

Digital capabilities follow distinct pathways to sustainable performance in county-level museums

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Article

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Abstract

Digital transformation is often treated as a uniformly beneficial condition for cultural institutions, although digital resources can create value only when they are embedded in organisational routines and management practices. This study examines whether three forms of digital capability—digital efficiency capability, digital operational capability, and digital dynamic capability—are differently associated with the perceived sustainable development performance of county-level museums and whether management efficiency transmits these relationships. A quantitative cross-sectional survey produced 320 valid staff responses from 78 participating county-level museums in Shaanxi Province, China. Confirmatory factor analysis and structural equation modelling were conducted in AMOS 24.0, and indirect effects were evaluated with 5,000 bootstrap resamples. Digital operational capability ($\beta = 0.184$, $p = .013$) and digital dynamic capability ($\beta = 0.166$, $p = .019$) showed significant positive direct associations with perceived sustainable performance, whereas the direct path from digital efficiency capability was not significant ($\beta = 0.054$, $p = .431$). All three capabilities were positively associated with management efficiency, which in turn showed the largest structural association with sustainable performance ($\beta = 0.448$, $p < .001$). The indirect effect was significant for each capability; the pattern was consistent with full mediation for digital efficiency capability and partial mediation for operational and dynamic capabilities. The findings challenge technologically deterministic accounts of museum digitalisation and show that different capabilities reach sustainable outcomes through different organisational pathways. Because the data are cross-sectional, self-reported, and institutionally nested, the results are interpreted as structural associations rather than causal effects.

1 Introduction

Museums are expected to preserve collections, provide education, widen cultural access, maintain viable operations, and respond to environmental responsibilities. Digital technologies can support these aims by extending access, improving collection information, enabling new forms of interpretation, and connecting institutions with audiences beyond the physical site (Li et al. 2024; Marty 2008; Massari et al. 2024). Yet the presence of technology does not establish that an institution possesses the capability to use it consistently or that digital investment will improve performance. Research on digital transformation repeatedly shows that value depends on complementary strategy, skills, coordination, routines, and organisational renewal (Kraus et al. 2021; Verhoef et al. 2021; Vial 2019). This distinction is especially important for county-level museums, where limited staffing, finance, and specialist expertise can magnify the consequences of fragmented systems and poorly integrated projects.

The sustainability of museums is also broader than financial continuity. Museums create social value through public education, access, cultural participation, and heritage continuity, while their operational choices carry economic and environmental consequences (Orea-Giner et al. 2021; Ross Nelson et al. 2022; San-Jose et al. 2023). A digital initiative may therefore influence several dimensions of performance at once, but it may also improve one activity without producing an institution-wide outcome. Studies of digital museums have often concentrated on visitor-facing applications, online

participation, or particular technologies. These perspectives are valuable, but they can leave the organisational conversion process underexplained: how do digital resources become routines, decisions, and sustained outcomes within the museum?

A second problem concerns conceptual aggregation. Treating digital capability as a single undivided construct can conceal meaningful differences among creating or improving digitally enabled offerings, integrating digital systems into recurring operations, and sensing change before reconfiguring resources. Digital innovation research distinguishes technologies from the organisational capability to mobilise them (Khin and Ho 2019; Nambisan et al. 2017). Dynamic-capability research likewise emphasises sensing, seizing, and reconfiguration rather than one-off adoption (Teece 2007; Warner and Wäger 2019). In a museum setting, these distinctions imply that efficiency-oriented digital development, routine digital operations, and adaptive digital renewal need not have identical relationships with sustainable performance.

A third problem concerns the internal mechanism. Technology may improve information availability or connectivity, but managers and employees must still redesign responsibilities, refine workflows, coordinate units, and experiment with new arrangements. Management innovation scholarship shows that the refinement and renewal of managerial practices can influence how organisations use resources and respond to change (Damanpour and Aravind 2012; Damanpour et al. 2009; Jansen et al. 2006). The present study uses the term management efficiency for a pre-specified, staff-reported construct comprising exploitation-oriented improvement of existing management practices and exploration-oriented renewal of management approaches. It is not an audited input–output efficiency ratio. This definition makes management efficiency a plausible organisational bridge between digital capability and perceived sustainable development performance.

