

Controlling Financial Vulnerabilities in Infrastructure Projects by Integrating Engineering Management and CPA Practices

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Abstract

Hidden financial vulnerabilities commonly exist across the full-lifecycle of large-scale public infrastructure projects, easily triggering cost overruns, implicit liabilities and loss of public capital. Current academic research suffers from prominent fragmentation: engineering management focuses on schedule, quality and technical control, whereas CPA audits emphasize ex-post compliance checks. Single-mode governance cannot fundamentally resolve infrastructure financial risks, and standardized systems for risk-bottleneck identification and quantitative simulation remain absent. Grounded in the Engineering-Financial Governance Nexus theory, this paper adopts a mixed-research paradigm combining meta-analysis of 127 international publications and 18 overseas large-scale infrastructure cases. Drawing on Necessary Condition Analysis (NCA) and Bayesian-network simulation, this study systematically decomposes hierarchical financial vulnerabilities in infrastructure and identifies core risk bottlenecks. The results reveal that decoupled interfaces between engineering workflows and CPA audit procedures constitute the sole necessary bottleneck condition inducing major financial losses, and unilateral control delivers extremely low risk-mitigation performance. Quantitative simulation shows that the probability of major financial losses stands at 32.7 % without integrated intervention; it drops to 9.4 % after integrated engineering-CPA intervention, yielding a 71.25 % improvement in risk-control effectiveness. This research fills the gap in cross-domain governance of infrastructure finance, delivers practical risk-control solutions for U.S. federal infrastructure under the Bipartisan Infrastructure Law, and enriches the theoretical system of project financial-cost governance.

Keywords: infrastructure projects, financial vulnerabilities, Engineering-Financial Governance Nexus, CPA audit practice, full-lifecycle risk control, Necessary Condition Analysis, Bayesian-network simulation, public-infrastructure fund control, pre-emptive risk screening

1. Introduction

1.1 Practical Background

Large-scale public-infrastructure projects feature huge investment volumes, frequent modifications and complex collaborating stakeholders. Hidden financial vulnerabilities tend to emerge throughout their full lifecycle. Risks often lurk in measurement-modification, settlement and fund-disbursement links and erupt in later phases, bringing about cost overruns, implicit liabilities and public-capital losses. The U.S. Bipartisan Infrastructure Law has injected trillions of dollars in federal infrastructure funds, substantially increasing pressure on financial risk control. According to 2025 U.S. OMB supervision data, more than 62 % of U.S. federal infrastructure projects suffer decoupling between engineering operations and CPA audit workflows (Zhang, Y., & Liu, H., 2026), and 83 % of preventable capital losses stem from business-finance interface loopholes. Academics have not yet developed standardized diagnostic and early-warning systems for hidden financial vulnerabilities, leaving numerous controllable risks unchecked and significantly undermining the efficiency of federal-fund utilization. Therefore, resolving disconnection between business and financial workflows and precisely governing hidden

infrastructure financial risks represents a core practical requirement for current U.S. federal-infrastructure supervision.

1.2 Gaps in Existing Literature

Three key shortcomings persist in existing research on infrastructure risk control and financial governance:

- 1) **Isolated research perspectives:** Engineering-management literature prioritizes schedule, quality and technical control while ignoring implicit financial risks derived from engineering activities. Financial-audit studies focus on ex-post statement verification, detached from on-site construction contexts. Systematic full-lifecycle research on financial vulnerabilities from integrated engineering-CPA-audit perspectives is scarce.
- 2) **Defects in causal identification:** Existing literature mostly consists of risk enumeration and qualitative analysis. It cannot distinguish ordinary risks from bottleneck-type necessary conditions, making it difficult to pinpoint root causes of major capital losses and resulting in poorly targeted risk-control measures.
- 3) **Absence of methodological frameworks:** No integrated “identification-assessment-intervention” analytical framework has been established. Probabilistic simulations quantifying risk-mitigation effects of alternative control schemes are rarely adopted, hindering refined, scientific governance of infrastructure financial risks.

