Advances in Consumer Research
https://acr-journal.com/
Volume-3 | Issue-1 | Jan 2026
Original Researcher Article

Non-Destructive Utilization and Digital Interpretation of Museum Relics: The Mediating Role of Cultural Value Transformation in Enhancing Cultural and Creative Innovation Performance

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ABSTRACT
The increasing demand for innovation in heritage management underscores the need to understand how technological and creative practices influence cultural and creative innovation performance (CCIP). This study addresses a research gap by examining the mediating role of cultural value transformation (OT) in linking non-destructive utilization technology (NDUT), digital interpretation and dissemination capability (DIDC), and creative design integration of cultural relics (CDICR) to CCIP, grounded in the Cultural Value Chain Theory. A survey was conducted among 400 museum professionals in Beijing, including curators, conservation scientists, digital curators, product-development managers, and heads of cultural-creative departments. Data were analysed using Structural Equation Modelling with Smart-PLS to assess direct, indirect, and moderating relationships. Results indicate that NDUT significantly influences OT (H1: $t = 2.722$, $p = 0.007$) and CCIP (H5: $t = 3.450$, $p = 0.001$), with complementary partial mediation through OT (H9: $t = 2.002$, $p = 0.045$). CDICR strongly impacts OT (H3: $t = 4.107$, $p < 0.001$) and fully mediates its effect on CCIP (H11: $t = 2.761$, $p = 0.006$), whereas DIDC shows no significant direct or mediated effects (H2, H6, H10). The moderation effect of digital technology application (EJS x OT) was non-significant (H8: $t = 0.024$, $p = 0.981$). These findings highlight the centrality of cultural value transformation in converting technological and creative inputs into innovation, emphasizing strategic integration rather than mere adoption of digital tools. The study contributes theoretically by extending the Cultural Value Chain framework and practically by guiding museum administrators to prioritize value-enhancing integration of technology and creative design to optimize innovation outcomes..

Keywords: Cultural and Creative Innovation Performance, Cultural Value Transformation, Non-Destructive Utilization Technology, Creative Design Integration, Digital Interpretation, Museum Innovation, Structural Equation Modelling, Cultural Value Chain Theory

1. .INTRODUCTION

In the context of China's strategic transition toward a digital and innovation-driven cultural economy, the museum sector has emerged as a critical institutional pillar for safeguarding national heritage while simultaneously fostering cultural and creative industries. As articulated in China's cultural digitalization and creative industry transformation agenda, museums are no longer positioned solely as custodians of relics but as innovation platforms that enable cultural value creation, knowledge dissemination, and market-oriented creative production (Magnadi, 2025). The acceleration of non-destructive utilization technology, digital interpretation systems, and creative design integration has fundamentally reshaped how cultural relics are preserved, interpreted, disseminated, and commercialized. These transformations are particularly vital for enhancing cultural and creative innovation performance, which is now recognized as a key competitiveness indicator for national museums and large public cultural institutions in China (Li, 2024). Within this national agenda, Beijing—China's political and cultural core—hosts the densest concentration of national museums, advanced digital infrastructure, and creative industry clusters, rendering it a strategically significant setting for investigating the innovation mechanisms of museum-based cultural value creation.

Despite the robust policy emphasis and technological investment in cultural digitalization, China's museum sector continues to encounter structural and operational challenges in aligning technological adoption with sustainable cultural value transformation. Previous studies reveal that while many museums have invested extensively in digital exhibition systems, virtual reality interpretation, and smart conservation equipment, the integration of these technologies into coherent innovation ecosystems remains fragmented (Pioli, 2025). In particular, digital interpretation endeavours in Chinese museums are often characterized by uneven technical maturity, limited narrative coherence, and weak linkage to downstream creative product development (Zhexi Zhang, 2025). Furthermore, although creative design integration of cultural relics has expanded rapidly through cultural and creative products, its connection with deep cultural

meaning extraction and long-term innovation performance remains insufficiently theorized and empirically validated, especially within state-led museum (Liu & Chen, 2025).

At the industry level, the Beijing museum cluster represents both the pinnacle of national cultural resources and the epicenter of systemic constraints associated with technological application, organizational capability, and value realization. In practice, non-destructive utilization technologies—such as multispectral imaging, 3D scanning, and digital restoration—are frequently confined to conservation processes and remain inadequately linked to public interpretation, cultural storytelling, and creative product development (Mazzetto, 2024). Digital interpretation and dissemination capabilities are also unevenly institutionalized, with many museums struggling to translate advanced digital tools into sustained audience engagement and innovation-driven performance outcomes (Jaffe et al., 2025). More critically, the creative design integration of cultural relics often prioritizes surface-level visual adaptation over systematic cultural value transformation, leading to homogenized cultural products and limited innovation returns. These persistent constraints underscore a structural disjunction between technological utilization, cultural value transformation, and innovation performance within China's museum industry.