The study addresses these issues in county-level museums in Shaanxi Province, China. These institutions carry substantial heritage and public-service responsibilities while operating with different levels of digital infrastructure and organisational capacity. The empirical model distinguishes digital efficiency capability (DIC), digital operational capability (DOC), and digital dynamic capability (DDC); models management efficiency (ME) as a higher-order construct; and represents sustainable development performance (SP) through economic, social, and environmental dimensions. The analysis asks two related questions. First, do the three digital capabilities have different direct associations with perceived sustainable performance? Second, does management efficiency transmit these associations?

The article makes three contributions. It provides evidence from resource-constrained county-level cultural institutions, a setting that is less visible than national museums and large urban organisations. It demonstrates that the three digital-capability dimensions follow empirically different pathways instead of forming one uniform digital effect. It also identifies management efficiency as a central organisational mechanism while maintaining appropriately cautious inference from cross-sectional, staff-reported data. The resulting account replaces the assumption that more technology automatically produces better outcomes with a capability–management–performance explanation.

2 Theoretical framework and hypotheses

2.1 Digital capability in museums

Digital capability refers to an organisation's capacity to mobilise digital resources in support of innovation, operations, decision-making, and adaptation. It is distinct from ownership of hardware or software because capability resides in patterned action: the organisation must combine technology with human knowledge, managerial processes, and strategic intent (Khin and Ho 2019; Lokuge et al. 2019; Vial 2019). The resource-based perspective explains why similar technologies can generate different outcomes when institutions differ in complementary resources and their capacity to combine them. Dynamic-capability reasoning extends this argument by focusing on how organisations recognise changes, mobilise opportunities, and reconfigure resources over time (Helfat and Peteraf 2015; Teece 2007).

This study differentiates three forms of digital capability. Digital efficiency capability concerns the capacity to use digital technologies to improve or create products, services, processes, audience experiences, and value propositions. The label does not mean that objective productivity has already increased; it describes an efficiency-oriented capacity to develop digitally enabled improvements. Digital operational capability concerns the integration of digital resources into routine work, including information sharing, process coordination, service delivery, resource allocation, and monitoring. Digital dynamic capability concerns sensing technological and audience change, seizing relevant opportunities, learning, and reconfiguring digital resources and organisational arrangements. The distinction parallels the broader separation between digital innovation, digitally supported operations, and strategic renewal (Nambisan et al. 2017; Warner and Wäger 2019).

The three capabilities can contribute to sustainability in different ways. Efficiency-oriented capability may support new services, digital products, and improved audience experiences. Operational capability may improve the reliability and coordination of recurring museum activities. Dynamic capability may help museums adjust to technological change, shifting visitor expectations, and policy developments. Museum research suggests that digital technologies can support access, exhibition, interpretation, communication, and value co-creation, but outcomes depend on organisational use and context (Agostino and Costantini 2022; Guccio et al. 2022; Li et al. 2024; Simone et al. 2021). The first set of hypotheses therefore tests the dimensions separately rather than assuming a single digitalisation effect.

H1a: Digital efficiency capability is positively associated with perceived sustainable development performance.

H1b: Digital operational capability is positively associated with perceived sustainable development performance.

H1c: Digital dynamic capability is positively associated with perceived sustainable development performance.

2.2 Management efficiency as an organisational mechanism

Digital resources create possibilities, but management practices determine whether those possibilities become coordinated organisational action. New information systems may expose inefficiencies without resolving them; visitor data may be collected without entering decisions; and online platforms may expand communication while remaining disconnected from collection, education, or operational teams. Digital transformation therefore requires changes in roles, routines, coordination, and managerial attention (Kraus et al. 2021; Verhoef et al. 2021; Vial 2019). Organisational readiness research similarly identifies leadership, culture, skills, and cross-functional alignment as complements to digital technology (Lokuge et al. 2019).

