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UNLOCKING DIGITAL MATURITY IN MUSEUMS: EMPIRICAL INSIGHTS FROM ITALY'S CULTURAL SECTOR

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Unlocking Digital Maturity in Museums: Empirical Insights from Italy's Cultural Sector

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Abstract

This study examines what drives digitisation in museums and cultural institutions using the Technological, Organisational, Environmental (TOE) framework. Drawing on data from the 2023 nationwide ISTAT survey of Italian museums, it analyses how internal capabilities and external conditions influence digital adoption. Two logistic regression models identify key determinants of digitisation for both displayed and stored collections. Results show that technological readiness, especially Wi-Fi availability, social media use, and the uptake of digital tools, strongly promotes digitisation. Organisational enablers such as public funding, staff training, institutional type, and visitor volume also play important roles, while partnerships and networks support digital engagement through cooperation and resource sharing. The findings additionally underscore the importance of sustained staff training and collaborative funding schemes, which help build digital competencies and support larger-scale projects across institutions. Overall, digitisation emerges as a systemic process shaped by infrastructure, human resources, and institutional relationships.

Keywords: Digitisation, Digitalisation, Museums, Digital Technologies
JEL classification: Z30, Z38, L83, L86

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Introduction

Rapid advancements in digital technologies (DT) and societal expectations in the characteristics of the information age are leading to a profound transformation of museums through the use of DT (Lunardo & Ponsignon, 2020). This transition enables boosting visitor engagement, facilitates broader access to collections, expands the scope of research, and implements more effective knowledge preservation strategies in light of the increasing security demands associated with physical assets (Guarino et al., 2020; Liao et al., 2020; Vaz & Veiga, 2017). The literature highlights the systematic integration of DT into four key domains, including collection, research, exhibition, and knowledge, which defines the ongoing digital transformation within museums (Wu et al., 2025). Moreover, the literature also demonstrates digitalisation in museums and common institutions primarily through the adoption of specific technologies, including Virtual Reality (VR) (Verhulst et al., 2021), Augmented Reality (AR) (Verhulst et al., 2021; Torres-Ruiz et al., 2020; Baker et al., 2020), Mixed Reality (MR) (Hammady et al., 2020; Sø rensen & Hansen, 2017), 3D Printing (Rossetti et al., 2018; Rener, 2017; Choi & Choi, 2014), Internet of Things (IoT) (Centorrino et al., 2021; Puddu et al., 2021; Usuda-Sato et al., 2019), Haptic Feedback (HP) (Pistofidis et al., 2023; Pistofidis et al., 2021; Vaz & Veiga 2018; Vi et al., 2017), Social Media (SM) (Centorrino et al., 2021; Budge & Burness, 2017; Borràs et al., 2014), Artificial Intelligence (AI) (Fararni et al., 2021; Renjith et al., 2020).

The COVID-19 period was a game-changer for museums, as they had no choice but to shift their activities to digital platforms in order to remain accessible to the public (Chu & Chiu, 2023; Noehrer et al., 2021; Markopoulos et al., 2021). In this regard, digital museums (DM) have become increasingly popular (Giannini & Bowen, 2022; King et al., 2021; Agostino et al., 2020). Compared to non-digitalised museums, they enable tourists to experience culture from a distance and at any time (Choi & Choi, 2014). Moreover, they progressively prioritise technology-driven, entertainment-based, and personalised practices (Lunardo & Ponsignon, 2020; Mirghadr et al., 2018), which require a comprehensive digital strategy (Samaroudi et al., 2020).

The literature reveals a predominant emphasis on specific technologies or DM, with most studies remaining qualitative and offering limited quantitative evidence. Moreover, the drivers of digitalisation in museums remain underexplored. To address this gap, the present study investigates these drivers by examining two dimensions: the digitisation of stored items and the digitisation of objects displayed to the public. Considering both allows for a comprehensive understanding of how digital strategies are implemented across museum collections and how they support broader goals such as accessibility, preservation, and visitor engagement. This study adopts the Technological, Organisational, and Environmental (TOE) framework, which integrates technological, organisational, and environmental factors. The empirical analysis uses data from the 2023 survey "Museums, Archaeological Areas and Parks, Monuments and Monumental Complexes," conducted by the Italian National Institute of Statistics (ISTAT), and employs logistic regression modelling. The results show that TOE factors jointly shape digitisation in museums. Technological variables such as Wi-Fi availability, SM use, and digital tool adoption significantly enhance digital maturity, while online ticketing shows no effect. Organisational enablers, including public funding, staff training, institutional type, and visitor volume, are strong predictors, whereas ownership structure is not.

Environmental factors, particularly partnerships and networking, further support digital development. These findings confirm the multidimensional nature of museum digitalisation and the value of the TOE framework in explaining how internal capacities and external collaborations drive progress.