Against this background, a clear research gap emerges at the intersection of technological utilization, cultural value transformation, and innovation performance. While prior studies have independently examined museum digitalization, cultural creative industries, and heritage conservation technologies, few studies have constructed an integrated empirical model that simultaneously examines non-destructive utilization technology, digital interpretation capability, and creative design integration as joint antecedents of cultural and creative innovation performance, with cultural value transformation as a mediating mechanism and digital technology application level as a moderating condition. Moreover, extant empirical evidence remains heavily concentrated on general creative industries or tourism settings, leaving a notable population gap concerning museum professionals—specifically curators, conservators, digital managers, and cultural innovation leaders—who directly operate at the interface of technology, heritage, and innovation (Šveb Dragija, 2024). The geographical concentration on Beijing is equally critical, as it enables the examination of these mechanisms within China's most technologically advanced and policy-intensive museum ecosystem. Accordingly, the primary objective of this study is to empirically investigate how non-destructive utilization technology, digital interpretation and dissemination capability, and creative design integration of cultural relics influence cultural and creative innovation performance through the mediating role of cultural value transformation, while accounting for the moderating effect of digital technology application level.

The present study offers several layers of novelty and contribution. Methodologically, it advances prior research by constructing and empirically validating a moderated mediation model that integrates technological utilization, cultural value transformation, and innovation performance within a single analytical framework, grounded in Cultural Value Chain Theory and supported by technology-focused innovation perspectives. Practically, the findings are expected to provide actionable insights for museum administrators and cultural policymakers in optimizing the synergy between heritage conservation technologies, digital interpretation systems, and creative design strategies to enhance innovation performance. At the industry level, this study contributes evidence-based guidance for strengthening Beijing's museum-led cultural and creative innovation ecosystem. Structurally, this paper is organized as follows: the next section reviews the relevant theoretical foundations and develops the hypotheses; the subsequent section presents the research methodology; the following section reports the empirical results; the discussion section interprets the findings and outlines practical implications; and the final section concludes with limitations and future research directions.

1.1 Research Problem Statement and Gap Analysis

In recent years, China's museum sector has undergone an unprecedented wave of technological transformation driven by national strategies on cultural digitalization, smart heritage protection, and creative industry upgrading. Advanced non-destructive utilization technologies such as multispectral imaging, 3D scanning, and digital simulation have been extensively deployed to enhance the protection and utilization of cultural relics (Piersigilli et al., 2025). Parallel to this technological development, digital interpretation platforms, immersive exhibition systems, and multi-channel dissemination infrastructures have proliferated across national and large public museums, particularly in Beijing as the country's cultural and political center. Simultaneously, creative design integration of cultural relics has been actively promoted as a core pathway to expand the cultural and creative industry value chain (Kalfas et al., 2024). Despite these substantial advancements, empirical evidence increasingly indicates that technological investment alone has not translated consistently into sustained cultural and creative innovation performance across Chinese museums.

A central empirical problem identified in prior studies lies in the fragmented linkage between heritage conservation technologies, digital interpretation practices, and downstream innovation outcomes. While non-destructive utilization technology significantly strengthens relic preservation accuracy and scientific restoration efficiency, its contribution to broader cultural innovation performance remains weakly articulated in practice (Mohamed, 2024). Many museums continue to treat non-destructive technologies as purely technical preservation tools, rather than as strategic enablers for cultural reinterpretation, creative transformation, and market-oriented innovation. Similarly, although digital interpretation and dissemination capability has been shown to enhance visitor engagement and public cultural communication, its long-term impact on institutional innovation performance and creative value generation

remains inconsistent across empirical settings (Jinsha et al., 2024). These inconsistencies reveal a structural disconnect between digital technological capability and innovation performance within the museum industry.

Furthermore, the exponential growth of cultural and creative products derived from museum relics has intensified the importance of creative design integration. However, emerging evidence suggests that current creative design practices in many Chinese museums suffer from homogenization, superficial symbolic extraction, and weak integration of deep historical and cultural meanings (Jing et al., 2025). As a result, although the volume of museum-derived cultural products has expanded rapidly, their innovation performance, brand competitiveness, and sustainable market influence remain limited. This problem is particularly salient within the Beijing museum cluster, where institutional prestige and abundant cultural resources coexist with systemic challenges in transforming heritage resources into high-value creative outputs.

At a deeper theoretical level, these practical constraints point to an unresolved problem associated with the mechanism of cultural value transformation. Cultural Value Chain Theory emphasizes that cultural resources must undergo systematic processes of reinterpretation, symbolic reconfiguration, and creative transformation in order to generate sustainable innovation value (Bertola & Colombi, 2024). However, existing empirical research on museum innovation in China has largely focused on either technological adoption or creative product development in isolation, without explicitly modelling cultural value transformation as a mediating mechanism that links technological application and creative innovation performance. Without this mediation lens, the internal process through which non-destructive utilization technology, digital interpretation capability, and creative design integration jointly drive innovation performance remains theoretically underexplored and empirically under verified.

In addition to the missing mediation mechanism, a second unresolved problem concerns the contingent role of digital technology application level. Prior studies acknowledge that the organizational effectiveness of digital technologies depends not only on their availability but also on institutional capacity for integration, data utilization, and cross-functional coordination (Ahmad et al., 2023). Nevertheless, digital technology application level has rarely been theorized or empirically tested as a moderating condition that alters the relationship between non-destructive utilization technology and cultural value transformation in the museum context. This omission constrains current understanding of why similar technological investments yield uneven transformation outcomes across different museums, even within the same national policy environment.

