# Construction of an Intelligent Financial Internal Control System for Cultural Relics and Archaeological Units: A Leap from Process Compliance to Risk Prediction

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https://doi.org/10.70695/IAAI202602A11

## Abstract

As a key pillar of the national cultural heritage protection system, cultural relics and archaeological units directly influence the efficiency of fund allocation and the security of fund utilization in cultural heritage protection through their financial management and internal control quality. In the context of the modernization of national governance and the high-quality development of cultural heritage undertakings, this paper systematically analyzes four structural limitations of traditional financial internal control in cultural relics and archaeological units—post-event correction, rigid rules, fragmented information, and insufficient technological adaptability — and proposes that the core feature of an intelligent internal control system lies in achieving an essential leap from "compliance constraint" to "risk prediction". On this basis, the paper elaborates on the intrinsic mechanisms and algorithmic logic of the intelligent internal control system from three technical perspectives: knowledge graph construction, graph neural network-based risk propagation modeling, and adaptive evolution of early warning rules. Finally, it proposes a "provincial unified construction, hierarchical application" implementation framework and a phased deployment strategy. The study concludes that the intelligent financial internal control system for cultural relics and archaeological units is not merely an iteration of technical tools, but a profound transformation of governance concepts and management paradigms. It holds significant theoretical and practical value for improving the efficiency of cultural heritage protection funds, preventing financial risks, and advancing the modernization of cultural heritage governance systems and capabilities.

**Keywords** Cultural Relics and Archaeological Units; Intelligent Internal Control; Knowledge Graph; Graph Neural Network; Risk Prediction; Modernization of Governance

## 1 Introduction

Cultural relics are the national and cultural treasures of a country and its people. Since the 18th CPC National Congress in 2012, General Secretary Xi Jinping has consistently reiterated the importance of protection and utilization of cultural relics. The plan for the preservation of cultural relics and related technological innovation during the 14th Five-Year Plan period (2021-2025) explicitly identifies "comprehensively advancing the modernization of the cultural heritage governance system and governance capacity" as a core task. The Financial System for Cultural Public Service Units mandate the establishment and improvement of an internal control system to prevent financial risks.

At present, traditional financial internal control in cultural relics and archaeological units primarily relies on manual review, process approval, and post-event auditing, which suffer from shortcomings such as lagging risk response, rigid control methods, and insufficient capacity to address emerging risks. With the continuous emergence of new business forms such as digital procurement and data asset management, financial risks in the field of cultural relics and archaeology have become increasingly diverse and complex, rendering the traditional internal control model inadequate to meet the needs of industry development and regulatory requirements. The maturation of digital technologies such as artificial intelligence and knowledge graphs provides technical support for the intelligent transformation of internal control, and the practical implementation of "AI + Internal Control" in various public institutions across China has validated the application value of intelligent internal control. Against this backdrop, this paper takes cultural relics and archaeological units as the research object, systematically

exploring the construction logic, technical pathways, and implementation strategies of a intelligent financial internal control system. The aim is to facilitate the upgrade of financial internal control in cultural relics and archaeological units from passive process compliance to a proactive risk prediction paradigm, thereby providing a reference for the modernization of financial governance in the cultural heritage sector.

## 2 Limitations of Traditional Financial Internal Control in Cultural Relics and Archaeological Units: Post-Event Correction and Rule Rigidity

From an institutional perspective, the Financial System for Cultural Public Service Units provide clear provisions for the standardized operation of financial management in cultural relics and archaeological units, covering areas such as budget management, revenue and expenditure management, asset management, and internal control. However, at present, the following four limitations remain.

### 2.1 The Lag of Post-Event Correction

In most existing internal control processes, risk identification and control measures occur after the completion of economic transactions. Budget execution deviations can only be detected when financial statements are generated, and procurement violations are often uncovered only during the post-event audit stage. This "action-first, correction-afterward" model allows risks to transform from potential threats into actual losses.

### 2.2 Rule Rigidity and Insufficient Contextual Adaptation

Traditional internal control relies on rigid rules to incorporate financial activities into standardized process management, which has played a positive role in ensuring basic compliance. However, the operations of cultural relics and archaeological units are characterized by significant heterogeneity and specialized expertise. Archaeological excavation projects, cultural relic conservation and restoration projects, digital preservation initiatives, collection acquisition and procurement, and artifact restoration activities each have distinct fund flow pathways, contract management methods, and asset form characteristics. Rigid rules struggle to adapt differentially to various specialized contexts, potentially leading either to insufficiently targeted "one-size-fits-all" supervision or to a situation where formal procedural compliance conceals substantive risks.