The paper proceeds as follows: after the introduction, a review of DT and the digitalisation process is presented alongside the research hypotheses; the dataset and methodology are then described, the empirical findings follow, and the paper concludes with implications, limitations and future study recommendations.

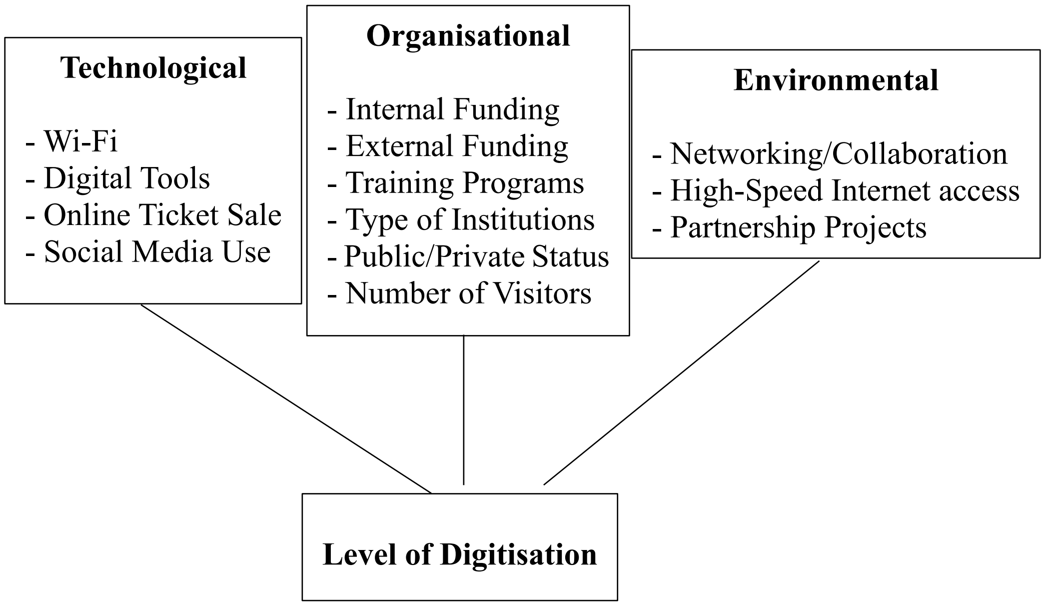
Literature Review and Research Framework

Studying museums is essential, as they offer platforms for cultural dialogue and play a key role in shaping regional cultural identities (Wu et al., 2025). Moreover, engaging in museum tourism can advance the process of identity formation by fostering national awareness (Zou et al., 2022), a concept also applicable to domestic tourism. Most importantly, they promote cultural heritage and diplomacy (Panzera, 2022; Grincheva, 2022). The literature also highlights other vital perspectives, such as their impact on urban development by attracting businesses and investments (Beccherle, 2023). In this regard, they serve as a source of local economic growth (Sacco et al., 2018).

The literature on DT underscores the pivotal role of technology within museums. Technologies now enable personalised educational journeys, multi-sensory interactions, and greater opportunities for visitor participation, all of which contribute to a heightened sense of virtual presence and increased satisfaction (Kamariotou et al., 2021). By adopting this process, museums have fundamentally altered how visitors experience and interact with cultural heritage (Lunardo & Ponsignon, 2019; Hashim et al., 2014), and it advances cultural learning opportunities (Petrelli, 2019; Bekele & Champion, 2019). Previous studies also illustrate that DT create a strong bond between tourists and museums (Fernandez-Lores et al., 2022), as it enables museums to effectively engage and educate a wide range of audiences (Comes et al., 2020).

As previously mentioned, the literature largely focuses either on specific technologies or on DM, with most studies relying on qualitative methods and offering limited quantitative evidence. Furthermore, the factors driving digitalisation in museums remain underexplored. Therefore, in this study, we explore factors such as education, funding, networking, SM, type and entity of the institution, high-speed internet, Wi-Fi, and digital tools. This research builds on the TOE framework as it encompasses not only technological factors but also considers organisational and environmental influences (see Figure 1). Moreover, multi-dimensional frameworks are generally more analytically effective than those that focus solely on a single aspect (Molla & Licker, 2005). Additionally, this framework adopts a dynamic perspective, acknowledging that organisational changes are influenced by both internal factors and the specific attributes of the organisation itself (Abdurrahman et al., 2024).

Figure 1. Technological, Organisational, Environmental model.



