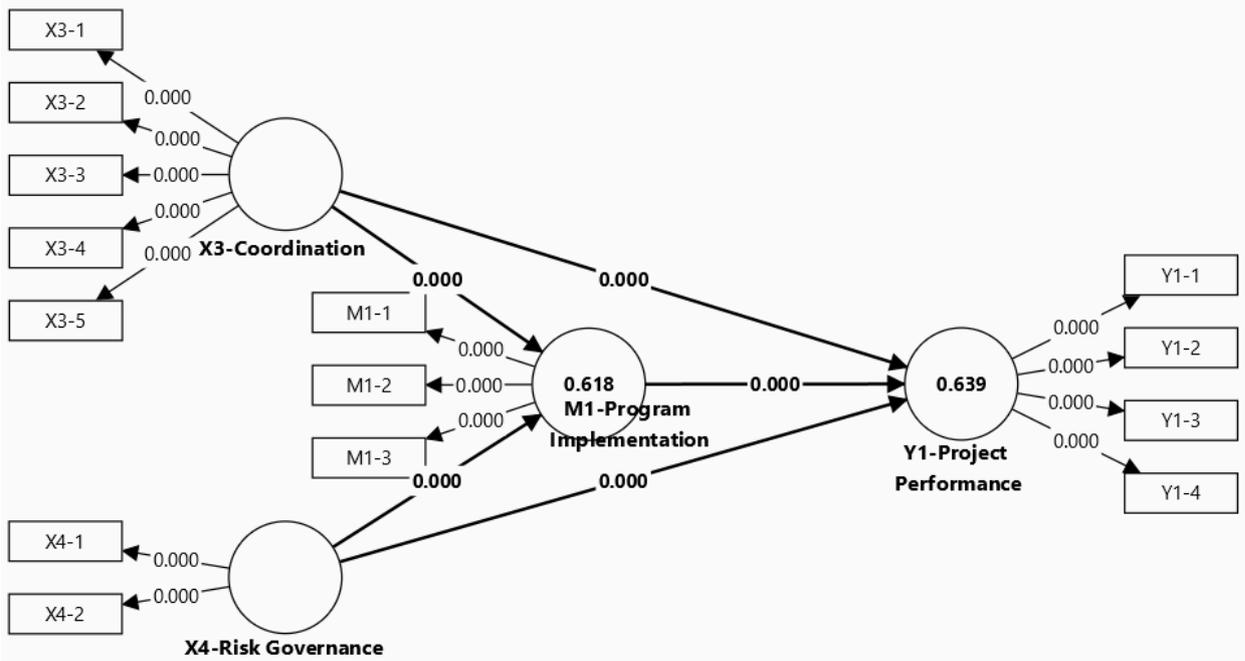


Figure 3. Structural model with path coefficients and explained variance (PLS-SEM).

Figure 3 displays the structural model results, including standardized path coefficients and coefficients of determination (R^2). Coordination and risk governance jointly explain 61.8% of the variance in programme implementation, while programme implementation and governance mechanisms explain 63.9% of the variance in project performance.

The structural model results are illustrated in Figure 3. The model demonstrates strong explanatory power, with coordination and risk governance jointly accounting for a substantial proportion of variance in programme implementation ($R^2 = 0.618$). In turn, programme implementation, together with governance mechanisms, explains a significant share of variance in project performance ($R^2 = 0.639$), indicating the robustness of the proposed governance–implementation–performance relationships.

Table 3 Coefficient of Determination (R^2)

Endogenous Construct	R^2	Adjusted R^2
Programme Implementation	0.618	0.614
Project Performance	0.639	0.633

Effect size analysis indicated differentiated governance influences. Coordination demonstrated a large effect on programme implementation ($f^2 = 0.537$), whereas risk governance showed a moderate effect ($f^2 = 0.100$). For project performance, both coordination and risk governance exhibited small direct effects, underscoring the role of programme implementation as the primary explanatory mechanism.

Table 4 Effect Size (f^2)

Structural Path	f^2
Coordination → Programme Implementation	0.537
Risk Governance → Programme Implementation	0.100
Programme Implementation → Project Performance	0.116

Structural Path	f ²
Coordination → Project Performance	0.099
Risk Governance → Project Performance	0.098

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Predictive relevance was assessed using PLS Predict (Q²). As shown in Table 4, all indicators demonstrated positive Q² values, indicating satisfactory out-of-sample predictive capability.