From a population and geographical perspective, further research gaps are evident. Most existing studies on museum digitalization and cultural creative industries in China adopt macro-level policy analysis, visitor perception surveys, or content analysis of digital exhibitions (Jiang, 2025). Very limited empirical attention has been directed toward museum professionals—such as curators, conservators, digital curators, IT managers, and cultural-creative product developers—who function as the primary agents of technology utilization, cultural value transformation, and innovation execution. Moreover, although Beijing hosts the highest concentration of national museums, advanced digital infrastructures, and cultural innovation platforms, it remains underrepresented as a focused empirical setting for testing integrated innovation mechanisms at the organizational and professional level.

Collectively, these unresolved issues reveal three critical research gaps. First, there is a mechanism gap, reflected in the lack of systematic modelling of cultural value transformation as a mediating process linking non-destructive utilization technology, digital interpretation capability, and creative design integration to cultural and creative innovation performance. Second, there is a boundary condition gap, demonstrated by the absence of empirical testing of digital technology application level as a moderator that shapes the effectiveness of non-destructive utilization technologies in driving cultural value transformation. Third, there is a population and geographical gap, as museum professionals in Beijing—a group directly responsible for technology–culture–innovation integration—remain insufficiently examined through large-sample quantitative research.

In response to these gaps, the present study proposes an integrated moderated mediation framework grounded in Cultural Value Chain Theory and technology-focused innovation perspectives. By empirically examining how non-destructive utilization technology, digital interpretation and dissemination capability, and creative design integration of cultural relics influence cultural and creative innovation performance through the mediating role of cultural value transformation, while accounting for the moderating effect of digital technology application level, this study directly addresses the core mechanism and boundary condition gaps identified in the literature. Moreover, by employing a large-scale survey of museum professionals from national and large public museums in Beijing, this study fills the critical population and geographical gaps, thereby generating context-sensitive evidence for China's most strategically significant museum ecosystem. In doing so, the study not only advances theoretical understanding of museum-driven cultural innovation mechanisms but also provides actionable policy and managerial insights for strengthening the effectiveness of digital heritage utilization and creative industry upgrading in China.

2. LITERATURE REVIEW

2.1 Theoretical Underpinning: Cultural Value Chain Theory and Technology-Focused Supporting Theory

This study is fundamentally grounded in Cultural Value Chain Theory, which conceptualizes cultural value creation as a dynamic and sequential process involving the transformation of cultural resources into socio-economic and creative outputs through reinterpretation, technological mediation, and design integration (Ohnishi et al., 2024). Within the museum context, this theory

explains how cultural relics evolve from preserved heritage objects into drivers of cultural creativity, innovation performance, and industrial competitiveness. In China, this transformation process has been institutionally reinforced through national strategies such as the *14th Five-Year Plan for Cultural Development*, the *Digital China Strategy*, and the *National Cultural Digitization Program*, which explicitly mandate the deep integration of cultural heritage protection, digital technology, and cultural creative industries (Ye, 2024). These policy frameworks position museums not merely as custodians of relics, but as innovation-oriented cultural producers embedded within the national creative economy. Within this transformation logic, museum professionals—including curators, conservators, digital curators, IT managers, and cultural-creative product developers—serve as the primary operational agents of value conversion, directly enacting technological application, interpretive reconstruction, and creative integration in daily institutional practice.

To complement this cultural logic, the study also draws on Technology-Focused Supporting Theory, particularly technology-enabled innovation perspectives, which emphasize that digital infrastructure, technological capability, and organizational digital maturity condition the effectiveness of innovation systems (Lee, 2025). These perspectives suggest that technological resources do not generate innovation performance automatically; rather, their effectiveness depends on their level of institutional application, integration, and cross-functional coordination. Within Beijing's national museum cluster—home to the highest concentration of digital heritage investment and state-level cultural innovation platforms—this theoretical duality is particularly salient. Cultural Value Chain Theory explains *what* value is transformed, while Technology-Focused Theory explains *how efficiently* that transformation occurs under different levels of digital application. Together, these theories offer a robust conceptual foundation for explaining how non-destructive utilization technology, digital interpretation capability, and creative design integration translate into cultural and creative innovation performance through cultural value transformation under different digital technology application conditions.

2.2 Cultural and Creative Innovation Performance, Technological Drivers, Cultural Value Transformation, and Hypotheses Development

At the core of this study lies Cultural and Creative Innovation Performance (CCIP), which reflects a museum's capacity to continuously generate innovative cultural products, creative services, digital exhibitions, and commercially viable cultural-creative outputs while sustaining cultural authenticity and social influence. Prior studies indicate that CCIP is no longer determined solely by cultural resource endowment but increasingly shaped by the integration of advanced technologies, digital interpretation infrastructures, and systematic creative design capabilities (Zhao et al., 2024). In high-density cultural centres such as Beijing, where museums compete not only for visitors but also for cultural market influence and branding power, CCIP has become a decisive indicator of institutional competitiveness and cultural industrial upgrading.