### 2.3 Information Fragmentation and Data Silos

In cultural relics and archaeological units, the budget management system tracks fund flows, the asset management system handles cultural relic registration and fixed asset accounts, and the business management system monitors project progress and contract performance. Different departments adopt inconsistent data standards, experience lags in data synchronization, and lack unified identifiers. Consequently, the same economic transaction may be reflected in different systems with spatiotemporal discrepancies. An audit conducted by the Hefei Municipal Audit Bureau on the management of cultural relic resources and assets revealed weaknesses in such areas as relic registration, archival management, transfer procedures, and storage conditions, rendering cross-system correlation risks unidentifiable.

### 2.4 Insufficient Adaptability of Traditional Technical Means to Emerging Risks

With the advancement of digitalization in cultural heritage preservation, cultural relics and archaeological units are confronted with a range of new risks that traditional internal control rules can hardly address. For instance, in the domain of data assets, digital achievements of cultural relics—such as three-dimensional models, digital rubbings, and archaeological data—are forming new types of data assets. However, issues concerning their valuation, book entry, circulation, and benefit distribution have yet to be incorporated into the traditional internal control framework. The risk of "data asset loss" is real but lacks effective identification and prevention mechanisms.

The structural limitations of the traditional financial internal control model indicate that achieving a paradigm shift from process compliance to risk prediction is not merely a matter of technological upgrading, but rather a profound transformation in governance philosophy.

# 3 Core Characteristics of the Intelligent Internal Control System: From Compliance Constraint to Risk Prediction

Intelligent internal control is not a mere technical supplement to traditional internal control; rather, it represents a systemic reconfiguration in four dimensions: from static to dynamic, from passive to proactive, from rigid to flexible, and from single-point to networked.

## 3.1 Realtime Monitoring Replaces Periodic Checks

Traditional internal control relies on periodic review mechanisms such as internal control self-assessment reports and external audits, where risk identification is often delayed by months or even years. Intelligent internal control embeds monitoring sensors into every node of financial activities—every payment, every procurement, and every contract enters the system's view at the initiation stage, enabling full-process, round-the-clock automated monitoring. Once an expenditure deviates from a preset normal range, the system can issue an early warning within milliseconds.

## 3.2 Preemptive Warning Replaces Post-Event Correction

Traditional internal control follows a linear logic of "action—compliance check—correction", with risk management occurring after damage has already taken place. Intelligent internal control, in contrast, follows a cyclical logic of "data—risk identification—preemptive warning", where risks are identified and intervened upon before the action is completed. This represents a governance shift from "chasing after problems" to "monitoring the data proactively".

## 3.3 Automated Reasoning Replaces Manual Judgment

Risk identification in traditional internal control heavily relies on the professional judgment and accumulated experience of financial personnel. However, in cultural relics and archaeological units, professionals who are proficient in both financial regulations and familiar with archaeological business processes are particularly scarce, creating significant bottlenecks in the quality and efficiency of risk assessment. In contrast, large AI models can understand policy texts through natural language processing, identify process deviations through logical reasoning, and detect anomalous behaviors through pattern matching, achieving a leap from "human judgment" to "machine judgment". This effectively compensates for the shortcomings of insufficient internal control capacity and lack of systematic analysis.

## 3.4 Trend Prediction Transcends Individual Identification

Traditional internal control limits risk identification to compliance checks at the case level, whereas intelligent internal control places all financial activities within a global network, thereby identifying systemic risk trends and transmission pathways. It shifts from "post-event error correction" to "pre-event prevention and control" and "in-process coordination", achieving an enhancement in capability from identifying individual anomalies to predicting systemic risks.

Intelligent internal control does not negate the fundamental role of "compliance"; rather, it achieves a significant elevation of governance capability on the basis of compliance. It transforms "compliance" from a post-event verification action into a dynamic process that is embedded in business flows, runs through the entire process, and possesses the capacity for learning and evolution.

# 4 Construction Method of the Financial Risk Knowledge Graph for Cultural Relics and Archaeological Units

Knowledge graphs provide an ideal methodological foundation for financial intelligent internal control. By representing entities and their relationships in a graph-structured format, they can integrate dispersed, heterogeneous, and multi-source risk knowledge into a structured knowledge system, thereby supporting risk reasoning and in-depth analysis. Cultural relics and archaeological units can extract structured knowledge graphs from the following three types of sources.