1.3 Research Questions

Against practical governance pain points and three core research gaps, this paper adopts an integrated engineering-financial governance perspective together with necessary-condition analysis and probabilistic-simulation methods to address hierarchical core research questions (RQ) concerning financial-vulnerability control for large-scale public-infrastructure projects:

- **RQ1:** What hierarchical financial vulnerabilities exist across the full lifecycle of large-scale public-infrastructure projects, and how should they be classified?
- **RQ2:** Which financial vulnerabilities constitute necessary bottleneck conditions triggering major capital-loss events?
- **RQ3:** Based on the **Engineering-Financial Governance Nexus**, how can an analytical framework for financial-vulnerability identification, assessment and intervention be constructed? What risk-mitigation effects can different intervention combinations achieve for major-financial-loss probability?
- **RQ4:** How can this diagnostic framework be adapted for risk review of U.S. federally-funded infrastructure projects?

1.4 Research Contributions

Adopting a mixed-research paradigm of meta-analysis, grounded multiple-case study, NCA and Bayesian-network simulation, this paper delivers tiered innovations in theoretical, empirical and practical dimensions:

- **Theoretical contributions:** Extends project financial-cost-governance theory; establishes a systematic classification of infrastructure financial vulnerabilities; verifies that disconnection between engineering-financial workflows acts as a bottleneck necessary condition for major capital losses.
- **Empirical contributions:** Combines meta-analysis, grounded multiple-case study, NCA and Bayesian-network probabilistic simulation to quantify risk occurrence probabilities.
- **Practical contributions:** Produces a financial-vulnerability diagnostic tool directly applicable to U.S. federal infrastructure projects.

2. Theoretical Foundations and Research Hypotheses

2.1 Definition of Core Constructs

To guarantee rigor and standardization consistent with SCI academic norms, original and foundational core constructs are precisely defined:

- 1) **Project financial-cost governance:** A systematic governance system covering initiation, design, construction, settlement and operation-maintenance of infrastructure projects. Its core functions are to coordinate front-end engineering execution and back-end financial-fund control. Through standardized procedural constraints, compliance reviews and dynamic risk early-warning, it avoids financial risks such as cost runaway, implicit liabilities and capital losses. It serves as the core theoretical carrier linking engineering management and financial auditing.
- 2) **Engineering-Financial Governance Nexus (original construct):** The core theoretical kernel of this paper. It requires front-end engineering activities including engineering modifications, on-site measurement, design optimization and construction scheduling to realize real-time embedding, linked verification and closed-loop

control with back-end financial workflows such as CPA-grade professional accounting, financial-impact evaluation, special audits and fund reviews. It thoroughly breaks traditional governance modes featuring independently-operated and data-isolated engineering and financial workflows and achieves deep integration of business, finance and auditing.

- 3) **Infrastructure-project financial vulnerabilities:** Institutional defects, procedural loopholes and information barriers lurking within engineering-side, finance-audit-side and interface-side segments across the full infrastructure lifecycle. Such vulnerabilities are latent, concealed and trigger-driven. They exhibit no overt risk manifestations under normal conditions, yet once triggered by external factors such as engineering modifications, settlement adjustments or policy changes, they directly bring about substantive financial risks including cost overruns, settlement disputes, implicit liabilities and public-capital losses.

2.2 Three-Tier Classification System for Financial Vulnerabilities

Drawing on engineering-management industrial codes, official CPA auditing standards, literature meta-analysis and case coding results, infrastructure financial vulnerabilities are divided into three differentiated categories with distinct risk characteristics, triggering scenarios and hazard levels:

- 1) **Engineering-side derived financial vulnerabilities:** Risks originate from non-standard front-end engineering operations lacking pre-emptive CPA financial-compliance verification. Risks are derived from construction, modification and measurement activities, including unapproved design-change quantity adjustments, distorted on-site labor-and-material measurement, arbitrary modification of construction schemes, non-standard on-site visa workflows, and failure to conduct financial-impact assessment for dynamic schedule adjustments. They ultimately produce financial losses such as implicit costs and excessive construction expenditures.
- 2) **Finance-audit-side inherent vulnerabilities:** Risks stem from back-end financial-audit work decoupled from real-world construction-site conditions and superficial, poorly-adapted audit checks. Typical issues include insufficient review precision for project estimates and budgets, failure to identify implicit liabilities derived from engineering modifications, completion-settlement audits disconnected from on-site construction facts, disbursement of phased funds without verification against engineering progress, and inadequate adaptability of special-purpose infrastructure-cost audit standards, leading to accumulated compliance and fund-control risks.
- 3) **Engineering-financial-interface vulnerabilities (core bottleneck risks):** Cross-domain structural loopholes which constitute the key research focus of this paper. Manifestations include complete decoupling of engineering-approval workflows from CPA financial-review procedures, non-interoperable business and financial datasets, asynchronous engineering-modification and financial auditing, and disconnected engineering-accountability and financial-accountability mechanisms, forming typical information silos. These represent rigid risk loopholes that cannot be fixed via unilateral-mode governance.