From a technological perspective, the literature highlights that free Wi-Fi offers museums far more than visitor connectivity. Wi-Fi networks enable valuable data collection, allowing institutions to monitor visitor flows, analyse spatial patterns, and better understand onsite behaviour (Jiang et al., 2022). Such insights support improved exhibition layouts, crowd management, and service personalisation. Digital technologies like Wi-Fi have therefore become essential resources for day-to-day operations and broader innovation strategies (Taormina & Baraldi, 2022).

Digital tools also help museums integrate traditional in-person experiences with digital interactions (Debono, 2021). The accelerated digital shift during the COVID-19 pandemic further demonstrated technology's importance, as museums expanded virtual exhibitions, online events, and interactive platforms to remain accessible (Giannini & Bowen, 2022). By adopting these tools, museums broaden access, personalise experiences, and enhance visitor engagement, strengthening both educational and cultural missions (Furferi et al., 2024).

SM platforms play an equally significant role. They help cultivate visitor loyalty and generate economic support (Zollo et al., 2021), while enabling museums to reach diverse audiences, build online communities, and share collections effectively (Budge & Burness, 2017). SM also offers tools for monitoring public opinion and responding quickly to feedback, contributing to continual improvements in service quality and visitor experience (Centorrino et al., 2021; Borràs et al., 2014).

With respect to the technological aspect, the following hypotheses are postulated in our analysis:

- H1: Museums with free public Wi-Fi are more likely to offer digital experiences to visitors.
- H2: Museums that use digital tools tend to digitalise more.
- H3: Museums with online ticket sales tend to digitalise more.
- H4: Museums that are active on SM platforms tend to digitalise more.

From an organisational perspective, museums increasingly view digitalisation as essential for maintaining relevance, yet they continue to face substantial barriers, especially persistent financial constraints (De Bernardi et al., 2019). Funding remains one of the most critical enablers of digital innovation strategies (Xu et al., 2024), supporting goals such as enhancing engagement, diversifying audiences, reducing operational costs, and responding to competitive pressures. Despite this, limited financial resources consistently appear as the main obstacle to adopting and implementing digital tools (Raimo et al., 2021). External funding consequently plays a pivotal role. Grants such as those from the U.S. National Science Foundation have contributed to progress in digitising collections (Rogers, 2016), though the scale and long-term sustainability of such initiatives remain restricted by overall resource limitations.

Institutional type also influences digitalisation. Both museums and archaeological parks benefit from developing a digital presence, with virtual tours and online engagement improving visitor ratings and enriching the overall experience (Gálicz et al., 2024). Remaining relevant requires balancing digital innovation with safeguarding cultural and historical value, enabling institutions to expand audiences while maintaining their role as cultural stewards (Massari et al., 2022). Ownership status introduces additional challenges, public museums confront, stricter regulations that complicate the transition to digital platforms (Dalle & Murzyn-Kupisz, 2024), whereas private museums generally have greater flexibility to pursue technological and functional innovation more rapidly (Li et al., 2023; Cavalieri et al., 2023).

The relationship between digitalisation and visitor experience is also well-established. Integrating advanced technologies and cultural attributes enhances engagement and strengthens museums' educational missions (Wang & Meng, 2023; Yap et al., 2024). A visitor-oriented approach further mediates successful digital transformation by linking communication practices, innovation processes, and strategic priorities (Stelmaszczyk et al., 2024).

As museum practices evolve, digital competencies have become increasingly important for professionals (Giannini & Bowen, 2019). Staff education and training thus remain central determinants of an institution's capability to adopt and sustain technological change. Targeted training programs play a crucial role in equipping employees with the skills needed to implement and maintain digital initiatives, making human capital development a key driver of museum digitalisation (Mammadov et al., 2024; Romero & Mammadov, 2023).

Therefore, concerning the organisational aspect, the following hypotheses are postulated:

- H5: Museums that use internal financial resources tend to digitalise more.
- H6: Museums that use external financial resources tend to digitalise more.
- H7: Museums digitalise more than other types of cultural institutions.
- H8: Private museums tend to digitalise more than public museums.
- H9: Museums that offer training programs for their staff tend to digitalise more.
- H10: Museums with a higher number of visitors tend to digitalise more.

From an environmental perspective, the literature highlights that access to high-speed internet is a crucial enabler for museums aiming to diversify and expand their programming. With robust internet connectivity, museums can develop and deliver a wide range of online and blended experiences, including virtual tours, live-streamed events, interactive workshops, and digital exhibitions. These offerings not only allow museums to reach audiences beyond their physical location, including international visitors and those unable to travel, but also enhance engagement with existing visitors (Moore, 2015). Apart from high-speed internet access, the literature has also examined the advantages of networking for museums. Museums frequently participate in active knowledge exchange and collaborative efforts with other institutions and specialists, particularly in the realm of preservation techniques. This ongoing interaction reflects a widespread recognition within the digital conservation community of the importance of sharing expertise, methodologies, and best practices to advance the field collectively (Aristidou & Stylianou-Lambert, 2024). Furthermore, collaborative partnerships that involve museum professionals, artists, and private technology companies have proven especially valuable. Such alliances not only foster the dissemination of knowledge and innovative ideas but also accelerate the adoption and integration of emerging technologies within museum settings. By working together across institutional and disciplinary boundaries, these stakeholders can pool resources, address common challenges, and drive forward the digital transformation of cultural heritage institutions (Aristidou & Stylianou-Lambert, 2024; Ensom & McConchie, 2021b).