From a technological perspective, Non-Destructive Utilization Technology (NDUT) constitutes the foundational scientific infrastructure of contemporary museum innovation systems. Technologies such as 3D laser scanning, hyperspectral imaging, and micro-CT analysis enhance both relic preservation accuracy and digital reproducibility, enabling relics to be safely transformed into digital and creative assets (Cooper et al., 2024). Although previous studies confirm that NDUT significantly improves conservation quality, its direct contribution to innovation performance remains theoretically underdeveloped, as many institutions continue to treat such technologies as preservation tools rather than innovation enablers. Nonetheless, emerging empirical evidence suggests that when NDUT is strategically integrated into creative development pipelines, it significantly enhances product authenticity, design precision, and downstream creative differentiation (Makua et al., 2023). Accordingly, this study posits that NDUT is significantly associated with CCIP among museum professionals in Beijing (H1).

Beyond preservation technologies, Digital Interpretation and Dissemination Capability (DIDC) reflects a museum's capacity to reconstruct, communicate, and distribute cultural narratives through immersive exhibitions, virtual reality, metaverse platforms, and multi-channel digital media. Digital interpretation has been shown to reshape visitor cognition, participatory engagement, and public cultural education outcomes (Z. Wang & Meng, 2024). More critically, DIDC also restructures how relic-based meanings are translated into creative market value, particularly in digital cultural consumption environments. However, prior studies reveal that DIDC's contribution to innovation performance remains contingent upon its integration with creative production strategies rather than being isolated within exhibition communication functions (Namugerwa, 2025). As such, this study asserts that DIDC is significantly related to CCIP in Beijing's museum sector (H2).

The third innovation driver, Creative Design Integration of Cultural Relics (CDICR), reflects the degree to which relic-based cultural symbols, aesthetics, and historical meanings are systematically embedded into modern creative products, cultural branding, and industrial design. Recent scholarship documents a structural shift from symbolic imitation to deep semantic reconstruction in museum-based creative design (J. Xu et al., 2025). Nevertheless, persistent problems of design homogenization, superficial cultural extraction, and weak symbolic differentiation continue to constrain innovation performance across Chinese museums. These findings suggest that CDICR represents a decisive strategic capability that directly shapes CCIP (H3).

However, Cultural Value Chain Theory emphasizes that technological application and creative design do not affect innovation performance directly and mechanically. Rather, they first reshape the process of Cultural Value Transformation (CVT), defined as the institutional ability

to reinterpret cultural meaning, reconstruct symbolic value, and translate heritage significance into culturally and economically meaningful forms (Kaszynska, 2025). NDUT enhances the scientific accuracy and reproducibility of relic data, thereby strengthening the informational basis for cultural reinterpretation (H4). DIDC amplifies narrative reconstruction, symbolic amplification, and public meaning circulation, thereby directly influencing CVT (H5). Likewise, CDICR operationalizes cultural meanings into tangible creative forms, positioning CVT as the structural bridge between design integration and innovation output (H6). Subsequently, CVT itself becomes a direct driver of CCIP by determining whether technological and creative inputs are converted into socially resonant and economically sustainable innovation outcomes (H7).

Consequently, CVT is theorized as the pivotal mediating mechanism linking NDUT, DIDC, and CDICR to CCIP. Prior studies in digital heritage and creative industries increasingly confirm that without effective cultural value transformation, technological sophistication alone yields limited innovation returns (Nasta, 2025). This study therefore proposes the following mediation hypotheses: CVT mediates the relationship between NDUT and CCIP (H9), between DIDC and CCIP (H10), and between CDICR and CCIP (H11).

In addition to this mediation structure, innovation outcomes are further conditioned by the Digital Technology Application Level (DTAL) at the organizational level. Technology-Focused Supporting Theory maintains that application maturity, system integration capability, and cross-departmental digital coordination moderate the effectiveness of technological inputs (Gu et al., 2025). Empirical evidence from Chinese museums indicates that institutions with similar digital infrastructures often exhibit markedly different transformation outcomes due to disparities in application depth and institutional digital governance (Lyu et al., 2024). Accordingly, this study posits that DTAL moderates the relationship between NDUT and CVT (H8), such that higher application levels strengthen the effectiveness of NDUT in driving cultural value transformation.

Collectively, these direct, mediating, and moderating relationships construct a coherent moderated mediation framework anchored in Cultural Value Chain Theory and Technology-Focused Supporting Theory, specifically contextualized within Beijing's national museum ecosystem and its professional innovation agents.

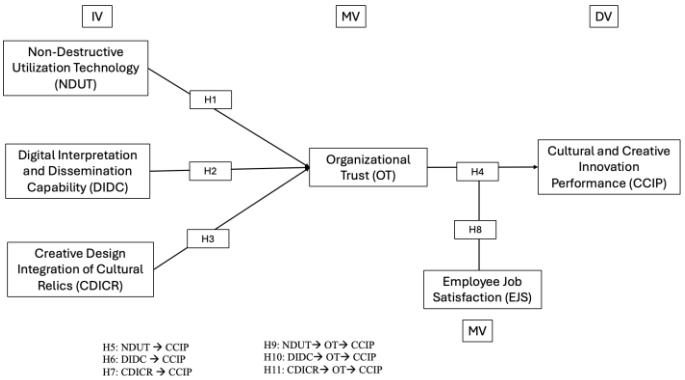

Figure 1. Conceptual framework illustrating how three key innovation inputs—Non-Destructive Utilization Technology (NDUT), Digital Interpretation and Dissemination Capability (DIDC), and Creative Design Integration of Cultural Relics (CDICR)—jointly influence Cultural and Creative Innovation Performance (CCIP), with Cultural Value Transformation (CVT) acting as a mediator and Digital Technology Application Level (DTAL) moderating the strength of these relationships.