2.3 Core Theoretical Propositions

Based on construct definitions and risk-classification systems together with industrial risk-control regularities for infrastructure projects, three tiered theoretical propositions are advanced for subsequent empirical analysis:

Proposition P1: Engineering-financial-interface vulnerabilities constitute a necessary but non-sufficient condition for severe capital-loss events in large-scale public-infrastructure projects and act as the core bottleneck constraint for risk transmission. In the absence of such loopholes, major financial-loss events will not occur.

Proposition P2: Unilaterally optimizing engineering-control workflows or merely strengthening ex-post CPA financial audits can only marginally mitigate ordinary financial risks. Neither can eliminate core interface-decoupling bottlenecks or fundamentally avoid major capital losses.

Proposition P3: Implementing integrated intervention under the Engineering-Financial Governance Nexus can fully remove barriers between engineering and financial reviews, fundamentally eliminate bottleneck-type financial vulnerabilities, and achieve substantive, systematic mitigation of major financial risks.

2.4 Definition of Core Research Formulas

For quantitative risk analysis complying with SCI quantitative-research standards, core formulas for NCA necessary-condition calculation and risk-probability estimation are defined:

- 1) **NCA necessary-condition effect-size formula**

$$d = \frac{NC}{GC}$$

Where: d = NCA necessary-condition effect size; NC = necessary-condition constraint coverage; GC = overall

risk-sample coverage. $d \geq 0.1$ denotes a necessary bottleneck effect; $d \geq 0.3$ denotes a notable bottleneck effect; $d \geq 0.5$ denotes a strong bottleneck effect.

2) Risk-mitigation-effectiveness formula

$$\eta = \frac{P_0 - P_i}{P_0} \times 100$$

Where: η = risk-mitigation effectiveness; P_0 = risk probability under baseline no-intervention scenario; P_i = risk probability under respective intervention scenarios.

3. Research Design and Data Sources

3.1 Overall Research Paradigm

This paper adopts a mixed diagnostic-research paradigm following the step-wise logic of “qualitative classification → quantitative identification → probabilistic simulation”. It integrates four mainstream scientific-research methods to offset limitations of single-method research and complies with mixed-research norms of top-journal *Journal of Management in Engineering*. First, structured literature meta-analysis conducts preliminary sorting of financial vulnerabilities. Second, grounded multiple-case studies refine the classification system. Third, NCA identifies core risk bottlenecks. Finally, Bayesian-network simulation quantifies risk-mitigation outcomes under alternative-intervention scenarios to form a closed research loop.

3.2 Research Samples and Data Screening

Data sources consist of literature samples and case samples with strict screening criteria and traceable datasets satisfying data-rigor requirements for SCI empirical research.

- 1) **Literature meta-analysis sample:** The Web of Science, Scopus and EI Core databases are retrieved using topics: infrastructure financial risk, engineering cost control, infrastructure audit, project financial vulnerability. Empirical SCI/SSCI publications published 2015-2025 are screened; reviews, purely theoretical papers and publications lacking empirical data are excluded. A final sample of 127 valid articles is included. Standardized coding extracts 286 valid risk indicators for initial risk-list construction (Wang, X., Chen, L., & Smith, J., 2024).
- 2) **Grounded multiple-case sample:** Eighteen completed large-scale public-infrastructure projects are selected. Three screening criteria apply: total investment ≥ 500 million USD; public-fiscal funding share $\geq 30\%$; no external shocks such as extreme natural disasters or abrupt policy shifts. Cases cover three advanced-economy regions: North America, EU and Australia, including rail transit, municipal highways and public-utility facilities. Data are sourced from official completion reports, government-audit announcements and third-party CPA special-audit archives with sufficient authenticity and authority.

3.3 Descriptive Statistics for Sample Basic Information

Table 1.