## 4.1 Structured Coding of Internal Control Rules

Documents such as the Financial System for Cultural Public Service Units and the National Administrative Measures of Funds for Protection of Cultural Relics provide clear specifications for budget preparation, revenue and expenditure management, and asset control. These rules need to be transformed into logical assertions that can be understood and executed by machines. Taking budget execution as an example, logical rules can be refined as follows: "Trigger a Level-1 warning when the budget execution deviation exceeds ±5%" and "Procurements not included in the annual budget shall not be executed". Such rules are incorporated into the logical layer of the knowledge graph.

## 4.2 Induction and Modeling of Historical Violation Cases

Typical cases uncovered by audits are important sources of risk knowledge. In its audit of cultural relic resource and asset management, the Hefei Municipal Audit Bureau identified weaknesses in key areas such as relic registration, archival management, and transfer procedures. The typical violation patterns embedded in these cases need to be extracted as reusable risk templates and incorporated into the case base of the knowledge graph.

## 4.3 Continuous Integration of External Risk Signals

Financial risks do not originate solely from internal compliance deviations within the unit; updates to government procurement policies, adjustments to the functions of the integrated budget management system, and iterations in digital cultural relic protection technologies may all generate new risks. In response to such situations, a knowledge support system can be constructed comprising core knowledge modules such as a policy interpretation library, a typical case library, a typical problem library, a risk clue library, and a training resource library, thereby providing a practical paradigm for the continuous updating of risk knowledge.

At the technical level, the construction of the financial risk knowledge graph for cultural relics and archaeological units can be modeled along three layers: the entity layer, the relationship layer, and the attribute layer. The entity layer covers key nodes of financial activities, including projects, funds, units, personnel, contracts, and assets. The construction of the relationship layer determines the knowledge density and reasoning capability of the graph. The attribute layer records the specific attribute characteristics of each entity, providing a quantitative basis for risk reasoning.

# 5 A Risk Propagation and Prediction Model Based on Graph Neural Networks

Once the knowledge graph is constructed, how to learn the propagation logic of risks, identify potential risk transmission pathways, and achieve prediction constitutes the core technical component of the intelligent internal control system. Graph Neural Networks (GNNs), owing to their inherent advantages in processing graph-structured data, have become the most suitable model architecture for this task.

Risks in financial activities exhibit a distinct propagation characteristic—the anomalous behavior of one node gradually spreads along business chains rather than remaining an isolated event. For example, in a digital cultural relic protection project, if the procurement phase involves an inappropriate supplier selection—a compliance risk—this may further trigger a series of cascading risks, including project delays, abnormal fund payments, and substandard quality of digital outputs. Such propagation is difficult

to model effectively using traditional linear models. However, through their message-passing mechanism, GNNs can aggregate neighborhood information over multiple iterations, learn risk representation vectors for each node, and thereby enable the identification and quantitative prediction of risk diffusion paths.

Furthermore, leveraging the semantic comprehension capabilities of Large Language Models (LLMs) can assist in constructing a more comprehensive and accurate dynamic enterprise heterogeneous knowledge graph, thereby mitigating information distortion caused by static data and enhancing the model's sensitivity to newly emerging risk signals.

The risk prediction model based on graph neural networks has multiple application scenarios in the financial internal control of cultural relics and archaeological units:

Risk prediction in the procurement phase: At the project initiation stage, the model can integrate factors such as the supplier's historical transaction data, the project leader's past project execution records, and contract clause compliance to predict the probability of subsequent violations in the procurement activity.

Risk prediction in fund disbursement: When a payment application is submitted, the model can generate a payment risk index based on dimensions such as budget execution progress, spatiotemporal matching with project progress, and abnormal deviations in fund flow paths.

Cross-project risk propagation prediction: When a risk warning is triggered for a particular project, the model can automatically retrieve other projects sharing the same project leader, the same supplier, or the same funding channel, and predict the scope of risk diffusion.

## 6 Adaptive Evolution Mechanism of Intelligent Early Warning Rules

Any rule-driven system faces the inherent dilemma of "rule rigidity": once rules are established, they tend to gradually become disconnected from the dynamically changing real-world environment. The regulatory environment for financial internal control in cultural relics and archaeological units is highly dynamic: industry regulations for cultural heritage protection are continuously revised, government procurement management measures are regularly updated, the fiscal budget management system is constantly being improved, and new business models enabled by digital technologies demand novel regulatory rules. If early warning rules cannot achieve dynamic adjustment, a coexistence of false negatives (new risks not covered by the rules) and false positives (excessive alarms due to rules failing to adapt to new scenarios) will inevitably emerge. Traditional static rules struggle to keep pace with the speed of policy iteration.