With respect to the environmental aspect, the following hypotheses are postulated:

- H11: Museums with access to high-speed internet in their region tend to digitalise more.
- H12: Museums that participate in networking are more likely to digitalise.
- H13: Museums that implement formal collaboration and partnership projects with other local cultural institutions are more likely to digitalise.

Data and Methodology

This section outlines the data used in this study before proceeding to the econometric methodology adopted.

Data and Variables

The analysis uses data principally from the national census survey on museums and other cultural institutions, jointly conducted by the ISTAT, the Ministry for Cultural Heritage and Activities and Tourism, and the Regions and Autonomous Provinces. The dataset encompasses over 4,500 institutions spread across the country. Collected information characterises institutions by type of collection (museums, galleries, archaeological sites and parks, monuments and historic buildings), size, governance and management model, and the range of activities and services offered. Many institutions in the sample are relatively recent, and the dataset therefore reflects substantial heterogeneity in institutional form, scope and regional distribution. Data were collected in the second quarter of 2023 (from the end of March to the end of June) through questionnaires filled out by the heads of each unit on the source list. They covered all public and private, state and non-state institutions of different types and sizes that were open to the public in the year 2022, as long as they had a regulated and organised mode of use. In the fieldwork, a response rate of 91.1% was obtained. We also have a variable called Quality_of_Services, representing high-speed internet access in the region in 2022, retrieved from I.STAT, the online database of ISTAT.

The final dataset used for this analysis comprises 3228 observations. The empirical model considers two dependent variables that capture two different dimensions of digitisation: the extent to which goods on public display and those held in storage have been digitised, coded as "No," "Not Yet," "Partially Yes," or "Entirely Yes." Explanatory variables cover three dimensions. The *technological dimension* encompasses the availability of free Wi-Fi, online ticketing services, SM accounts, and digital tools, including apps, interactive screens, multimedia aids, QR codes, and tablets. The organisational dimension encompasses funding sources (private and public), staff training programs, the type of institution, ownership (public or private), and the number of visitors. The environmental dimension considers whether the institution participates in museum networks or integrated cultural systems. Below is a detailed description of the variables and the related survey question.

A. Dependent Variables

- *Goods on public display (DIGITALIZZ1)* and *Goods held in storage (DIGITALIZZ2)*. These two distinct ordinal variables are based on the following question: By 3a1 December 2022, had the Museum/Institute digitised its holdings and/or collections? Answer "Yes" if the museum/institution has digitised the immovable and/or movable assets at its disposal by means of a digital inventory (example: a list on digital media in which the assets are recorded with their identification and numbering). The answers were coded as binary: "Yes/ Partially Yes" →"Yes" (1) and "No/Not Yet"→ "NO" (0).

B. Explanatory Variables

i) Technological Dimension

- *Wi-fi (WIFI).* This binary variable takes the value 1 if in 2022, a museum/institution has free Wi-fi available to the public (2 otherwise).

- *Digital Tools (Digit_tools).* This explanatory variable is a combination of a set of five binary questions (yes=1, no=2), and these questions capture in 2022, whether the museum/institution has and makes available to the public. Therefore, this dummy variable takes the value 1 if at least one of the variables support1-support5 takes the value 1:

a) Smartphone and tablet applications *(SUPPORT1).*

b) Video and/or touch screen *(SUPPORT2).*

c) Multimedia aids (interactive displays, VR, AR) *(SUPPORT3).*

d) QR Code and/or proximity systems *(SUPPORT4).*

e) Tablets available to the public *(SUPPORT5).*

- *Online Ticket Service (WEB1).* This binary variable takes the value 1 if in 2022, the museum/institution had the online ticketing service, including booking visits and purchasing tickets (2 otherwise).

- *Social Media Accounts (WEB2).* This binary variable takes the value 1 if in 2022, the museum/institution had SM accounts such as Facebook, Twitter, YouTube, Instagram, and Pinterest (2 otherwise).

ii) Organisational Dimension

- *Private Funding (FINANZ1*). This binary variable takes the value 1 if the museum/institution receives income through private financing, including contributions, donations, bank loans, company funding, and individual donations (2 otherwise).