Management efficiency is modelled here through two dimensions. Exploitation-oriented management efficiency captures the improvement of existing procedures, allocation of responsibilities, coordination, and implementation. Exploration-oriented management efficiency captures the search for new managerial ideas, processes, structures, and methods. This operationalisation draws on the distinction between exploitative and exploratory organisational activity (Jansen et al. 2006) and on management-innovation research concerning changes in managerial processes and structures (Damanpour and Aravind 2012). The construct was specified during framework and instrument development, before formal data collection and model estimation. Its interpretation is limited to employees' perceptions of improvements and renewal in management practices.

Each digital capability can be associated with management efficiency through a different route. DIC can supply tools and digitally enabled possibilities that prompt changes in managerial methods. DOC can embed information exchange and coordination in daily routines, making its connection with management practices especially immediate. DDC can support learning and reconfiguration when managers respond to technological, audience, or institutional change. These relationships lead to the following hypotheses.

H2a: Digital efficiency capability is positively associated with management efficiency.

H2b: Digital operational capability is positively associated with management efficiency.

H2c: Digital dynamic capability is positively associated with management efficiency.

Management efficiency should also be associated with sustainable development performance. Refining established routines can reduce duplication, clarify responsibilities, and improve the use of limited resources. Exploring new managerial arrangements can support collaboration, service adaptation, and institutional learning. In museums, these practices can matter economically through more coherent resource use, socially through better coordinated public services, and environmentally through more responsible operations. Because sustainable museum value is multidimensional and context-dependent,

the hypothesis concerns the higher-order perceived outcome rather than identical effects on every individual indicator (Orea-Giner et al. 2021; San-Jose et al. 2023).

H3: Management efficiency is positively associated with perceived sustainable development performance.

2.3 The mediating role of management efficiency

A mediation model follows from the capability–management–performance sequence. Digital capability can affect performance directly where technology is integrated into service delivery or adaptation, but it can also operate indirectly by changing the way managerial work is organised. The relative importance of these routes may differ by capability. Efficiency-oriented digital development may require incorporation into management practices before it is visible in institution-wide performance. Operational capability can have a direct relationship with execution while also improving coordination. Dynamic capability can support adaptation directly and can stimulate managerial renewal. Related evidence outside the museum sector shows that organisational innovation and operational mechanisms help connect digital transformation with sustainable performance (Costa Melo et al. 2023; Xu et al. 2023). These studies do not establish the museum-specific pathway, but they justify testing an intervening organisational mechanism.

H4a: Management efficiency mediates the association between digital efficiency capability and perceived sustainable development performance.

H4b: Management efficiency mediates the association between digital operational capability and perceived sustainable development performance.

H4c: Management efficiency mediates the association between digital dynamic capability and perceived sustainable development performance.

3 Methods

3.1 Research design and setting

The study used a quantitative, cross-sectional questionnaire design. The setting comprised county-level museums in Shaanxi Province, a region with extensive cultural heritage resources and a geographically dispersed museum system. The questionnaire captured staff-reported assessments of the museum in which each respondent worked. The statistical observations were individual employees; they were not independent audited museum records or visitor evaluations.

The institutional frame contained 95 eligible county-level museums. A Yamane calculation was used in the wider study to establish a target of 77 participating museums, and geographic stratification allocated the institutional coverage across ten prefecture-level cities. At the employee level, recruitment sought knowledgeable respondents in senior or middle management, digital or platform-related work, and frontline operations. Approximately four respondents per participating museum served as an initial

planning guide rather than an equal quota. Actual participation varied by institution. Direct institutional contact and assistance from the Shaanxi Museum Association were used to circulate online and paper questionnaires. This combination broadened access but included contact-based and voluntary recruitment; it should not be described as a simple random sample of all museum employees.

A separate and independent pilot sample was used before the formal survey. Two hundred pilot questionnaires were distributed and 188 valid responses were obtained. Pilot assessment addressed wording, contextual relevance, reliability, and factorability. Pilot cases were not pooled with the formal analytical sample. For the formal survey, 350 questionnaires were distributed and 327 were returned. Seven cases with a completion time below 120 seconds were excluded during screening, leaving 320 valid responses. The achieved sample corresponded to approximately 7.44 observations per measured item for the 43-item instrument.