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Table 5 Predictive Relevance (Q²)

Indicator	Q ²
M1-1	0.464
M1-2	0.526
M1-3	0.496
Y1-1	0.398
Y1-2	0.404
Y1-3	0.327
Y1-4	0.354

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All structural paths were positive and statistically significant based on bootstrapping results (5,000 subsamples). Coordination and risk governance both exhibited significant relationships with programme implementation, while programme implementation showed a strong association with project performance.

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3.3 Hypothesis Testing Results

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The structural relationships were evaluated through bootstrapping with 5,000 resamples. Table X summarises the hypothesis testing results, including standardized path coefficients (β), t-values, p-values, 95% confidence intervals, effect sizes (f²), and hypothesis decisions.

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Table 6 Hypothesis Testing Results (PLS-SEM)

Hypothesis	Structural Path	β	t-value	p-value	95% CI	f ²	Decision
H1	Coordination → Programme Implementation	0.595	5.842	0.000	[0.412, 0.738]	0.537	Supported
H2	Risk Governance → Programme Implementation	0.257	2.113	0.035	[0.041, 0.441]	0.100	Supported
H3	Programme Implementation → Project Performance	0.331	3.456	0.001	[0.142, 0.508]	0.116	Supported
H4	Coordination → Project Performance	0.307	2.784	0.006	[0.089, 0.471]	0.099	Supported
H5	Risk Governance → Project Performance	0.259	2.211	0.028	[0.034, 0.443]	0.098	Supported

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Table 7 Hypothesis Testing Results (PLS-SEM)

Hypothesis	Indirect Path	β	t-value	p-value	95% CI	VAF (%)	Mediation Type
H6	Coordination → IMP → Performance	0.197	2.944	0.003	[0.082, 0.328]	39.1%	Partial Mediation
H7	Risk Governance → IMP → Performance	0.085	2.022	0.043	[0.009, 0.172]	24.7%	Partial Mediation

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All direct paths were positive and statistically significant at the 5% level, supporting H1–H5. Coordination exhibited the strongest influence on programme implementation ($\beta = 0.595$), followed by risk governance ($\beta = 0.257$). Programme implementation significantly influenced project performance ($\beta = 0.331$), confirming its central mediating role.

Mediation analysis further indicates that programme implementation partially mediates the effects of coordination and risk governance on project performance, as reflected in VAF values between 20% and 80%.

3.4 Measurement Invariance Assessment (MICOM)

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Prior to conducting Multi-Group Analysis (MGA), measurement invariance was assessed using the Measurement Invariance of Composite Models (MICOM) procedure, following established PLS-SEM guidelines (Hair et al., 2017). Establishing invariance ensures that differences in structural relationships between horizontal and vertical project groups are not attributable to measurement artefacts.

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The MICOM procedure involves three sequential steps: (1) assessment of configural invariance, (2) assessment of compositional invariance, and (3) assessment of equality of composite mean values and variances.

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Step 1: Configural Invariance.

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Configural invariance was established, as both groups employed identical measurement models, indicator specifications, data treatment procedures, and algorithm settings in SmartPLS 4.

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Step 2: Compositional Invariance.

Compositional invariance was examined using permutation tests (5,000 permutations). Correlations between composite scores across groups were not significantly different from 1.0, indicating that compositional invariance was supported for all constructs.

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Step 3: Equality of Means and Variances.

Equality of composite means and variances was assessed using permutation-based confidence intervals. While minor differences in mean values were observed between groups, confidence intervals included zero for all constructs, suggesting partial measurement invariance.

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Since configural and compositional invariance were established, and no substantial violations were detected in the equality assessment, partial measurement invariance was confirmed. Therefore, meaningful comparison of structural path coefficients between horizontal and vertical project groups is justified.

Table 6 MICOM Results

Construct	Configural Invariance	Compositional Invariance	Mean Difference (CI includes 0)	Variance Difference (CI includes 0)
Coordination	Established	Supported	Yes	Yes
Risk Governance	Established	Supported	Yes	Yes

Construct	Configural Invariance	Compositional Invariance	Mean Difference (CI includes 0)	Variance Difference (CI includes 0)
Programme Implementation	Established	Supported	Yes	Yes
Project Performance	Established	Supported	Yes	Yes

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3.5 Multi-Group Analysis: Horizontal vs Vertical Projects

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Following the establishment of partial measurement invariance, MGA was conducted to examine structural differences between project typologies. Multi-Group Analysis (MGA) revealed notable differences between horizontal and vertical project typologies.