- *Public Funding (FINANZ2*). This binary variable takes the value 1 if the museum/ institution receives income through public financing, including ministries, regions, municipalities, and other public administrations (2 otherwise).

- *Training programs (CORSI).* This binary variable takes the value of 1 if, in the last three years (from 2019), the museum/institution staff attended training and/or professional development courses, including online courses (2 otherwise).

- *The type of the institution (CATEGO).* Refer to the object of greatest interest of the exhibition and/or the goods and collections on display, the one considered most relevant for public enjoyment. This categorial variable distinct the three types: "Museums" (includes: museum, gallery and/or collection); "Archaeological Parks" and "Other Institutions" (such as monument or monumental complex, including castle, industrial or archaeological artefact, historic villa, church or building of a religious character).

- *Ownership (PUBBPRIV).* This categorical variable takes the value 1 if the ownership of the museum/institute belongs to a public entity (2 for private).

- *Number of Visitors (TOTVISIT_CAT).* This continuous variable captures the number of visitors and is separated into three parts: "Low", which corresponds to up to 25,000; "Medium", from 25,000 to 50,000; and "High", more than 50,000 visitors.

iii) Environmental Dimension

- *Networking (RETE).* This binary variable takes the value 1 if in 2022, the museum/institution joined any museum networks and/or integrated cultural service systems (2 otherwise).

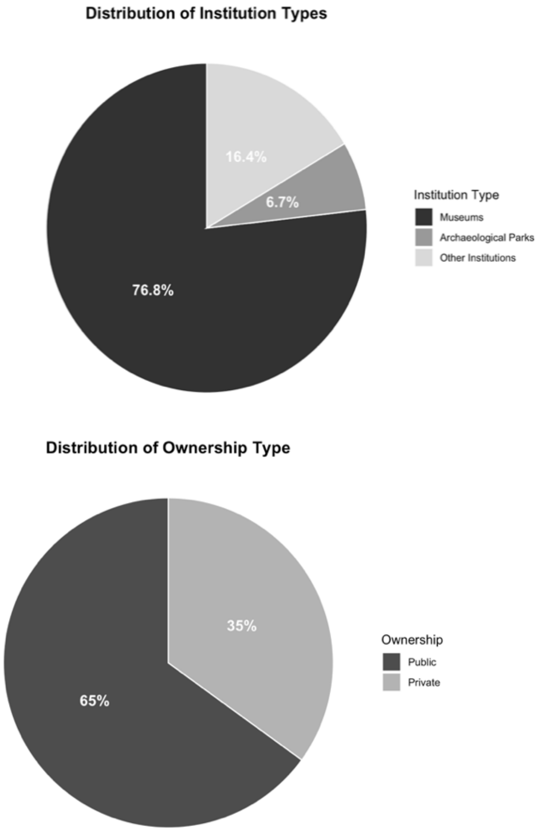
- *High-Speed Internet Access (Quality_of_services).* This continuous variable demonstrates access to high-speed internet within the region.

- *Partnership Projects (PARTNER).* This binary variable takes the value 1 if, in 2022, the museum/institution implemented formal collaboration and partnership projects with other local cultural institutions (2 otherwise).

Descriptive analysis

Figure 2 illustrates the distribution of institutions by type (i.e., Museums, Archaeological Parks, and Other Institutions) and by ownership (either Public or Private). The institutional characteristics indicate that the majority of the sample consists of museums (76.8%), compared to archaeological parks (6.7%) and other institutions (16.4%). Regarding ownership type, most institutions are publicly owned 65%, while private institutions account for 35% of the sample.

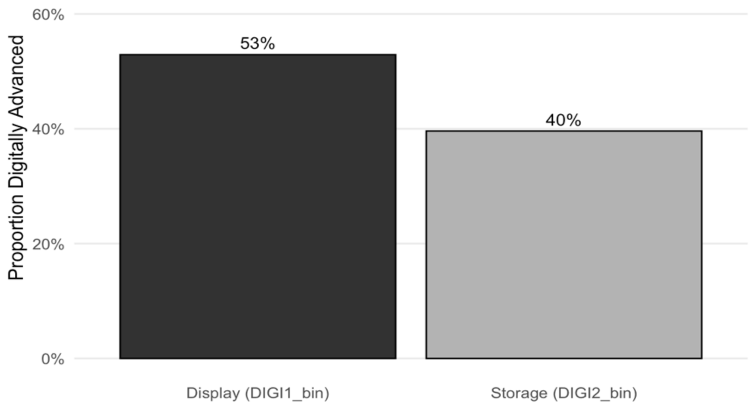
Figure 2. Distribution of Institutions



Source: Authors'eloboration

Figure 3 presents the distribution of digitisation levels for the goods on Display and those in storage, that is, for our two dependent variables. The darker colour represents the digitisation of goods on public display, while the lighter colour refers to the digitisation of goods in storage. The figure illustrates that goods on Display are more digitised than those in storage, at 53% and 40%, respectively. The difference is noticeable, and it might be driven by both supply and demand factors. The empirical analysis aims to investigate the main factors explaining the digitisation of museums and similar institutions with respect to these two different goods.