3.2 Participants

Among the 320 formal respondents, 171 were men (53.4%) and 149 were women (46.6%). The sample included 163 frontline employees (50.9%), 78 middle-level managers (24.4%), and 79 senior managers (24.7%). A total of 253 respondents (79.1%) reported prior experience with digital projects. All participating museums represented in the formal sample had been established for more than ten years. These characteristics describe the realised sample and are not treated as proof of province-wide probability representativeness.

3.3 Measures

All substantive items used a five-point Likert response format from 1 (strongly disagree) to 5 (strongly agree). The full questionnaire contained 43 measured items. The focal article uses 38 items covering the three digital capabilities, management efficiency, and sustainable development performance; the remaining five items measured government support for a separate conditional analysis not reported in this article. Items were informed by established digital-capability, digital-transformation, management-innovation, and sustainability research and were adapted to county-level museums. They were not copied as one complete scale from a single source. Literature review, expert evaluation, museum-manager feedback, and independent pilot testing supported content adaptation. One further background item asked whether the museum pays attention to social and environmental responsibility; it was carried over from the wider study and is likewise not analysed in this article.

DIC was measured with five items concerning digitally enabled products and services, process improvement, business or service-model development, and audience experience. DOC was measured with five items concerning the integration of digital resources into routine operational work: using digital information for market positioning analysis, optimising processes and resource allocation, marketing and audience services, real-time monitoring and adjustment, and decision support. DDC was measured with seven items concerning sensing technological and environmental developments, establishing a long-term digital vision, seizing opportunities, learning, reconfiguring resources, and building new digital

ecosystems. These first-order constructs were retained separately because the theoretical model predicted different pathways.

ME was specified as a second-order construct. Four exploitation-oriented items assessed the improvement of existing management processes, systems, work procedures, and allocation of responsibilities. Five exploration-oriented items assessed the introduction of new management concepts, processes, structures, and methods. Although the retained item codes reflect their management-innovation source dimensions, the higher-order construct was defined before data collection as perceived management efficiency: improvement and renewal of managerial practices rather than objective technical efficiency. Table 2 reports the two dimensions as ‘exploitative ME’ and ‘exploratory ME’; the Appendix provides the correspondence between these labels and the item codes retained from the wider study.

SP was specified as a second-order construct with three four-item dimensions. Economic performance items concerned perceived operational and resource-related outcomes and the museum’s contribution to the local economy. Social performance items concerned public welfare, cultural and educational access, audience response, institutional image, and cultural continuity. Environmental performance items concerned perceived resource use, waste, environmental management, and responsible operation. These were employee assessments rather than audited financial, visitor, energy, or emissions records. Construct definitions and the measurement structure are summarised in Table 1, and the full questionnaire is provided in the Appendix.

Table 1 Constructs and measurement structure		
Construct	Items	Operational meaning in this study
Digital efficiency capability (DIC)	5	Capacity to develop digitally enabled products, services, process improvements, value propositions, and audience experiences
Digital operational capability (DOC)	5	Integration of digital resources into routine operational work: using digital information for market positioning analysis, optimising processes and resource allocation, marketing and audience services, real-time monitoring and adjustment, and decision support
Digital dynamic capability (DDC)	7	Capacity to sense change and potential digital contexts, establish a long-term digital vision, seize opportunities, learn, reconfigure digital resources, and build new digital ecosystems
Management efficiency (ME)	9	Higher-order staff-reported construct combining exploitation-oriented improvement and exploration-oriented renewal of management practices
Sustainable development performance (SP)	12	Higher-order staff-reported construct combining economic, social, and environmental performance

3.4 Analytical strategy

SPSS 26.0 was used for screening, descriptive statistics, reliability analysis, and exploratory procedures. AMOS 24.0 was used for confirmatory factor analysis and structural equation modelling. The measurement model evaluated factor loadings, composite reliability (CR), average variance extracted (AVE), and discriminant validity. CR values above .70 and AVE values above .50 were used as reference criteria, while the square root of AVE was compared with inter-construct correlations (Fornell and Larcker 1981; Hair et al. 2019). Model fit was assessed jointly using χ^2/df , RMSEA, GFI, AGFI, and NFI rather than by relying on a single index.