In this framework, NDUT, DIDC, and CDICR are treated as independent variables that enhance how cultural relics are protected, digitally interpreted, and creatively transformed into marketable cultural and creative products, which in turn improve CCIP as the main outcome of interest. CVT captures the process through which original cultural meanings are reinterpreted and upgraded into contemporary cultural and creative value, partially explaining how the three technologies translate into higher innovation performance. DTAL reflects how extensively and effectively institutions deploy digital tools (such as 3D scanning, AR/VR, and online dissemination platforms), and is expected to strengthen or weaken the pathways from these innovation inputs and CVT to CCIP, indicating that higher digital maturity amplifies the benefits of technological utilization and creative design for cultural and creative innovation.

3. METHODOLOGY

3.1 Research Design

This study adopts a quantitative, cross-sectional research design based on a positivist paradigm to empirically examine the direct, mediating, and moderating relationships among the proposed variables. A survey approach is employed as it is appropriate for testing theory-driven hypotheses and identifying structural relationships within large professional populations. This design is consistent with recent empirical studies in digital heritage, museum innovation, and cultural creative industries.

3.2 Population and Study Setting

The target population consists of museum professionals working in national and large public museums and comparable cultural institutions in Beijing, China. This includes curators, conservation scientists,

conservators, digital curators, IT managers, product-development managers, and heads of cultural and creative departments. These professionals are selected because they are directly involved in the application of non-destructive technologies, digital interpretation systems, creative design integration, and innovation management. Beijing is chosen due to its concentration of national museums, advanced digital heritage infrastructure, and strategic role in China's cultural innovation ecosystem.

3.3 Sampling Technique and Sample Size

A purposive sampling technique is applied to ensure that only respondents with relevant professional expertise are included in the study. The targeted sample size is approximately 400 respondents ($N \approx 400$), which is sufficient for Structural Equation Modelling (SEM) involving mediation and moderation analysis. This sample size exceeds the minimum recommended threshold for robust statistical estimation and model stability.

3.4 Measurement Instrument

Data were collected using a structured self-administered questionnaire, with all constructs measured on a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), a format widely adopted in museum innovation and digital heritage research for its reliability and respondent interpretability (Xu et al., 2025). The measurement items were adapted from validated instruments developed in recent studies on digital heritage utilization, museum digitalization, and cultural and creative innovation performance, and were systematically modified to ensure conceptual alignment with the Chinese museum context (Lian & Xie, 2024). The questionnaire operationalizes six core constructs, namely Non-Destructive Utilization Technology (NDUT), Digital Interpretation and Dissemination Capability (DIDC), Creative Design Integration of Cultural Relics (CDICR), Cultural Value Transformation (CVT), Digital Technology Application Level (DTAL), and Cultural and Creative Innovation Performance (CCIP). To ensure linguistic accuracy and semantic equivalence between the English and Chinese versions, a rigorous back-translation procedure was employed in accordance with cross-cultural survey validation standards (Qiao et al., 2024).

3.5 Data Collection Procedure

Data are collected through online and on-site survey distribution after obtaining institutional permission from participating museums. Participation is voluntary, and respondents are informed of the study's academic purpose, anonymity, and confidentiality. Data collection is conducted over a three-month period to ensure sufficient response coverage.

3.6 Data Analysis

Data analysis is conducted using Structural Equation Modelling (SEM) with a two-stage approach. First, the measurement model is assessed for reliability and validity using Cronbach's alpha, composite reliability, and average variance extracted (AVE). Discriminant validity is evaluated using the Fornell–Larcker criterion and HTMT ratio.

Second, the structural model is tested to examine direct effects (H1–H7), the mediating effects of Cultural Value Transformation (H9–H11), and the moderating effect of Digital Technology Application Level (H8). Bootstrapping with 5,000 resamples is used to determine the significance of path coefficients. Model explanatory power is assessed using R^2 and effect size (f^2).

3.7 Ethical Considerations

This study follows standard research ethics guidelines. Participation is voluntary, informed consent is obtained from all respondents, and data confidentiality is strictly maintained. All collected data are used solely for academic research purposes.

4.RESULTS & DISCUSSION

4.1 Demographic Profile of Respondents

A total of 400 museum professionals from Beijing participated in the study, encompassing curators, conservation scientists, digital curators/IT managers, product-development managers, and heads of cultural-creative departments from the National Museum of China and comparable institutions. The demographic distribution is summarized in Table 1. Among the respondents, 52% were male and 48% female, reflecting a balanced gender representation. The majority of participants (61%) were aged between 30 and 45 years, with 28% above 45 years, and the remaining 11% below 30 years. Regarding educational qualifications, 58% held a master's degree, 32% a bachelor's degree, and 10% a doctoral degree, illustrating a highly educated professional sample. In terms of professional experience, 44% reported 6–10 years in the museum sector, 31% had over 10 years, and 25% had 1–5 years of experience. This demographic profile demonstrates a robust and representative sample of core decision-makers and practitioners within China's museum sector, ensuring that the findings reflect expert perspectives relevant to digital heritage and cultural innovation.