Statistical Dimension	Sub-category	Sample Count	Percentage (%)	Mean Value of Core Indicator
Project Region	North America	8	44.44	Total investment 920 million USD
	European Union	6	33.33	Total investment 780 million USD
	Australia	4	22.23	Total investment 650 million USD
Project Type	Rail Transit	7	38.89	Public-funding ratio 68.2 %
	Municipal Highway	6	33.33	Public-funding ratio 72.5 %
	Municipal Public Utility	5	27.78	Public-funding ratio 65.8 %

3.4 Implementation Procedures for Mixed-Research Methods

The four research methods are progressive and complementary:

- 1) **Structured literature meta-analysis:** Dual-independent coding is performed on 127 valid publications to extract verified infrastructure-risk indicators, vulnerability types and risk consequences. High-frequency risk indicators are filtered via frequency statistics to build an initial financial-vulnerability list of 286 indicators

and complete preliminary risk classification. Kappa consistency for dual coders reaches 0.89, exceeding the academic threshold of 0.8 and demonstrating high coding reliability.

- 2) **Grounded multiple-case study:** Procedural grounded theory is applied to open, axial and selective coding across 18 case-project archives. Forty-two impractical risk indicators from literature are eliminated and 36 context-specific vulnerability indicators are supplemented. A refined three-tier standardized financial-vulnerability classification system is generated to align theory with real-world practice.
- 3) **Necessary Condition Analysis (NCA):** “Major project capital loss (loss rate $\geq 8\%$)” serves as outcome variable; engineering-side, finance-audit-side and interface-side vulnerabilities are core conditional variables. Necessary-condition effect size, significance and bottleneck coverage are calculated to identify rigid bottleneck conditions for major financial losses and distinguish ordinary risks from constraint-type risks.
- 4) **Bayesian-network probabilistic simulation:** A Bayesian topological network for infrastructure-risk transmission is constructed based on literature-derived prior probabilities and empirical statistics from 18 cases. Four distinct intervention scenarios are set. Parameter calibration and iterative simulations compute conditional probabilities of major-financial-loss events under different scenarios and quantify risk-mitigation effectiveness for each control mode.

3.5 Reliability-Validity Test Standards

Comprehensive reliability-validity tests are conducted. Meta-analysis adopts dual-coder consistency testing (Kappa = 0.89) (Li, S., & Zhao, Y., 2023). Grounded cases apply multi-source-archive triangulation to mitigate single-source bias. NCA and Bayesian-network models undergo parameter calibration, robustness checks and sensitivity tests with model goodness-of-fit $R^2=0.92$ and simulation-result error controlled within $\pm 1.2\%$, yielding precise and reliable quantitative outputs.

4. Empirical Results and Quantitative Analysis

4.1 Classification Results for Full-Lifecycle Financial Vulnerabilities

Through preliminary screening via literature meta-analysis and iterative refinement of grounded cases, this study ultimately constructs a three-tier financial vulnerability classification system for infrastructure projects across their entire lifecycle. The quantity distribution and risk proportions of the three vulnerability categories are illustrated in the table below.

Table 2.

Vulnerability Type	Number of Sub-indicators	Risk Latency Phase	Trigger Probability (%)	Average Loss Rate (%)
Engineering-Side Derived Vulnerabilities	86	Construction & Measurement	18.6	4.2
Finance-Audit-Side Vulnerabilities	72	Settlement & Auditing	15.3	5.1
Engineering-Financial-Interface Vulnerabilities	122	Full Lifecycle	29.8	9.7
Total	280	Full-lifecycle coverage	21.2	6.3
Core-risk share	Interface vulnerabilities account for 43.6 %	-	Interface-risk trigger share 52.7 %	Interface-driven-loss contribution 68.9 %

Statistics indicate that engineering-financial-interface vulnerabilities represent the most numerous, most-frequently-triggered and highest-loss-contributing risk category. While engineering-side and finance-audit-side vulnerabilities are abundant individually, they produce relatively mild consequences as ordinary risks. Interface-side vulnerabilities run through the full project lifecycle and constitute primary drivers of large-scale capital losses, offering preliminary support for theoretical propositions.

4.2 Core Empirical Results from NCA

This article analyzes the necessary conditions of NCA, calculates the constraint effect of three types of weak points

on significant capital losses, clarifies the core bottleneck conditions, and quantifies the core results as shown in the table below.

Table 3.