Structural equation modelling was selected because the specified model contained multiple latent constructs, second-order factors, simultaneous structural paths, and mediated effects. Direct paths were assessed with standardised estimates and p values. All hypothesis tests were two-tailed and used an alpha level of .05. Indirect effects were evaluated through maximum-likelihood bootstrap estimation with 5,000 resamples and 95% confidence intervals. An indirect effect was treated as statistically significant when its confidence interval excluded zero (Hayes 2018; Preacher and Hayes 2008). Full and partial mediation describe statistical patterns in the specified model: full mediation denotes a significant indirect effect with a non-significant remaining direct effect, whereas partial mediation denotes significant indirect and direct effects. These labels do not establish temporal causation in cross-sectional data.

All major constructs were measured in the same questionnaire at one point in time. Procedural safeguards included anonymous participation, confidentiality assurances, clear instructions, and separation of construct blocks. No Harman single-factor test or common latent factor model was conducted. Common method variance therefore remains a possible influence and is not claimed to be absent (Podsakoff et al. 2003; Podsakoff et al. 2012). In addition, multiple employees could respond from the same museum. The reported single-level SEM did not estimate intraclass correlations, cluster-robust standard errors, or a multilevel model. These design features are addressed directly in the interpretation and limitations.

3.5 Ethical procedures

Respondents were informed of the study purpose, intended academic use of the data, confidentiality arrangements, and their right to decline or discontinue participation. Participation was voluntary, questionnaires were anonymous, and results were reported in aggregate. Sensitive personal questions were avoided, and access to the collected data was restricted.

4 Results

4.1 Measurement model

The complete measurement model for the full survey produced $\chi^2/df = 1.087$, RMSEA = .016, GFI = .905, AGFI = .907, and NFI = .924. These values indicated acceptable fit for the specified measurement structure. For the focal constructs, standardised factor loadings ranged from .719 to .853 for the three

digital capabilities, from .727 to .826 for the two management-efficiency dimensions, and from .757 to .818 for the three sustainability-performance dimensions. CR values ranged from .853 to .914 and AVE values ranged from .577 to .635. The reported inter-construct correlations were below the corresponding square roots of AVE, supporting discriminant validity within the sample. These diagnostics support interpretation of the specified constructs but do not eliminate all measurement overlap or common method variance.

Table 2
Reliability and convergent validity of focal measurement dimensions

Construct	Items	Standardised loadings	AVE	CR
DIC	5	.719–.846	.598	.881
DOC	5	.722–.853	.609	.886
DDC	7	.761–.806	.603	.914
Exploitative ME	4	.733–.826	.604	.859
Exploratory ME	5	.727–.771	.577	.872
Economic performance	4	.768–.796	.617	.866
Social performance	4	.757–.791	.593	.853
Environmental performance	4	.781–.818	.635	.875
Note. AVE = average variance extracted; CR = composite reliability. Values are reproduced from the formal-sample measurement analysis.				

4.2 Structural model and direct associations

The structural model produced $\chi^2/df = 1.103$, RMSEA = .018, GFI = .897, AGFI = .902, and NFI = .900. GFI was marginally below the conventional .900 reference, whereas the remaining reported indices met the stated benchmarks. Considered jointly, the indices indicated acceptable overall fit with one boundary indicator.

The direct capability–performance results were differentiated. DIC was not significantly associated with SP ($\beta = .054$, $p = .431$), so H1a was not supported. DOC showed a significant positive association with SP ($\beta = .184$, $p = .013$), supporting H1b. DDC also showed a significant positive association with SP ($\beta = .166$, $p = .019$), supporting H1c.