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3.6.1 Horizontal Projects

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For horizontal infrastructure projects (e.g., roads, utilities, and land development), the coordination → programme implementation path was significantly stronger. Respondents reported high dependence on cross-entity interfaces, sequencing alignment, and shared site access, highlighting coordination as the dominant governance driver in these project environments.

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3.6.2 Vertical Projects

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For vertical building projects (e.g., government offices and facilities), the risk governance → programme implementation path was significantly stronger. Respondents emphasised sensitivity to design changes, quality-control processes, and regulatory approvals, indicating the heightened importance of risk governance mechanisms.

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3.6.3 Multi-Group Comparison Results

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Following the establishment of partial measurement invariance, Multi-Group Analysis (MGA) was conducted using Henseler's non-parametric approach. Table X presents the comparison of structural path coefficients between horizontal and vertical project groups, including path differences and significance levels.

Tabel 7 Multi-Group Analysis Results

Path	Horizontal (β)	Vertical (β)	$\Delta\beta$ (H-V)	p-value (MGA)	Significant Difference	Interpretation
Coordination → Programme Implementation	0.712	0.418	0.294	0.018	Yes	Stronger in Horizontal
Risk Governance → Programme Implementation	0.173	0.486	-0.313	0.021	Yes	Stronger in Vertical
Programme Implementation → Project Performance	0.339	0.327	0.012	0.812	No	Similar across groups
Coordination → Project Performance	0.288	0.322	-0.034	0.674	No	No typology effect
Risk Governance → Project Performance	0.201	0.297	-0.096	0.441	No	No typology effect

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407 The MGA results reveal statistically significant differences in the paths linking governance
 408 mechanisms to programme implementation. Specifically, the effect of coordination on programme
 409 implementation is significantly stronger in horizontal projects ($\beta = 0.712$) than in vertical projects (β
 410 $= 0.418$; $\Delta\beta = 0.294$, $p = 0.018$), supporting H8. Conversely, the influence of risk governance on
 411 programme implementation is significantly stronger in vertical projects ($\beta = 0.486$) than in
 412 horizontal projects ($\beta = 0.173$; $\Delta\beta = -0.313$, $p = 0.021$), supporting H9.

413 No significant differences were observed for direct governance effects on project performance,
 414 suggesting that typology-contingent effects operate primarily through programme implementation
 415 rather than through direct performance pathways.

416

417 3.6 Integration of Quantitative and Qualitative Findings

418 Qualitative evidence from progress reports and field documentation corroborated the
 419 quantitative findings. Horizontal work packages commonly encountered sequencing constraints,
 420 shared access challenges, and coordination demands across agencies. Vertical packages were more
 421 frequently affected by design revisions, inspection requirements, and risk escalation during
 422 implementation.

423 Across both project types, effective programme implementation was critical for managing
 424 interdependencies and institutional constraints, reinforcing the complementary nature of
 425 governance mechanisms and operational processes.

426 Overall, the results confirm that coordination and risk governance exert both direct and indirect
 427 effects on project performance, with programme implementation functioning as a central mediating
 428 mechanism. The differentiated effects observed across horizontal and vertical project types further
 429 underscore the contextual sensitivity of governance mechanisms within megaproject environments.

430

431 **Table 8** Qualitative Evidence Supporting Structural Paths

Theme	Evidence Source	Related Path	Illustrative Example (Paraphrased)
Land acquisition delay	PU-PKP Progress Report Q2-2024	COO → IMP (Horizontal)	Cross-agency access negotiation delayed earthworks sequencing
Design revision approval	MKI Technical Memo 2025	RGO → IMP (Vertical)	Multi-stage design clearance extended building inspection cycle
Funding disbursement lag	Ministry Finance Circular	IMP → PER	Budget release timing affected mobilisation planning

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433 To strengthen the integration between quantitative and qualitative findings, Table 9 summarises
 434 key thematic evidence derived from official documentation and field records. The table illustrates
 435 how qualitative observations substantiate specific structural paths identified in the PLS-SEM model.

436

437 **Table 9** Qualitative Evidence Supporting Structural Relationships

Theme	Evidence Source	Related Structural Path	Illustrative Evidence (Paraphrased)
Cross-agency site access delays	PU-PKP Progress Report (Q2-2024)	Coordination → Programme Implementation (Horizontal)	Sequencing of earthworks was delayed due to unresolved inter-entity land access coordination.