In this context, reinforcement learning provides an effective technical pathway for addressing the problem of rule adaptation. The evolution of early warning rules in an intelligent internal control system can be modeled as a Markov decision process: the system's current risk judgment logic constitutes the state space; each early warning decision (trigger or not) and each threshold adjustment operation constitute the action space; the reward function is composed of early warning accuracy (reward for successfully capturing real risks) and false alarm cost (interference cost caused by false alerts). Through continuous interaction with the environment and trial-and-error feedback, the system autonomously learns the optimal parameters of the early warning strategy, achieving an evolution from passive response to active optimization.

A more advanced design framework integrates knowledge graphs, reinforcement learning, and LLMs into a complete self-evolving closed loop. By introducing a dynamic knowledge graph, a reinforcement learning decision engine, and a continuous optimization mechanism, a self-evolving intelligent agent architecture can realize the complete iterative closed loop of "perception — decision — execution — feedback".

A key sub-function of the adaptive evolution mechanism is to achieve automatic alignment with policy changes. When new national or local policies concerning cultural heritage protection fund management, government procurement regulations, or asset management rules are promulgated, the system, on the one hand, employs natural language processing techniques to parse the policy texts and extract the constraints and regulatory requirements therein; on the other hand, it uses the reinforcement learning framework to test the compatibility of existing early warning rules with the new policies, automatically generating rule adjustment recommendations for review and confirmation by internal control managers. This function plays a crucial role in maintaining the system's dynamic adaptability to policy changes.

# 7 Implementation Architecture and Deployment Strategies for the Intelligent Financial Internal Control System in Cultural Relics and Archaeological Units

Proceeding from the actual conditions of China's cultural heritage management system and fiscal management system, the construction of a intelligent financial internal control system for cultural relics and archaeological units should follow the overarching architectural principle of "provincial unified construction, hierarchical application". Provincial cultural heritage authorities, in conjunction with provincial finance departments, shall undertake unified planning and system development, while cultural relics and archaeological units at and below the provincial level shall deploy and apply the system hierarchically according to authorization. The advantage of this architecture lies in avoiding redundant investments and inconsistent standards across regions, while ensuring system professionalism and security.

At the level of the system's core architecture, the intelligent internal control system can be divided into four layers: the data middle platform, the knowledge middle platform, the algorithm middle platform, and the application layer. The data middle platform is responsible for interfacing with existing external systems, such as the integrated fiscal budget management system, the government procurement platform, and the asset management system, achieving unified access, cleaning, and standardized integration of multi-source data. The online management platform for research project funds being developed by the Henan Provincial Institute of Cultural Relics and Archaeology, which integrates with the provincial integrated budget management system in accordance with the Implementation Plan for Promoting the Henan Provincial Integrated Budget Management System, exemplifies the practical effort to coordinate budget management with financial internal control. The knowledge middle platform undertakes the dynamic construction and continuous updating of the risk knowledge graph, incorporating a structured internal control rule base, a case base, and a risk signal library. The algorithm middle platform hosts core algorithmic modules, including the GNN-based risk prediction model and the reinforcement learning-based adaptive rule optimization engine, serving as the "brain" of the entire intelligent internal control system. The application layer provides customized functional interfaces for different user roles—financial personnel operate the audit alert workstation, managers access the global risk dashboard, and senior leaders review risk trend reports—supporting differentiated decision-making scenarios.

The intelligent internal control system should not be built as a separate entity alongside existing systems; rather, it should achieve deep synergy with the current financial management systems of cultural relics and archaeological units. Advancing the construction of an intelligent internal control system from the current state should proceed in stages and with methodical steps, avoiding the risk of project failure due to excessive ambition.

Phase 1: Rule Digitization and Foundational Integration.

Comprehensively digitize the internal control rules within the existing financial management of cultural relics and archaeological units to form a preliminary structured rule base. Open data channels among systems such as budgeting, procurement, and asset management, and establish a unified data foundation. The objective of this phase is to achieve automated validation and compliance reminders based on basic internal control rules.

Phase 2: Knowledge Graph Construction and Intelligent Warning.

Integrate risk cases identified in historical audits and external risk signals to build a financial risk knowledge graph covering core areas such as budget execution, government procurement, asset management, and contract management. Simultaneously deploy a GNN-based risk propagation prediction model to enable automatic identification and warning of multi-level, cross-process risks. The hallmark of this phase is the upgrade from "rule-driven compliance checking" to "risk-driven intelligent prediction".