All three capabilities were positively associated with ME. The DIC–ME path was significant ($\beta = .221$, $p = .002$), supporting H2a. DOC showed the largest capability-to-ME coefficient ($\beta = .240$, $p = .002$), supporting H2b. DDC was also positively associated with ME ($\beta = .179$, $p = .015$), supporting H2c. Finally, ME was positively associated with SP ($\beta = .448$, $p < .001$), supporting H3. This was the largest structural coefficient in the model.

Table 3
Structural paths

Hypothesis	Path	β	SE	CR	p	Decision
H1a	DIC $\rightarrow$ SP	.054	.057	.788	.431	Not supported
H1b	DOC $\rightarrow$ SP	.184	.055	2.472	.013	Supported
H1c	DDC $\rightarrow$ SP	.166	.063	2.348	.019	Supported
H2a	DIC $\rightarrow$ ME	.221	.062	3.055	.002	Supported
H2b	DOC $\rightarrow$ ME	.240	.059	3.145	.002	Supported
H2c	DDC $\rightarrow$ ME	.179	.067	2.439	.015	Supported
H3	ME $\rightarrow$ SP	.448	.093	4.642	< .001	Supported
<i>Note.</i> β = standardised estimate; SE = standard error; CR = critical ratio. DIC = digital efficiency capability; DOC = digital operational capability; DDC = digital dynamic capability; ME = management efficiency; SP = sustainable development performance.						

4.3 Indirect effects

The DIC indirect effect through ME was .082, with a 95% bootstrap confidence interval of [.023, .166] and $p = .007$. The corresponding direct effect in the bootstrap decomposition was .045 ($p = .375$), with a confidence interval that included zero. This pattern was consistent with full statistical mediation and supported H4a.

The DOC indirect effect through ME was .080, with a 95% bootstrap confidence interval of [.023, .158] and $p = .009$. The remaining direct effect was .136 ($p = .018$). Both paths were significant, producing a pattern consistent with partial mediation and supporting H4b. The DDC indirect effect through ME was .071, with a 95% bootstrap confidence interval of [.010, .152] and $p = .022$. Its direct effect remained significant at .147 ($p = .021$), indicating partial mediation and supporting H4c.

The findings therefore show three related but non-identical pathways. DIC was connected with SP through ME without a significant remaining direct path. DOC and DDC were connected with SP both directly and indirectly through ME.

Table 4
Bootstrap decomposition of capability effects on sustainable performance through management efficiency

Hypothesis	Capability	Effect type	Effect	Boot SE	95% CI	p	Pattern
H4a	DIC	Total	.127	.057	[.027, .252]	.013	
H4a	DIC	Direct	.045	.054	[-.057, .155]	.375	Full mediation
H4a	DIC	Indirect	.082	.035	[.023, .166]	.007	
H4b	DOC	Total	.216	.051	[.117, .320]	< .001	
H4b	DOC	Direct	.136	.055	[.023, .246]	.018	Partial mediation
H4b	DOC	Indirect	.080	.034	[.023, .158]	.009	
H4c	DDC	Total	.218	.061	[.104, .344]	.001	
H4c	DDC	Direct	.147	.065	[.022, .280]	.021	Partial mediation
H4c	DDC	Indirect	.071	.036	[.010, .152]	.022	
Note. Bootstrap estimates are based on 5,000 resamples. CI = confidence interval. Mediation labels describe the statistical pattern in this cross-sectional model and do not establish temporal causation.							

5 Discussion

5.1 Digital capability is not a uniform predictor

The central finding is that digital capability should not be treated as one homogeneous organisational condition. DOC and DDC retained significant positive direct associations with perceived sustainable development performance, whereas DIC did not. The difference is theoretically meaningful. Operational capability concerns whether digital systems are embedded in recurring work. When information, communication, service delivery, and monitoring are integrated into daily routines, staff may observe an immediate relationship with the continuity and quality of organisational performance. Dynamic capability concerns how a museum recognises change and reorganises resources. Its direct association is consistent with the value of adaptation in environments shaped by technological development, changing audience expectations, and evolving public-service demands (Teece 2007; Warner and Wäger 2019).