Figure 2. Distribution of Digitisation Level



Source: Authors'eloboration

Econometric methodology

The probability that cultural institutions digitise their goods on display and storage for a given value of x_j, is given by the following logit model:

$$p = \frac{exp\left(\beta_0 + \sum_j \beta_j x_j\right)}{1 + exp\left(\beta_0 + \sum_j \beta_j x_j\right)} \qquad (2)$$

where p stands for the probability that $y = 1$, where y alternatively represents the digitisation dummies (DIGI1_ and DIGI2_), x_j are the independent variables (explanatory variables), and β_j denotes the regression coefficients $(j = 1 \ldots k)$.

Accordingly, the logistic regression model, estimated using the maximum likelihood method, is specified as follows:

$$\ln\left(\frac{p}{1-p}\right) = z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k \qquad (1)$$

Table 1: Descriptive Statistics

Variable	Description	Mean	Stand. Dev.	Min.	Max.
DIGI1_bin	Binary (yes=1; no=0)	0.529	0.499	0	1
DIGI2_bin	Binary (yes=1; no=0)	0.396	0.489	0	1
WIFI	Binary (yes=1; no=2)	1.59	0.492	1	2
SUPPORT1	Binary (yes=1; no=2)	1.79	0.408	1	2
SUPPORT2	Binary (yes=1; no=2)	1.63	0.482	1	2
SUPPORT3	Binary (yes=1; no=2)	1.76	0.425	1	2
SUPPORT4	Binary (yes=1; no=2)	1.68	0.465	1	2
SUPPORT5	Binary (yes=1; no=2)	1.91	0.288	1	2
WEB1	Binary (yes=1; no=2)	1.76	0.426	1	2
WEB2	Binary (yes=1; no=2)	1.30	0.457	1	2
FINANZ1	Binary (yes=1; no=2)	1.47	0.499	1	2
FINANZ2	Binary (yes=1; no=2)	1.68	0.466	1	2
CORSI	Binary (yes=1; no=2)	1.48	0.500	1	2
CATEGO	Categorial (museums=1; archeological parks=2; others=3)	1.40	0.754	1	3
PUBBPRIV	Categorial (public=1; private=2)	1.35	0.477	1	2
TOTVISIT	Continius	24,782	168,938	0	5,832,996
RETE	Binary (yes=1; no=2)	1.55	0.498	1	2
Quality_of_Services	Continius	48.8	16.9	12.4	86.6
PARTNER	Binary (yes=1; no=2)	1.39	0.488	1	2

Table 1 reports the descriptive statistics for all variables included in the analysis. On average, 52.9% of institutions have achieved digitisation of displays (DIGI1_bin), while 39.6% have digitised their storage collections (DIGI2_bin), indicating moderate levels of digital adoption across the sector. The availability of Wi-Fi is relatively high (mean = 1.59, where 1 = yes), and most institutions report limited digital tools, with SUPPORT variables averaging between 1.6 and 1.9. Regarding digital communication, about 76% of institutions maintain a website (WEB1 = 1.76), and around 30% use SM platforms (WEB2 = 1.30). Access to internal

(FINANZ1 = 1.47) and external (FINANZ2 = 1.68) funding, as well as participation in staff training activities (CORSI = 1.48), shows variation across institutions.

In terms of institutional characteristics, museums represent the majority category (CATEGO mean = 1.40), followed by archaeological parks and other institutions, while most organisations are publicly managed (PUBBPRIV = 1.35). The average annual number of visitors (TOTVISIT) is approximately 24,782, though the large standard deviation indicates substantial variation in visitor volumes. The average service quality score (Quality_of_Services = 48.8) reflects a generally moderate level of perceived quality. About half of the institutions are involved in networks (RETE = 1.55) or partnerships (PARTNER = 1.39).

Results

Models for the two dependent variables, namely the digitisation of goods on display and goods in storage, are estimated separately. Collinearity was not identified as a concern in either model. Table 2 presents the results of the logistic regression analyses examining the determinants of digitisation in cultural institutions for goods on display (Model 1) and for goods in storage (Model 2). Both models are statistically significant and explain a comparable share of variance (Nagelkerke R^2 = 0.276 and 0.272, respectively), based on a total of 3,228 observations. Consistent with the Technological, Organisational, Environmental framework, significant predictors emerge across all three dimensions. Within the technological dimension, Wi-Fi availability and the use of SM (WEB2) are both strongly and positively associated with digitisation for display and storage, suggesting that technological infrastructure and digital communication tools play a crucial role in enabling digital maturity. In contrast, online ticketing (WEB1) is not significant in either model, indicating that transactional digital functions alone do not reflect broader technological advancement. Moreover, the combined adoption of digital tools is highly significant, reinforcing the importance of comprehensive technological engagement.

