



Measuring the Museums' Economic and Social Sustainability: Evidence from the Italian Museum System

Carla Galluccio¹ · Francesca Giambona¹

Received: 28 December 2024 / Accepted: 2 October 2025
© The Author(s) 2025

Abstract

Museums offering high-quality products and services have a direct impact on both economic and social sustainability. Economic sustainability is linked to efficiently managing resources, securing diverse revenue streams, and maximising visitor engagement, which ensures financial viability over time. Social sustainability, on the other hand, involves fostering inclusivity, education, and cultural engagement within the community. In Italy, the Ministry of Culture introduced the *Carta dei servizi e standard di qualità*, a framework that aligns with national and international standards to assess museum governance, collections management, and public engagement. The framework is designed not only to enhance the visitor experience but also to strengthen community ties and promote accessibility. The relationship between quality and sustainability is thus clear: museums with high-quality standards are better equipped to attract funding and visitors, supporting their economic sustainability, while their educational and cultural services foster social sustainability. In this vein, our work aims to integrate these aspects to provide a tool that enables museums to evaluate their performance and societal impact over time, thereby facilitating continuous improvement and ensuring they remain both culturally rich and sustainable entities. Following the guidelines provided by the OECD, we developed the Museums' Economic and Social Sustainability composite indicator, aligning it with the ministerial decree. The data used in the analysis come from the Istat survey on Museums and Other Cultural Institutions for 2022. This comprehensive dataset enables us to examine how these factors impact museum operations, providing valuable insights into the intersection of quality and sustainability in the cultural sector.

Keywords Service quality · Museums' sustainability · Italian museums · Composite indicator · Confirmatory factor analysis

✉ Carla Galluccio
carla.galluccio@unifi.it

¹ Department of Statistics, Computer Science, Applications "G. Parenti", University of Florence, Florence, Italy

1 Introduction

Museums' efforts to provide high-quality products and services have a significant impact on sustainability, particularly in economic and social terms (Brown, 2019; Pop & Borza, 2016). Economic sustainability in museums refers to their ability to efficiently manage resources, attract funding, and maintain financial viability over time. This includes strategies such as diversifying revenue streams, securing external sponsorship, and maximising visitor engagement (Orea-Giner et al., 2021; Stylianou-Lambert et al., 2014). Social sustainability, on the other hand, focuses on the museum's role in fostering inclusivity, education, and cultural engagement within the community (Pencarelli et al., 2016; Pop & Borza, 2014; Pop et al., 2019).

International standards for defining quality in museums are shaped by frameworks and guidelines established by organisations such as the International Council of Museums (ICOM) and UNESCO. ICOM's Code of Ethics for Museums (<https://icom.museum/en/resources/standards-guidelines/code-of-ethics/>) serves as a foundational document, outlining principles that ensure high-quality practices in areas such as collections management, accessibility, governance, and public engagement. Additionally, standards like the ISO 9001 for quality management systems provide a framework that museums can adopt to ensure consistent service delivery and continuous improvement. Quality in museums is often assessed through various aspects, including visitor satisfaction, inclusivity, educational programming, and the sustainable management of cultural resources. These international standards emphasise the importance of balancing professional best practices with the evolving needs of society, fostering cultural participation while safeguarding heritage for future generations.