The non-significant DIC direct path does not mean that efficiency-oriented digital development is irrelevant. DIC remained positively associated with ME, and its indirect association with SP was significant. The result instead suggests that digitally enabled products, services, or process ideas do not automatically become institution-wide sustainable outcomes. In resource-constrained museums, an initiative may remain isolated unless responsibilities, coordination, and managerial routines change around it. This interpretation aligns with digital-transformation research that rejects a technology-only explanation of value creation (Khin and Ho 2019; Verhoef et al. 2021; Vial 2019).

The differentiated pattern also clarifies why studies based on broad digitalisation indices can produce inconsistent results. Aggregation combines capabilities that may operate at different organisational distances from performance. Routine operational integration and adaptive reconfiguration can retain direct associations, while efficiency-oriented development can depend more strongly on an internal organisational mechanism. The empirical separation of DIC, DOC, and DDC therefore adds explanatory precision to museum digitalisation research.

5.2 Management efficiency is the principal organisational bridge

ME had the largest structural association with SP and mediated each capability–performance relationship. This result supports a process view of digital transformation. Digital resources supply information, connectivity, and technical possibilities, but management practices determine how these possibilities enter decisions, roles, and services. Exploitation-oriented practices refine existing systems and coordination; exploration-oriented practices create room for new approaches and structures. Both are relevant when museums must maintain reliable public services while experimenting with digital forms of access and engagement.

The full-mediation pattern for DIC is particularly informative. Efficiency-oriented digital capability may generate potential improvements, but those improvements appear in reported performance only when translated through management practices in the specified model. By contrast, the partial mediation patterns for DOC and DDC imply dual routes. Operational capability can be associated with performance through execution while also supporting management coordination. Dynamic capability can be associated with adaptation while also stimulating managerial renewal. Similar process arguments appear in research linking digital transformation, organisational innovation, and sustainable performance, although sector and construct differences prevent claims of exact replication (Costa Melo et al. 2023; Xu et al. 2023).

The finding also sharpens the meaning of ME. It should not be presented as an audited efficiency ratio or as verified cost savings. It captures staff perceptions of how existing management practices are improved and how new practices are explored. Its contribution lies in modelling an internal organisational mechanism that is often omitted when digitalisation is represented by technology adoption alone.

5.3 Theoretical contributions

First, the study extends capability reasoning to county-level cultural institutions. The setting matters because public cultural organisations combine preservation and educational responsibilities with operational constraints and non-financial objectives. Evidence from large firms or national institutions cannot simply be assumed to apply to them. By examining 78 participating county-level museums, the study shows how capability theory can be used without reducing museum performance to commercial outcomes.

Second, the study demonstrates that capability heterogeneity exists within digital transformation. DIC, DOC, and DDC were empirically distinguishable and showed different structural relationships. This result develops the distinction between digital technology and digital capability (Khin and Ho 2019) and complements process accounts of strategic renewal (Warner and Wäger 2019). The theoretical implication is not merely that capabilities matter, but that the type of capability determines the pathway through which it is associated with performance.

Third, the study specifies management practices as a transmission mechanism. Digital-transformation literature commonly notes the importance of complementary organisational conditions, but empirical models can leave those conditions as broad contextual statements. Modelling ME as a mediator gives the conversion process a testable position. The results suggest a capability–management–performance sequence in which internal refinement and renewal are central, particularly for DIC.

Fourth, the study treats sustainable performance as multidimensional. Economic, social, and environmental responsibilities are combined in the higher-order SP construct, reflecting the institutional mission of museums more adequately than a single financial or attendance indicator. This choice connects digital capability with the broader public-value and sustainability literature while recognising that the survey measures perceptions rather than objective outcomes (Orea-Giner et al. 2021; Ross Nelson et al. 2022; San-Jose et al. 2023).