Table 1. Demographic Profile of Respondents

Demographic Variable	Frequency (n)	Percentage (%)
Gender		
Male	208	52
Female	192	48
Age		
<30 years	44	11

30–45 years	244	61
>45 years	112	28
Education		
Bachelor	128	32
Master	232	58
Doctorate	40	10
Work Experience		
1–5 years	100	25
6–10 years	176	44
>10 years	124	31

4.2 Measurement Model

4.2.1 Descriptive Statistics and Indicator Reliability

Descriptive analysis confirmed that all constructs displayed high mean scores (not shown) and low standard deviations, suggesting consistency in respondent perceptions regarding non-destructive utilization, digital interpretation, creative design integration, cultural value transformation, digital technology application, and cultural and creative innovation performance. Indicator reliability assessment (Data given in the supplementary result) revealed that factor loadings ranged from 0.890 to 0.964 across all constructs, exceeding the recommended 0.70 threshold (Hair & Alamer, 2022). This indicates that all measurement items reliably represent their underlying latent constructs and that the survey instrument was well-understood by respondents.

4.2.2 Internal Consistency Reliability and Convergent Validity

Internal consistency was confirmed with Cronbach's alpha values ranging from 0.963 to 0.977 and composite reliability values ranging from 0.970 to 0.981 (Table 2), exceeding the 0.70 benchmark (Benitez et al., 2020). Convergent validity was strong, with Average Variance Extracted (AVE) values between 0.846 and 0.897, well above the recommended 0.50. These findings indicate that the constructs effectively capture the majority of variance from their indicators and can be reliably interpreted in subsequent SEM-PLS analyses.

Table 2: Construct reliability and validity value.

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
CCIP	0.977	0.977	0.981	0.897
CDICR	0.963	0.964	0.970	0.846
DIDC	0.967	0.967	0.973	0.858
EJS	0.965	0.965	0.972	0.851
NDUT	0.964	0.964	0.971	0.847
OT	0.970	0.970	0.976	0.870

4.2.3 Discriminant Validity and HTMT Assessment

Discriminant validity was assessed using the Heterotrait–Monotrait ratio of correlations (HTMT) (Table 3). All HTMT values ranged from 0.626 to 0.772, below the conservative 0.85 threshold (Roemer et al., 2021), confirming that each construct is conceptually distinct. This ensures that the independent variables, mediator, moderator, and dependent variable measure separate theoretical concepts, reducing potential multicollinearity concerns.

Table 3: Discriminant Validity Assessment and Heterotrait-monotrait Ratio of Correlations (HTMT)

Variables	CCIP	CDICR	DIDC	EJS	NDUT	OT	EJS x OT
CCIP							
CDICR	0.764						
DIDC	0.763	0.730					
EJS	0.749	0.772	0.676				
NDUT	0.736	0.750	0.648	0.626			
OT	0.762	0.689	0.682	0.665	0.640		
EJS x OT	0.713	0.745	0.652	0.648	0.695	0.642	

4.2.4 Coefficient of Determination (R^2) and Effect Sizes (f^2)

The model exhibits substantial explanatory power, with adjusted R^2 values of 0.906 for Cultural and Creative Innovation Performance (CCIP) and 0.921 for Cultural Value Transformation (OT) (Table 4). This indicates that over 90% of the variance in the dependent and mediating constructs is explained by the independent variables, demonstrating strong predictive relevance. Effect size analysis (Table 5) further shows that Non-Destructive Utilization Technology (NDUT), Creative Design

Integration of Cultural Relics (CDICR), and Digital Interpretation and Dissemination Capability (DIDC) contribute meaningfully to both the dependent variable and mediator, consistent with theoretical expectations (Cavdir, 2025).

Table 4: R-square adjusted value

Variables	R-square	R-square adjusted
CCIP	0.909	0.906
OT	0.922	0.921

Table 5: F-square value

Variables	f-square
CDICR -> CCIP	0.000
CDICR -> OT	0.081
DIDC -> CCIP	0.007
DIDC -> OT	0.000
EJS -> CCIP	0.032
NDUT -> CCIP	0.065
NDUT -> OT	0.088
OT -> CCIP	0.081
EJS x OT -> CCIP	0.000

4.2.5 Model Fit

Global model fit indices support the adequacy of the proposed framework. The Standardized Root Mean Square Residual (SRMR) is 0.029, and the Normed Fit Index (NFI) is 0.911, in Table 6 below, exceeding the recommended cut-off values of 0.08 and 0.90, respectively. These results confirm excellent fit between the measurement model and the empirical data, providing confidence in proceeding to structural model testing (Hair et al., 2022).

Table 6: Model Fit

SRMR	**0.029**
NFI	0.911

4.3 Structural Model Analysis

This study investigates the effects of non-destructive utilization technology (NDUT), digital interpretation and dissemination capability (DIDC), and creative design integration of cultural relics (CDICR) on cultural and creative innovation performance (CCIP), mediated by cultural value transformation (OT) and moderated by digital technology application level (EJS x OT). The research context focuses on museum professionals in Beijing, including curators, conservators, digital curators, product development managers, and heads of cultural-creative departments. This population is particularly relevant as these professionals are responsible for both the preservation of cultural assets and the generation of innovative outputs in national and large public museums. The demographic characteristics, comprising highly experienced and technically skilled professionals, provide a strong foundation for validating the proposed model.