As regards the concept of sustainability in the museum sector, several countries have adopted frameworks for evaluating museums' sustainability, aiming to define standards that ensure museums are well-managed and trusted by both the public and funding bodies. For instance, the UK Museum Accreditation Scheme (<https://www.artscouncil.org.uk/supporting-arts-museums-and-libraries/uk-museum-accreditation-scheme>), the industry standard for museums and galleries in England, ensures institutions manage their collections effectively, engage with visitors, and adhere to governance best practices. This framework encourages museums to meet agreed standards in their operations, collections management, and visitor engagement, ultimately helping to preserve cultural heritage for future generations. Another example is the German Cultural Foundation, which actively supports numerous artistic projects addressing ecological issues and has launched its initiatives to foster sustainability in the cultural sphere. Among these, the pilot project Carbon Footprinting in Cultural Institutions (https://www.kulturstiftung-des-bundes.de/fileadmin/user_upload/Klimabilanzen/Carbon-Footprinting-in-Cultural-Institutions.pdf) supported 19 organisations in measuring their CO₂ emissions, providing a model for the sector to achieve climate neutrality. Similarly, the Zero funding programme (https://www.kulturstiftung-des-bundes.de/en/programmes_projects/sustainability_and_future/detail_1/programm_zero.html) encourages artists to develop climate-neutral approaches to art production.

In the literature, the link between quality and sustainability is not straightforward but often implicit. In this sense, one contribution that discusses this relationship well is the work of Pop and Borza (2016), which demonstrates that improving service quality can enhance the sustainability of museums. Their study, which surveyed Romanian museum experts, highlighted that while quality is widely recognised as crucial, few institutions have imple-

mented formal quality management systems. The authors advocate for adapting museum services to meet visitor expectations and using quality assessments to improve sustainability, competitiveness, and long-term viability. Similarly, international organisations like ICOM emphasise the importance of sustainability (social, economic, and environmental) as part of their core mission. Museums are seen as dynamic institutions that preserve heritage while fostering community engagement and social memory.

In this vein, this work aims to integrate these aspects to provide a tool through which museums can evaluate their performance and societal impact over time. Following the guidelines provided by the OECD and the Econometrics and Applied Statistics Unit of the Joint Research Centre (JRC) of the European Commission (2008), we developed the Museums' Economic and Social Sustainability (MESS) composite indicator, aligned with the ministerial decree.

In particular, this work focuses on the Italian context, as the Italian cultural landscape is unique due to the widespread distribution of cultural heritage across the country, making it a distinctive global destination (Di Fazio & Modica, 2018). Museums, including those in smaller towns, play a crucial role in preserving and showcasing both tangible and intangible cultural assets (Cracolici & Nijkamp, 2009; Ursache, 2015). However, these smaller institutions often face challenges such as limited financial and professional resources, which hinder their ability to remain sustainable and reduce their influence on the cultural and social life of their communities, a situation exacerbated by the COVID-19 pandemic.

To address these challenges, in 2018, the Ministry of Culture introduced the *Carta dei Servizi e Standard di Qualità* (<http://musei.beniculturali.it/wp-content/uploads/2021/11/D.M.-21-FEBBRAIO-2018-REP.-113.pdf>), which establishes a structured approach to assess the quality of museum products and services. This system, aligned with both national legislation and international best practices, is instrumental in evaluating key domains, including governance, collections management, and public engagement. More specifically, the document, adopted through the Ministerial Decree of February 2018, sets minimum standards that all accredited museums in the National Museum System (<http://musei.beniculturali.it/progetti/sistema-museale-nazionale>) must meet, ensuring consistency across the Italian museum landscape. These standards are essential for ensuring that even smaller institutions can maintain a high level of quality, despite often facing financial or organisational challenges. Furthermore, the rationale behind the *Carta dei Servizi e Standard di Qualità* is to improve the visitor experience while fostering stronger connections with local communities and promoting accessibility.

The Italian standards for defining quality in museums are aligned with international frameworks, such as those developed by ICOM and UNESCO, while also incorporating specific national priorities. They focus on key areas, including accessibility, inclusivity, educational services, conservation, and public engagement, ensuring that museums operate with transparency, efficiency, and sustainability. While international standards provide an overarching framework, Italian regulations emphasise delivering measurable quality through specific criteria tailored to the local cultural heritage sector. For example, the Italian standards place particular importance on fostering relationships with the local community, promoting territorial development, and enhancing visitor experiences, aligning with international goals of cultural preservation and societal impact. This dual approach ensures that Italian museums meet global benchmarks while addressing national cultural and social needs.