5.4 Practical implications

Museum managers should distinguish acquisition from capability building. Purchasing software, scanning collections, or launching a platform may be necessary, but these actions do not ensure that digital resources are integrated into work. Investment plans should specify who uses the system, how information moves between functions, how decisions change, and how outcomes will be reviewed. This is especially important for DIC, whose relationship with SP was transmitted through ME in the estimated model.

Operational integration deserves priority. The significant DOC paths suggest that digital value becomes more visible when technology supports recurring processes such as collection information, communication, audience services, coordination, and monitoring. Managers should therefore assess

whether digital projects reduce fragmentation between departments and whether staff can use the resulting information in routine decisions.

Museums should also develop adaptive capacity rather than treating transformation as a completed installation. DDC requires attention to technological developments, audience feedback, policy change, learning, and resource reconfiguration. Small institutions may not be able to maintain every specialist capability internally, but they can establish shared training, inter-museum collaboration, external technical partnerships, and periodic review of digital priorities.

Finally, management improvement should accompany every major digital initiative. Existing procedures may need refinement, while some projects require new roles, cross-functional teams, or decision rules. The evidence does not justify indiscriminate restructuring; it supports deliberate alignment between digital capability and managerial practice. Performance monitoring should include social and environmental outcomes alongside operational or economic indicators.

5.5 Limitations and future research

Several limitations define the scope of the conclusions. First, the design is cross-sectional. The structural directions follow the theoretical model, but temporal precedence was not observed. Significant direct and indirect effects therefore represent associations in the specified model rather than demonstrated causal processes. Longitudinal, time-lagged, or intervention-based research could examine whether capability changes precede changes in management practices and performance.

Second, all focal variables were measured through one staff questionnaire. Procedural safeguards were used, but no statistical common-method diagnostic was reported. Common method variance, consistency motives, and social desirability may have influenced covariance among the constructs. Future studies should combine staff surveys with digital-system logs, administrative records, visitor evidence, energy use, financial data, or independently assessed social outcomes.

Third, respondents were nested within 78 museums. The single-level model treated employees as observations and did not estimate intraclass correlations, cluster-robust standard errors, or a multilevel structure. Standard errors may therefore be sensitive to unmodelled within-museum dependence. Future research should retain anonymous museum identifiers, obtain sufficient observations at both levels, and compare individual- and museum-level relationships through multilevel modelling.

Fourth, contact-based access and voluntary response limit probability representativeness. The participating institutions covered ten city strata and multiple staff roles, but the sample should not be treated as a simple random sample of every county-level museum employee in Shaanxi or China. Replication across provinces, museum types, and governance arrangements is needed.

Fifth, ME is a perceptual construct operationalised through exploitation-oriented and exploration-oriented management practices. The label should not be interpreted as objective input–output efficiency. Future work could compare this construct with audited operating indicators, management-innovation measures,

organisational agility, and learning capability. Measurement invariance across employee roles and museum grades should also be assessed before subgroup comparisons are made.

6 Conclusion

Digital transformation in museums is not a single technological condition with a uniform performance effect. Among staff from county-level museums in Shaanxi, operational and dynamic digital capabilities were directly associated with perceived sustainable development performance, while digital efficiency capability was associated with performance through management efficiency. All three capabilities were related to management efficiency, and management efficiency had the strongest structural association with performance. The results identify distinct capability pathways and place organisational practice at the centre of digital value creation. They also caution against equating technology acquisition with sustainable transformation. The evidence supports a capability–management–performance account, but causal, museum-level, and province-wide claims require stronger longitudinal, multi-source, and multilevel designs.

Declarations

Author Contribution

The authors' identities are redacted for double-anonymised review. The two authors jointly contributed to conceptualisation, methodology, investigation, formal analysis, writing—original draft, and writing—review and editing, and both read and approved the final manuscript.

Data Availability

The de-identified dataset and analysis files generated and analysed during the current study are not publicly available because the participant consent process did not specify unrestricted public release and the responses are clustered within a relatively small group of potentially identifiable institutions. The materials are available from the corresponding author on reasonable request, including for editorial and peer-review purposes, subject to appropriate safeguards for participant and institutional confidentiality.

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