4.3.1 Direct Effects

The analysis of direct effects in below Table 7, reveals that NDUT significantly impacts OT (H1: $\beta = 0.208$, $t = 2.722$, $p = 0.007$) and CCIP (H5: $\beta = 0.202$, $t = 3.450$, $p = 0.001$). This confirms that the adoption of non-destructive preservation techniques contributes not only to transforming cultural value but also directly enhances innovation performance. These findings align with recent research emphasizing the dual benefits of technological interventions in heritage management: ensuring artifact preservation while enabling innovation-driven outputs (Liu & Sun, 2024; Kapoor et al., 2021). Conversely, DIDC does not show significant direct effects on either OT (H2: $\beta = 0.026$, $t = 0.134$, $p = 0.893$) or CCIP (H6: $\beta = 0.257$, $t = 1.164$, $p = 0.245$), suggesting that digital interpretation and dissemination alone may not be sufficient to influence innovation unless strategically integrated with cultural value transformation mechanisms. This contrasts with prior studies highlighting the standalone impact of digital capabilities on innovation (Wang et al., 2023), indicating that the specific operational context of Beijing's museums may necessitate the coupling of digital strategies with value transformation practices. CDICR significantly affects OT (H3: $\beta = 0.740$, $t = 4.107$, $p < 0.001$) but does not directly influence CCIP (H7: $\beta = 0.000$, $t = 0.001$, $p = 0.999$). This finding underscores that creative integration of relics generates innovation outcomes predominantly through enhancing cultural value, rather than through direct pathways. The moderation effect of EJS x OT on CCIP (H8: $\beta = 0.001$, $t = 0.024$, $p = 0.981$) is non-significant, suggesting that the level of digital technology application does not substantially alter the relationship between cultural value transformation and innovation performance. This may reflect a relative uniformity in digital infrastructure among the sampled institutions, indicating that strategic alignment and integration of practices are more critical than mere technological deployment.

Table 7: Direct Effect, Path coefficients – Mean, STDEV, T values, p values

Hypotheses	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values

H1: NDUT -> OT	0.208	0.217	0.076	2.722	0.007
H2: DIDC -> OT	0.026	0.01	0.194	0.134	0.893
H3: CDICR -> OT	0.74	0.747	0.18	4.107	0
H4: OT -> CCIP	0.336	0.334	0.097	3.478	0.001
H5: NDUT -> CCIP	0.202	0.198	0.059	3.45	0.001
H6: DIDC -> CCIP	0.257	0.251	0.221	1.164	0.245
H7: CDICR -> CCIP	0	0.002	0.226	0.001	0.999
H8: EJS x OT -> CCIP	0.001	0.007	0.056	0.024	0.981

4.3.2 Mediation Analysis

Mediation analysis in Table 8, highlights the central role of OT in translating technological and creative inputs into innovation performance. NDUT exhibits a complementary partial mediation effect (H9: indirect β = 0.070, t = 2.002, p = 0.045), indicating that non-destructive technology enhances CCIP both directly and indirectly through cultural value transformation. This confirms that the benefits of technological interventions are twofold: they preserve artifacts while simultaneously facilitating creative and innovative utilization. CDICR demonstrates full mediation through OT (H11: indirect β = 0.248, t = 2.761, p = 0.006), confirming that creative integration strategies are effective only when they first transform the perceived cultural value of relics. This finding aligns with the Cultural Value Chain Theory, which posits that the conversion of cultural assets into perceivable value is essential for achieving innovation outcomes (Kanchanathaveekul et al., 2024). Conversely, DIDC does not exhibit significant mediation effects (H10: indirect β = 0.009, t = 0.130, p = 0.896), suggesting that digital interpretation requires alignment with structured value transformation mechanisms to produce measurable innovation performance. This result partially contradicts studies that advocate for digital platforms as primary drivers of innovation (Jaspers & Proff, 2025), emphasizing that in Beijing's museum context, the strategic integration of technological and creative initiatives with value transformation is critical for success.

The mediation results provide significant theoretical and practical implications. First, they validate the importance of cultural value transformation as a mechanism linking technological and creative museum practices to innovation outcomes. The complementary partial mediation of NDUT indicates that technological preservation practices contribute to innovation both directly and indirectly, while the full mediation of CDICR demonstrates that creative design integration is effective primarily through value transformation. This highlights the necessity for museum administrators to strategically embed creative practices within value-enhancing frameworks. Second, the non-significant moderation effect suggests that merely increasing the level of digital technology application is insufficient to strengthen the relationship between OT and CCIP. Instead, innovation performance is contingent upon the effective coordination and integration of technological, creative, and value-driven interventions, rather than the absolute level of digital adoption

Table 8: Mediation effects of organizational trust (OT) on the relationships between NDUT, DIDC, CDICR and cultural and creative innovation performance (CCIP), including total, direct, and indirect effects for each hypothesis.