To the best of our knowledge, Italy currently lacks a synthetic measure to evaluate the quality of museum products and services. This gap highlights the need for a comprehensive tool to assess museums' sustainability performance. Therefore, this study aims to develop a composite indicator aligned with the guidelines of the *Carta dei Servizi e Standard di Qualità*, providing a practical approach to measuring and enhancing the sustainability of Italian museums. Therefore, by examining the correlation between quality and sustainability, this research aims to provide a practical tool for enhancing museum management, enabling continuous improvement, and ensuring that museums remain both culturally rich and sustainable entities.

From a methodological point of view, the data used in the analysis come from the Istat Survey on Museums and Other Cultural Institutions for 2022, the most recent year available. This web-based survey provides comprehensive data on various dimensions, including visitor services, financial performance, and technological infrastructure, allowing us to examine how these factors influence overall museum operations.

The paper is organised as follows. Section 2 presents the methodology, focusing on the sample selection, model validation, and the methods used to construct the composite indicator. Section 3 presents the results, focusing also on the main economic and policy implications. Conclusions in Section 4 end the paper.

2 Methodology

2.1 Data and Sample

The data under analysis come from the Istat Survey on Museums and Other Cultural Institutions (<https://www.istat.it/en/microdata/survey-on-museums-and-other-cultural-institutions/>). This web-based survey, conducted annually since 2018, provides a comprehensive overview of museums and cultural institutions in Italy. The questionnaire explores various aspects of museum services and organisation, such as financial performance, visitor services, technological infrastructure, and governance practices. The survey collects over 113 variables, making it an invaluable source for studying the operational and structural characteristics of museums.

For our study, we focused on the 2022 edition, the most recent dataset available. Out of the 4,416 museums surveyed, we excluded those without a proper denomination or those that answered fewer than 70% of the questions. This threshold was chosen to ensure the robustness of the dataset, minimising the risk of biases introduced by incomplete responses while retaining a representative sample of Italian museums. This left us with a final sample of 4,126 museums (93.4% of the total). The geographical distribution of the sample is as follows: 24.9% in the North-East, 22.3% in the North-West, 28.5% in the Centre, and 24.3% in the South and Islands (13.7% and 10.6%, respectively). This distribution reflects a fairly homogeneous representation across Italian macro-regions, with a slight predominance of museums located in the Centre of Italy.

To ensure robust variable selection, we included only variables with a response rate of at least 93% in the selected sample, resulting in a final dataset of 103 variables (or indicators¹).

¹Throughout this paper, the terms *indicator* or *variable* refer to the elementary variables derived from the ISTAT survey (including binary and categorical variables), whereas *composite indicator* denotes the aggre-

Missing values in these variables were handled using the hot deck imputation method, a non-parametric approach that replaces missing data with observed values from similar records in the dataset (Andridge & Little, 2010). This technique was chosen for its ability to preserve the dataset's original distribution and inter-variable relationships, which are critical for constructing reliable composite indicators.

2.2 Indicators for Measuring Museums' Economic and Social Sustainability

The *Carta dei Servizi e Standard di Qualità* provides a comprehensive and detailed framework for assessing the quality of Italian museums. It defines three overarching domains: Organisation, which refers to the structural and operational aspects of museum management, including governance, staff qualifications, and financial planning to ensure effective and sustainable operations; Collections, that focuses on the preservation, documentation, and enhancement of cultural assets, emphasising accessibility and proper conservation practices; and, lastly, Communication and Community Engagement, a domain that highlights museums' roles in promoting activities, fostering relationships with local communities, and encouraging cultural participation through educational programmes and outreach initiatives. Each domain is further subdivided into several sections and subsections, which detail specific aspects of museum management and operations. For instance, the Organisation domain includes sections such as legal status, accounting and finance, structure, activities, and human resources. These sections are, in turn, articulated into subsections. The structure section, for example, is subdivided into subsections such as use of space, comfort of exhibition areas, accessibility for people with disabilities, and safety. Together, these subsections define both minimum standards and improvement objectives that museums are expected to meet or pursue to maintain and enhance their quality levels.