Within the organisational dimension, private funding (FINANZ1) is significant only for display, whereas public funding (FINANZ2) contributes positively to both forms of digitisation. Staff training (CORSI) demonstrates a strong and consistent positive effect, highlighting the fundamental role of human capital development in sustaining digital transformation. Conversely, ownership structure (PUBBPRIV) shows no significant influence, suggesting that public and private institutions face similar challenges in digital adoption.

Furthermore, the environmental dimension underscores the role of institutional context and external relationships. Institutional type (CATEGO) is strongly significant, with archaeological parks and other heritage institutions being considerably less likely than museums to undertake digitisation. Visitor volume exerts a positive and significant effect in both models, while its quadratic term (TOTVISIT_CAT.Q) is not significant, suggesting a linear relationship between audience size and digital engagement. The quality of services (Quality_of_Services) is positively associated with both outcomes, confirming that service excellence aligns with higher levels of digitalisation. Networking (RETE) shows marginal significance only for storage, whereas partnerships (PARTNER) are consistently significant across both models, underlining the importance of external collaboration in fostering digital development.

Table 2. Logistic Regression for Models 1 and 2

Variable	Model 1 (Display) β	SE	p value	Sig	Model 2 (Storage) β	SE	p value	Sig
(Intercept)	-1.642	0.188	0.000	***	-2.255	0.198	0.000	***
Technological dimension								
WIFI	0.202	0.086	0.019	*	0.228	0.087	0.009	***
WEB1	-0.115	0.104	0.268		0.077	0.102	0.450	
WEB2	0.457	0.100	0.000	***	0.492	0.111	0.000	***
Digit tools combined	0.227	0.034	0.000	***	0.156	0.033	0.000	***
Organizational dimension								
FINANZ1	0.305	0.089	0.001	***	0.145	0.092	0.115	
FINANZ2	0.465	0.098	0.000	***	0.560	0.096	0.000	***
CORSI	0.650	0.092	0.000	***	0.642	0.094	0.000	***
PUBBPRIV Private	0.017	0.094	0.854		0.017	0.096	0.858	
CATEGO Archaeological Parks	-1.240	0.163	0.000	***	-0.925	0.174	0.000	***
CATEGO Other Institutions	-0.924	0.114	0.000	***	-1.081	0.127	0.000	***
TOTVISIT_CAT (L)	0.382	0.125	0.002	***	0.500	0.120	0.000	***
TOTVISIT_CAT (Q)	0.124	0.152	0.417		0.096	0.147	0.516	
Environmental dimension								
RETE	0.135	0.086	0.118		0.166	0.087	0.057	*
Quality of Services	0.012	0.002	0.000	***	0.012	0.003	0.000	***
PARTNER	0.306	0.092	0.001	***	0.395	0.098	0.000	***

*** $p<0.01$. ** $p<0.05$. * $p<0.1$. Number of observations=3228. Model 1: Nagelkerke R-squared = 0.276. Chi-square = 749.883 (***). Model 2: Nagelkerke R-squared = 0.272. Chi-square = 723.150 (***).

Discussion

The findings highlight the central role of technological factors in advancing museum digitalisation, confirming the literature that positions technology as a key driver of visitor engagement and institutional development. Wi-Fi availability shows a strong positive relationship with both forms of digitisation, supporting H1 and reinforcing the view that free public Wi-Fi functions not only as a connectivity tool but as an essential infrastructure for data-driven management and innovation (Jiang et al., 2022; Taormina & Baraldi, 2022). The significance of the Digital Tools composite variable further supports H2, demonstrating that museums benefit most when they adopt a broad set of visitor-oriented technologies rather than isolated tools. This aligns with studies emphasising that mobile applications, touchscreens, multimedia systems, QR codes, and tablets create integrated digital environments that enhance accessibility, interactivity, and the blending of physical and virtual experiences (Debono, 2021; Furferi et al., 2024; Kamariotou et al., 2021; Petrelli, 2019). SM usage is also strongly significant, confirming H4 and aligning with prior research that sees digital communication as central to audience engagement, loyalty building, and online community development (Zollo et al., 2021; Budge & Burness, 2017). SM appears to function as a broader catalyst for digital maturity rather than simply a promotional channel. Conversely, online ticketing is not significant, contradicting H3 and suggesting that transactional digital functions alone do not indicate deeper digital transformation, which instead depends on integrative and experiential technologies (Lunardo & Ponsignon, 2019).