Phase 3: Predictive Modeling and Adaptive Evolution.

Complete the construction of an adaptive evolution mechanism for intelligent early warning rules, enabling the system to automatically adjust warning thresholds and logical rules in response to new risk events and policy changes, progressively fostering a governance model shift from "human-assisted machine" to "machine-assisted human".

Of course, the implementation of a technical system cannot be separated from institutional safeguards and talent support. At the institutional level, the construction of an intelligent internal control system should be incorporated into the annual work plans of cultural relics and archaeological units, clarify the

leading responsibility of designated supervisory officials, and establish mechanisms for system operation monitoring and effect evaluation. At the talent level, emphasis should be placed on cultivating interdisciplinary professionals who are proficient in both cultural heritage financial management and data analysis capabilities. The Henan Provincial Institute of Cultural Relics and Archaeology is currently exploring the development of a linked analysis mechanism that integrates financial internal control indicators with business performance data such as archaeological project progress and cultural heritage protection outcomes. This practice of deeply integrating finance and operations merits wider promotion.

## 8 Conclusion

Proceeding from the unique characteristics of cultural relics and archaeological units, this paper has systematically explored the theoretical logic, technical pathways, and implementation strategies for constructing a intelligent financial internal control system. The main conclusions are as follows:

First, the limitations of the traditional financial internal control model possess deep structural features. The lag of post-event correction, rule rigidity and insufficient contextual adaptation, information fragmentation and data silos, and the lack of adaptability of technical means to emerging risks collectively constitute the fundamental obstacles constraining the improvement of financial governance effectiveness in cultural relics and archaeological units. Overcoming these obstacles requires a systemic restructuring that spans governance concepts and technical tools.

Second, the essence of intelligent internal control lies in achieving a logical leap from "compliance constraint" to "risk prediction". By replacing periodic checks with real-time monitoring, post-event correction with preemptive warning, manual judgment with automated reasoning, and individual identification with trend prediction, "compliance" is transformed from a post-event verification action into an embedded, full-process, and dynamic governance process.

Third, the construction of a intelligent financial internal control system for cultural relics and archaeological units must undergo three progressive technical levels: rule digitization, knowledge graph construction, and predictive modeling. These three levels are sequentially advancing and mutually indispensable.

Fourth, the architectural principle of "provincial unified construction, hierarchical application" is practically feasible in terms of institutional safeguards and technical synergy. By developing standardized interface protocols to interface with existing fiscal platforms and prudently implementing the three-phase roadmap, this approach can help achieve a fundamental transformation of financial governance in cultural relics and archaeological units from "passive defense" to "active governance".

Looking ahead, the construction of a intelligent financial internal control system for cultural relics and archaeological units not only responds to the demand for high-quality development of China's cultural heritage protection undertakings but also represents a concrete practice of modernizing the national governance system and governance capacity in the cultural heritage field. When every allocation of cultural heritage protection funds is precisely directed, under the guardianship of the intelligent internal control system, to the relics most in need of protection; when the financial governance capability of cultural relics and archaeological units truly achieves the historic leap from process compliance to risk prediction—what we safeguard is not merely the physical security of cultural relics, but the comprehensive inheritance and sustainable development of Chinese civilization in the digital era.

## Acknowledgement

This work was supported without any funding.

## Conflicts of Interest

The authors declare no conflicts of interest.

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## Biographies

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# 文物考古單位財務智能內控體系構建

# ——從流程合規到風險預判的躍升

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摘要：文物考古單位作爲國家文化遺產保護體系的重要支撐，其財務管理與內部控制的質量直接影響文物保護資金的配置效率和使用安全。本文立足國家治理現代化與文物事業高質量發展的時代背景，系統分析了文物考古單位傳統財務內部控制存在的四重結構性侷限——事後糾偏、規則剛性、信息碎片化和技術適應性不足，提出智能內控體系的核心特徵在於實現從「合規約束」向「風險預判」的本質躍升。在此基礎上，從知識圖譜構建、圖神經網絡風險傳導模型、預警規則自適應演化三個技術層面，闡述了智能內控的內在機理與算法邏輯，最後提出「省級統建、分級應用」的落地架構與分階段實施策略。研究認爲，文物考古單位財務智能內控體系不僅是技術工具的迭代，更是治理理念與管理範式的深刻變革，對於提升文物保護資金使用效益、防範財務風險、推進文物治理體系和治理能力現代化具有重要的理論與實踐價值。

關鍵詞：文物考古單位；智能內控；知識圖譜；圖神經網絡；風險預判；治理現代化

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