Building on the variables available in the Istat survey, we undertook a systematic mapping process to align the survey items with the decree's subsections and their associated standards. This process involved cross-referencing the decree's criteria with the empirical data to identify which aspects could be operationalised. This mapping process involved assessing the conceptual relevance of available variables while ensuring empirical adequacy. As a result, 48 variables were selected from the survey and grouped into seven dimensions: finances and accounting, educational activities, inclusivity, communication and promotion, accessibility, public relations, and relations with the territory and stakeholders. Each of these dimensions represents a measurable facet of museum quality within the ministerial framework.

However, given the nature and availability of data, a fully exhaustive operationalisation of all criteria was not feasible. In particular, the detailed data collected directly by the Ministry for museum accreditation are not publicly accessible for most institutions. The Istat survey, although more limited in scope, provides a census dataset covering a wide range of Italian museums. This dataset allowed us to map the decree's conceptual priorities onto measurable indicators, using an iterative process to define the seven operational dimensions.

Table 1 summarises this alignment, showing how the selected Istat variables correspond to the criteria set out in the decree. This mapping provided the conceptual and empirical foundation for constructing the MESS composite indicator.

gated measure of museum sustainability constructed from these variables. This distinction is maintained consistently throughout the manuscript to avoid ambiguity.

Table 1 Alignment between museum sustainability dimensions and Istat variables for the year 2022. Square brackets show the Istat variable code, the original question number in the survey, and whether the question is binary, categorical, or continuous. This table outlines the correspondence between key dimensions of museum performance, such as finances, educational activities, inclusivity, and public relations, and the relevant ISTAT data. It provides a structured framework for assessing museum effectiveness and sustainability based on the available statistical indicators

Dimension	Description	Istat Variables
<i>Finances and accounting</i>	Adequate management of financial resources to ensure the museum's financial sustainability; budget allocation for key activities such as exhibitions, educational programmes, staff, and maintenance; adoption of transparent accounting practices and regular reporting to ensure responsible management and efficient use of funds	– In 2022, which products and services of the museum/institution were available on the web: online ticketing service (for booking visits, purchasing tickets, etc.). [WEB1 31.1 binary] – Does the museum/institution have a set opening schedule for the public? [OPENPRESTAB 13 categorical] – In 2022, the museum/institution generated revenue from: public contributions and funding (from ministries, regions, municipalities, other public administrations, etc.). [FINANZ1 27.1 binary] – In 2022, the museum/institution generated revenue from: private funding (sponsorships, contributions, donations, bequests, funding from former banking foundations, businesses, citizens, etc.). [FINANZ2 27.2 binary] – In 2022, the museum/institution generated revenue from: other income from additional services for the public (e.g. bookshop, café, audio guides/radio guides, bookings, guided tours, artwork loans, sale of other services, rentals, etc.). [FINANZ3 27.3 binary] – In 2022, was museum/institution entry completely free or were there paid access options? [ACCESSO 16 binary] – In 2022, the museum/institution carried out the following on-site activities: conferences, lectures, and seminars. [ATTIVITA4 30.4 binary] – In 2022, the museum/institution carried out the following on-site activities: live performances and/or cultural events. [ATTIVITA5 30.5 binary] – In 2022, the museum/institution carried out the following on-site activities: exhibitions and/or temporary displays. [ATTIVITA6 30.6 binary]
<i>Educational activities</i>	Design and delivery of educational programmes catering to a diverse range of audiences, promoting active learning and participation; promotional activities to highlight the museum's cultural offerings, including workshops, seminars, educational events, and collaborations with schools and other institutions	– As of 31 December 2022, the museum/institution had digitised its assets and/or collections: the items exhibited to the public. [DIGITALIZZ1 12.5.a categorical] – In 2022, it carried out: educational workshops for school groups. [LABSTUD 19.1 binary] – In 2022, it carried out: guided tours for school groups. [PRESSTUD 19.2 binary] – In 2022, the following facilities were available to the public: classroom/laboratory for educational activities, study, research, and/or conferences. [SALAATTDIDATT 28.1 binary] – In 2022, the following facilities were available to the public: video/multimedia room. [SALAVIDEO 28.2 binary] – In 2022, the following facilities were available to the public: wi-fi connection. [WIFI 28.3 binary] – In 2022, the museum/institution carried out the following on-site activities: thematic and/or educational paths specifically dedicated to children. [ATTIVITA1 30.1 binary] – In 2022, the museum/institution carried out the following on-site activities: educational workshops. [ATTIVITA2 30.2 binary]