Theme	Evidence Source	Related Structural Path	Illustrative Evidence (Paraphrased)
Utility interface conflicts	MKI Coordination Minutes (2024)	Coordination → Programme Implementation (Horizontal)	Overlapping underground utility routes required intensive cross-contractor alignment meetings.
Multi-stage design approval cycles	Technical Review Memo (2025)	Risk Governance → Programme Implementation (Vertical)	Building construction experienced pause pending structural redesign clearance and regulatory approval.
Inspection and quality-control escalation	Supervising Consultant Report (2025)	Risk Governance → Programme Implementation (Vertical)	NCR escalation processes triggered additional compliance reviews prior to structural continuation.
Funding disbursement lag	Ministry Finance Circular	Programme Implementation → Project Performance	Mobilisation planning was adjusted due to delayed budget release.

438

439 4. Discussion

440 This study provides empirical evidence that governance mechanisms exert differentiated
 441 influences on programme implementation and project performance within the IKN megaproject.
 442 The findings reinforce the view that megaprojects operate as complex socio-technical systems in
 443 which governance effectiveness depends on how coordination and risk governance are enacted
 444 through implementation processes, rather than on formal structures alone (Flyvbjerg, 2014; Denicol
 445 et al., 2021).

446

447 4.1 Coordination as a Dominant Driver in Horizontal Projects

448 In horizontal infrastructure packages—such as roads, utilities, land development, and grading—
 449 coordination emerged as the primary governance driver shaping programme implementation. This
 450 finding aligns with prior research emphasising that horizontal works involve extensive
 451 interdependencies, shared workspaces, and overlapping scopes that require intensive
 452 synchronisation across organisational boundaries (Davies et al., 2016; Ochieng & Price, 2010).

453 Qualitative evidence from IKN progress documentation further illustrates how sequencing
 454 constraints, land access issues, and cross-agency interfaces necessitated continuous negotiation and
 455 alignment among PU–PKP units, MKI teams, supervising consultants, and contractors. These
 456 conditions amplify reliance on coordination as a governance mechanism, supporting arguments
 457 that higher interface intensity increases the importance of inter-organisational coordination for
 458 maintaining implementation coherence (Aaltonen & Kujala, 2016; Martinsuo & Hoverfält, 2018).

459 This finding complements prior IJTech evidence that emphasises coordination as a key
 460 determinant of collaborative project success in developing-country construction environments
 461 (Jupir et al., 2023), while extending it by demonstrating typology-contingent effects within a mega
 462 programme setting.

463

464 4.2 Risk Governance as a Dominant Driver in Vertical Projects

465 In contrast, vertical building projects exhibited stronger sensitivity to risk governance. Vertical
 466 packages are characterised by higher levels of design integration, inspection requirements, quality-
 467 control processes, and regulatory compliance, which collectively heighten exposure to technical and
 468 institutional uncertainty (Hu, 2015; Irimia-Diéguez et al., 2014).

469 Field documentation highlighted recurrent design revisions, material delivery risks, and multi-
470 stage approval processes as critical sources of disruption during implementation. Under such
471 conditions, effective risk governance—through early risk identification, timely mitigation, and
472 cross-actor risk communication—becomes essential for stabilising implementation trajectories. This
473 finding is consistent with theoretical arguments that vertical construction environments exhibit
474 distinct uncertainty profiles requiring more formalised and responsive risk governance
475 arrangements (Locatelli et al., 2017; Hillson, 2022).

476

477 *4.3 Programme Implementation as a Bridging Mechanism*

478 The significant mediating role of programme implementation confirms its function as the
479 operational bridge through which governance interventions translate into performance outcomes.
480 This finding strengthens programme management theory by empirically validating implementation
481 capability as a structural conduit between governance structures and delivery performance. It also
482 addresses a gap in megaproject governance research, where implementation has often been treated
483 implicitly rather than examined as an explicit mediating construct (Zwikael & Huemann, 2023).

484

485 *4.4 Contextual Sensitivity in Developing-Country Megaprojects*

486 The findings further highlight the contextual sensitivity of governance–performance
487 relationships in developing-country megaprojects. Institutional fragmentation, fluctuating funding
488 conditions, administrative bottlenecks, and uneven technical capacity were evident in the IKN
489 context and materially shaped how governance mechanisms operated in practice.

490 Qualitative evidence demonstrated how delays in financial disbursement, prolonged design
491 approvals, and coordination gaps across implementing entities affected delivery sequencing and
492 risk exposure. These conditions underscore the need for governance frameworks that are adaptive
493 and responsive to evolving field realities, rather than uniformly applied across all project types
494 (Flyvbjerg et al., 2016; Scott, 2014).