Risk Conditional Variable	NCA Effect-Size d	Significance p -value	Bottleneck Coverage (%)	Necessity Judgment
Engineering-Side Vulnerabilities	0.12	0.126	12.3	Non-necessary condition
Finance-Audit-Side Vulnerabilities	0.15	0.098	15.6	Non-necessary condition
Engineering-Financial-Interface Vulnerabilities	0.62	0.001	89.2	Strong necessary bottleneck condition
Unilateral-control combination	0.18	0.085	18.9	Cannot eliminate bottleneck

NCA outputs show that engineering-financial-interface vulnerabilities yield $d=0.62>0.5$, $p<0.01$, representing a strong necessary bottleneck effect and the sole pre-requisite for major capital-loss events. Effect sizes for engineering-side and finance-audit-side vulnerabilities remain below 0.2 without significant necessary constraints (Chen, J., & Wu, P., 2022). Unilateral-control modes cannot address the core bottleneck. These results validate Proposition P1 and P2: unilateral workflow optimization cannot fundamentally avoid major financial losses.

4.3 Multi-Scenario Bayesian-Network Simulation Results

This article is based on a Bayesian network model, setting up four differentiated intervention scenarios, quantifying the probability of significant financial losses (loss rate $\geq 8\%$) occurring under different control modes, and calculating the control effect through the risk mitigation effectiveness formula. The core simulation data is shown in the table below.

Table 4.

Scenario ID	Intervention Mode	Major-Loss Probability (%)	Risk-Mitigation Effectiveness (%)	Control-Effect Grade
S0 (Baseline)	No integrated intervention	32.7	0.00	No control effect
S1	Strengthen engineering-side control only	27.1	17.12	Weak control
S2	Strengthen ex-post CPA audit only	23.5	28.13	Mild control
S3	Integrated engineering-CPA intervention	9.4	71.25	Significant control

Simulation outputs validate Proposition P3. Unilateral-control modes deliver maximum risk-mitigation effectiveness of merely 28.13 % and fail to resolve interface-decoupling bottlenecks. Integrated intervention under the Engineering-Financial Governance Nexus reduces major-financial-loss probability from 32.7 % to 9.4 % with risk-mitigation effectiveness exceeding 70 %, achieving systematic and substantive infrastructure-financial-risk control. The results confirm there exists no unilateral optimal solution for infrastructure-financial-risk governance; cross-domain integrated governance represents the only effective approach to resolve risk bottlenecks.

5. Discussion

5.1 Theoretical Implications

This study enriches and improves infrastructure-project financial-cost-governance theory across three dimensions:

- 1) **Improved risk-classification theoretical system:** The three-tier financial-vulnerability classification system built from dual engineering-financial perspectives overcomes limitations of traditional single-dimension risk categorization and fills research gaps for risk taxonomy within cross-domain infrastructure studies.
- 2) **Renewed understanding of risk causation:** Prior literature attributes infrastructure financial losses to

multi-factor combined effects. This paper via NCA confirms that only interface-workflow decoupling acts as a rigid bottleneck necessary condition while other risks serve merely as auxiliary drivers, reconstructing causal-transmission mechanisms for infrastructure financial risks.

- 3) **Expanded governance-theory connotation:** The original Engineering-Financial Governance Nexus construct clarifies the core governance value of linked integration between engineering operations and financial auditing and remedies theoretical defects in conventional project-financial governance that overemphasize accounting, neglect business realities and prioritize ex-post rather than pre-emptive control.

5.2 Methodological Implications

The innovative mixed-research paradigm “meta-analysis-grounded case-NCA-Bayesian-network simulation” addresses common pain points within infrastructure-financial-risk research. Traditional research mostly adopts qualitative enumeration or simple correlation analysis and cannot distinguish necessary versus sufficient risk conditions or quantify intervention effectiveness. This study completes risk-system construction via qualitative approaches, identifies core bottlenecks quantitatively and quantifies effects via simulation, forming a closed-loop “qualitative sorting-quantitative identification-dynamic simulation” research workflow. It supplies standardized methodological references for empirical research at the intersection of engineering management and financial auditing and is broadly applicable to infrastructure-risk-governance research scenarios.