Organisational factors also show substantial influence. Public funding significantly increases the likelihood of digitisation for both display and storage collections, supporting H6 and aligning with studies that emphasise the role of external financial support in enabling costly technological investments (Raimo et al., 2021; Rogers, 2016). Private funding is significant only for the digitisation of goods on display, providing partial support for H5 and suggesting that storage-related digitisation is typically more resource-intensive and may depend more on public funding programmes. Ownership structure is not significant, contradicting H8 and implying that digitalisation depends more on strategic orientation and resource allocation than governance type (Li et al., 2023; Cavalieri et al., 2023). Institution type is a strong predictor: museums are more likely to digitalise than archaeological parks and other institutions, supporting H7 and consistent with findings that museums possess greater organisational flexibility and digital capacity (Gálicz et al., 2024; Massari et al., 2022). Staff training shows a robust, positive effect, supporting H9 and emphasising human capital as a core component of digital transformation (Mammadov et al., 2024; Romero & Mammadov, 2023). Visitor volume is also significant, supporting H10 and indicating that institutions with larger audiences tend to adopt digital tools to improve experience and operational efficiency (Wang & Meng, 2023).

Environmental factors also demonstrate their importance. Partnership projects are consistently significant, confirming H13 and highlighting the importance of collaboration for knowledge sharing, resource pooling, and innovation diffusion (Aristidou & Stylianou-Lambert, 2024). Networking provides partial support for H12, while regional high-speed internet indirectly supports H11, indicating that broader infrastructural conditions shape institutional digital capacity (Moore, 2015).

Conclusion: Implications, Limitations and Future Study

This study examined the determinants of digitalisation in museums and cultural institutions using the TOE framework. By analysing the digitisation of both displayed and stored collections, the findings demonstrate how technological readiness, organisational capacity, and environmental conditions jointly shape digital maturity in the cultural heritage sector. Technological factors, particularly Wi-Fi availability, SM use, and the adoption of digital tools, play a central role in enabling digitalisation. Organisational features such as funding, staff training, visitor volume, and institutional type also emerge as significant predictors, highlighting the importance of internal resources and strategic orientation. Environmental aspects, especially partnerships and networking, further reinforce the value of collaborative ecosystems and infrastructural support. Overall, digitalisation in museums appears to be a systemic and context-dependent process, requiring alignment between technological assets, organisational capabilities, and external collaborations.

Theoretically, this study extends the application of the TOE framework to the cultural heritage domain and offers quantitative evidence to complement a literature dominated by qualitative approaches. It contributes to a more comprehensive understanding of how digital transformation in museums is embedded within broader institutional and environmental structures rather than being driven solely by technology adoption.

From a managerial and policy perspective, several implications arise. First, investments in digital infrastructure, such as public Wi-Fi, multimedia tools, and SM engagement, form a foundational layer of digital maturity while also enhancing visitor experience and enabling data-informed decision-making. However, these technologies generate sustainable value only when integrated into a coherent organisational strategy supported by adequate human and financial resources. The strong influence of staff training highlights the need for continuous professional development to build digital competencies, foster an innovation-oriented culture, and ensure that new technologies complement curatorial and educational expertise. Funding structures also matter; public grants and collaborative funding mechanisms are especially important for large-scale digitisation initiatives. Policymakers should therefore prioritise financing models that encourage cross-institutional collaboration and the sharing of technological infrastructure. Moreover, the significance of partnerships suggests that museums should strengthen cooperation with universities, technology firms, and other cultural organisations to accelerate knowledge transfer, reduce costs, and promote interoperability in digital practices. Ultimately, digital transformation should be approached as an organisational and cultural shift that integrates technology into core missions of preservation, education, accessibility, and public engagement.

Despite its contributions, this study has several limitations. Some potentially influential factors, such as leadership style, organisational culture, or visitor demographics, could not be included due to data constraints. The use of binary indicators may also oversimplify the complexity and depth of technological adoption. Finally, the study focuses on a specific geographic context, and results may differ in other cultural, economic, or policy environments.

Future research should employ longitudinal and mixed-method approaches to capture the evolving nature of digital transformation in museums. Qualitative work could explore how leadership, staff attitudes, and institutional culture shape technology adoption, while quantitative analyses could incorporate more nuanced indicators of digital intensity. Cross-country comparisons would help identify contextual factors that facilitate or hinder digitalisation. Furthermore, incorporating visitor perspectives could illuminate how digital tools influence learning, satisfaction, and engagement, thereby linking internal digital strategies with external audience outcomes.

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