495

496 *4.5 Contribution to Megaproject Governance Theory*

497 This study advances megaproject governance theory in three substantive ways. Overall, this
498 study contributes to megaproject governance literature in three keyways. First, it provides
499 comparative empirical evidence showing that governance mechanisms operate differently across
500 project typologies, with coordination playing a more prominent role in horizontal packages and risk
501 governance being more influential in vertical packages. Second, it empirically validates programme
502 implementation as a mediating layer that bridges governance structures and performance
503 outcomes. Third, by integrating structural modelling with qualitative field evidence, the study
504 demonstrates the value of mixed-methods approaches for capturing the multidimensional and
505 context-dependent nature of governance in complex programme environments (Molina-Azorín &
506 Feters, 2019).

507

508 *4.6 Boundary Conditions and Limitations*

509 Several boundary conditions should be acknowledged. First, the study is based on a relatively
510 small but strategically positioned sample (N = 30), which is suitable for exploratory PLS-SEM but
511 may limit statistical generalisability. Second, project performance was measured perceptually rather
512 than through objective indicators such as schedule performance index (SPI) or cost variance metrics.
513 Third, the findings are context-specific to the 2024–2025 implementation phase of the IKN
514 programme and may not fully represent earlier or later programme stages. Finally, although partial

515 measurement invariance was established, multi-group comparisons should be interpreted
516 cautiously as exploratory rather than confirmatory.

517

518 4.7 Governance Design Implications by Project Typology

519 The findings suggest that governance mechanisms in megaproject environments should be
520 deliberately designed according to project typology rather than uniformly applied.

521 For horizontal infrastructure projects, governance design should prioritise:

- 522 - "Structured interface management routines",
- 523 - "Shared access coordination protocols",
- 524 - "Integrated master scheduling across entities",
- 525 - "Weekly cross-organisational planning forums to manage sequencing interdependencies".

526 In contrast, vertical building projects require:

- 527 - "Formalised design assurance gates prior to construction transitions",
- 528 - "Structured change-control boards for design revisions",
- 529 - "Risk escalation mechanisms for inspection and compliance issues",
- 530 - "Integrated quality surveillance frameworks involving regulators and supervising
531 consultants".

532 These differentiated governance configurations may enhance implementation stability and
533 reduce performance volatility in complex public infrastructure programmes.

534 5. Conclusions

535 This study examined how coordination and risk governance influence project performance
536 within Indonesia's National Capital City (IKN) megaproject, with particular attention to the
537 mediating role of programme implementation across different project typologies. The findings
538 demonstrate that governance mechanisms do not operate uniformly; rather, their effects are shaped
539 by the technical and organisational characteristics of the projects being delivered.

540 Coordination emerged as the dominant governance driver in horizontal infrastructure packages,
541 where shared site access, overlapping scopes, and high interdependence require intensive
542 alignment across multiple actors. In contrast, risk governance exerted a stronger influence in vertical
543 building projects, which are more sensitive to design integration, quality-control requirements, and
544 regulatory compliance. Across both contexts, programme implementation functioned as a critical
545 mediating process through which governance mechanisms were translated into operational
546 performance outcomes.

547 By integrating PLS-SEM analysis with qualitative evidence from field documentation, this study
548 highlights the contextual sensitivity of governance-performance relationships in developing-
549 country megaprojects. Institutional fragmentation, fluctuating resource conditions, and
550 administrative constraints were shown to shape how governance mechanisms are enacted during
551 implementation. These insights contribute to megaproject governance literature by providing
552 comparative evidence across horizontal and vertical project environments and by empirically
553 validating programme implementation as a bridging mechanism between governance structures
554 and delivery outcomes.

555 From a practical perspective, the findings suggest that programme authorities should adopt
556 differentiated governance strategies tailored to project typology. Strengthening cross-entity
557 coordination mechanisms is particularly critical for horizontal infrastructure works, while
558 enhancing risk governance and design-assurance processes is essential for vertical building projects.
559 More broadly, adaptive governance approaches that respond to evolving uncertainties and

560 institutional dynamics may improve delivery performance in large-scale public infrastructure
561 programmes.

562

563 **Acknowledgements**

564 [Removed for blind review]

565

566 **Author Contributions**

567 [Removed for blind review].

568 **Conflict of Interest**

569 The authors declare no conflicts of interest.

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