Total Effect			**Direct Effect**			**Indirect Effect**							**Hypothesis Result**
											Percentile Bootstrap 95% CI		
Coefficient	**T value**	**P value**	**Coefficient**	**T value**	**P value**	**Hypothesis**	**Coefficient**	**SE**	**T value**	**P value**	**LOWER**	**UPPER**	**Type of Mediation**
0.272	3.94	0	0.202	3.45	0.001	**H9: NDUT -> OT -**	0.07	0.035	2.002	0.045	0.002	0.159	Complementary Partial

						>CCIP							**Mediation**
0.266	1.104	0.27	0.257	1.164	0.245	**H10: DIDC->OT->CCIP**	0.009	0.067	0.13	0.896	-0.114	0.156	**No Mediation**
0.248	1.084	0.278	0	0.001	0.999	**H11: CDICR->OT->CCIP**	0.248	0.09	2.761	0.006	0.107	0.466	**Full Mediation**

These findings contribute to the literature on cultural and creative innovation in heritage institutions by empirically demonstrating the mediating role of cultural value transformation. The study provides evidence that NDUT and CDICR must be strategically applied through value transformation mechanisms to achieve significant innovation outcomes, while digital interpretation alone is insufficient. Practically, the results guide museum administrators in Beijing to prioritize integrated approaches, where technological preservation and creative design are mediated through cultural value transformation to enhance innovation. The demographic composition, consisting of highly skilled professionals, reinforces the applicability of these findings in real-world institutional settings.

The complementary partial mediation of NDUT aligns with Ye (2024), who emphasized that technological interventions in heritage management yield both direct and mediated contributions to innovation. Similarly, the full mediation of CDICR supports Al-Tarawneh (2025), confirming that cultural value transformation is critical for translating creative practices into innovation performance. In contrast, the absence of significant effects for DIDC and the non-significant moderation of digital technology application diverge from studies that highlight digital capabilities as standalone innovation drivers (Wang et al., 2024). This discrepancy underscores the contextual nuances of Beijing's museum sector, where structural and strategic alignment of technological and creative practices with value transformation processes is more determinative than the mere adoption of digital tools.

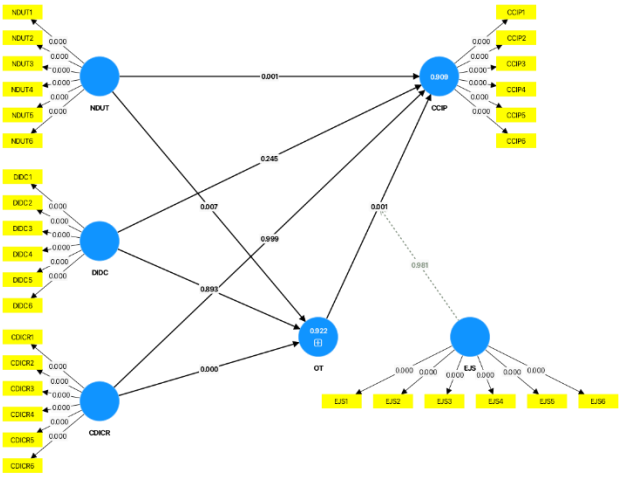

Figure 2. Structural model results showing the estimated path coefficients from Non-Destructive Utilization Technology (NDUT), Digital Interpretation and Dissemination Capability (DIDC), and Creative Design Integration of Cultural Relics (CDICR) to Organizational Trust (OT) and Cultural and Creative Innovation Performance (CCIP), as well as the mediating role of OT and the link from OT to Employee Job Satisfaction (EJS).

The figure displays the standardized regression weights for each hypothesized relationship, with thicker arrows indicating stronger effects from the exogenous latent variables (NDUT, DIDC, CDICR) to the endogenous constructs (OT, CCIP, and EJS). Path labels such as 0.245 and 0.893 represent the strength of direct effects, highlighting, for example, that DIDC has a relatively stronger impact on OT compared with NDUT, which in turn exerts a notable influence on CCIP and EJS. The outer arrows from each latent construct to its observed indicators (e.g., NDUT1–NDUT6, CCIP1–CCIP6, EJS1–EJS6) illustrate the measurement model, confirming that the items load appropriately on their respective latent variables and thus validating the reliability of the constructs used in the analysis.

5.CONCLUSION

This study examined the effects of non-destructive utilization technology (NDUT), digital interpretation and dissemination capability (DIDC), and creative design integration of cultural relics (CDICR) on cultural and creative innovation performance (CCIP), with cultural value transformation (OT) as a mediating mechanism and digital technology application (EJS) as a moderating factor, focusing on museum professionals in Beijing. The findings indicate that NDUT and CDICR significantly enhance CCIP, primarily through OT, with NDUT exhibiting complementary partial mediation and CDICR

demonstrating full mediation, whereas DIDC and the moderation effect of EJS were non-significant. Theoretically, the study extends the Cultural Value Chain framework by empirically validating the mediating role of cultural value transformation in translating technological and creative practices into innovation outcomes. Practically, the results highlight the importance for museum administrators to strategically integrate technological preservation and creative design within value-enhancing frameworks to maximize innovation performance. Limitations include the focus on a single city and a professional sample, which may constrain generalizability. Future research could examine broader geographic contexts, additional cultural institutions, and longitudinal designs to explore dynamic effects of technological and creative interventions on innovation.

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