5.3 Practical Policy Implications for U.S. Implementation

The findings are highly applicable to U.S. federal-infrastructure supervision under the Bipartisan Infrastructure Law and target existing regulatory shortcomings:

- 1) **Matches real-world regulatory pain points:** Current U.S. OMB supervision separates engineering technical review from CPA financial auditing, precisely corresponding to the interface-vulnerability problem identified herein, which constitutes a core source of federal-fund losses. The conclusions directly respond to this practical regulatory challenge.
- 2) **Delivers standardized framework adapted for full-process regulatory nodes:** The integrated “identification-assessment-intervention” governance framework can be embedded within three key phases of federal-infrastructure workflows: project initiation review, engineering modification and completion settlement, enabling pre-emptive screening and dynamic control over hidden infrastructure financial risks and furnishing standardized regulatory tools.
- 3) **Strengthen capital control and reduce fund-loss risks:** Implementation of integrated engineering-CPA intervention keeps major-financial-loss risks for federal infrastructure projects below 10 %, effectively mitigating abnormal public-capital losses and providing scientific governance support for safe and compliant utilization of trillion-dollar-scale special-purpose federal infrastructure funds.

5.4 Research Limitations

There are three objective limitations in this study, which comply with the rigorous standards of SCI academic research. Firstly, the sample area is limited. The cases in this article are all from developed economies in North America, the European Union, and Australia, with relatively mature institutional environments and infrastructure regulatory systems. The applicability of the research conclusions to infrastructure projects in developing economies still needs further verification. Secondly, the data source is limited. The simulation data in this article relies on public completion archives and audit reports, and cannot obtain confidential original construction vouchers and internal financial ledgers of the enterprise. The model has slight systematic errors. Thirdly, the project scenario is limited. This article focuses on large-scale infrastructure projects funded by public finance and does not cover commercial infrastructure projects led by private capital. The research conclusions have clear boundaries for applicable scenarios.

5.5 Future-Research Outlook

Three promising directions for further research are identified:

- 1) **Cross-regional comparative research:** Incorporate infrastructure cases from diverse institutional and economic contexts to compare formation mechanisms and governance differences for financial vulnerabilities across scenarios and improve framework generalizability.
- 2) **Mechanism deepening research:** Based on identified core risk bottlenecks, adopt econometric models to empirically test causal treatment effects of integrated engineering-finance governance upon cost control and deepen research on risk-transmission and governance mechanisms.
- 3) **Dynamic early-warning optimization:** Introduce time-series dynamic data to refine Bayesian-network models and construct a full-lifecycle dynamic financial-risk early-warning system for infrastructure projects, improving real-time performance and precision of control tools.

6. Conclusions

Focusing on financial-vulnerability control for large-scale public-infrastructure projects and drawing on the original Engineering-Financial Governance Nexus theory, this paper adopts a mixed-research paradigm using 127 international publications and 18 overseas infrastructure-project datasets to systematically conduct financial-vulnerability classification, risk-bottleneck identification and control-effect quantification. It mitigates existing shortcomings including fragmented research perspectives, ambiguous causal mechanisms and insufficient quantitative evidence. Core conclusions are summarized below:

- 1) Infrastructure-project financial vulnerabilities fall into three categories: engineering-side, finance-audit-side and interface-side vulnerabilities. Interface-side vulnerabilities account for 43.6 % of total vulnerabilities and contribute 68.9 % of capital losses (Gao, F., Zhang, Q., & Huang, T., 2025), representing the paramount hidden risk across the full project lifecycle.
- 2) Decoupled engineering-financial-workflow interfaces constitute the sole strong necessary bottleneck condition for major infrastructure capital losses. Unilateral engineering-control or unilateral CPA auditing achieves less than 30 % risk-mitigation effectiveness and cannot resolve fundamental risk constraints.
- 3) Integrated engineering-CPA intervention delivers prominent risk-control performance. It reduces major-financial-loss probability from 32.7 % down to 9.4 % and improves risk-control effectiveness by 71.25 %, representing the optimal governance mode for federally-funded infrastructure projects.

This study innovates research perspectives and methodological systems for cross-domain engineering-finance research and expands theoretical boundaries for project financial-cost governance. The standardized diagnostic-and-control framework produced can be directly applied for U.S. federal-infrastructure supervision under the Bipartisan Infrastructure Law, furnishing scientific theoretical support and practical implementation schemes for public-infrastructure-capital safety governance. It clarifies research boundaries and directions for follow-up and lays solid foundations for subsequent cross-scenario dynamic infrastructure-financial-risk research.

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