Table 1 (continued)

Dimension	Description	Istat Variables
<i>Inclusivity</i>	Commitment to offering cultural experiences that are accessible to all individuals, regardless of their socio-economic, cultural, or physical characteristics; implementation of inclusive programmes and initiatives that encourage participation from diverse social groups, with particular focus on people with disabilities and minorities	– In 2022, the museum/institution renovated the building, rooms, and/or facilities, strengthened and/or secured the spaces and facilities, and/or expanded the surfaces. [ATTIVITA10 32.4 binary] – In 2022, the following services were available to the public: ramps, wedges and/or slopes, lifts or platforms to overcome any level differences in the building. [ACCESS_SERV1 37.1 binary] – In 2022, the following services were available to the public: accessible toilets for people with disabilities. [ACCESS_SERV2 37.2 binary] – In 2022, the following services were available to the public: non-slip and/or anti-reflective floors. [ACCESS_SERV3 37.3 binary] – In 2022, the following services were available to the public: dedicated assistant during the visit (e.g., guided tours with the participation of a sign language interpreter, etc.). [ACCESS_SERV8 37.8 binary] – In 2022, the following services were available to the public: maps and routes with symbols for Augmentative and Alternative Communication (AAC) (suitable for the public with verbal communication difficulties). [ACCESS_SERV9 37.9 binary] – In 2022, the following services were available to the public: routes and visit programmes dedicated to people with cognitive disabilities (e.g., those with autism spectrum disorder, Alzheimer's, or other intellectual disabilities). [ACCESS_SERV10 37.10 binary]
<i>Communication and promotion</i>	Effective communication strategies to publicise the museum's offerings; development of well-structured promotional campaigns to reach a wide and diverse audience; active presence on digital platforms, social media, and traditional media to ensure visibility and engage the public	– In 2022, which products and services of the museum/institution were available on the web: social media accounts (Facebook, Twitter, YouTube, Instagram, Pinterest, etc.). [WEB2 31.2 binary] – In 2022, which products and services of the museum/institution were available on the web: online virtual tours. [WEB3 31.3 binary] – In 2022, which products and services of the museum/institution were available on the web: online guided tours and/or alternative online visit modes of the museum/institution. [WEB4 31.4 binary] – In 2022, which products and services of the museum/institution were available on the web: online educational workshops (for children, teenagers, and school groups). [WEB5 31.5 binary] – In 2022, which products and services of the museum/institution were available on the web: online conferences, seminars, and lectures. [WEB6 31.6 binary] – In 2022, which products and services of the museum/institution were available on the web: digital catalogues of the heritage collection (photos, videos, databases, etc.). [WEB7 31.7 binary] – In 2022, the museum/institution carried out information and communication campaigns to promote services or activities specifically aimed at the following categories of users (e.g., guided tours, workshops, courses, events): children (up to 12 years old). [COMUNIC1 35.1 binary] – In 2022, the museum/institution carried out information and communication campaigns to promote services or activities specifically aimed at the following categories of users (e.g., guided tours, workshops, courses, events): students of all grades. [COMUNIC2 35.2 binary]

Table 1 (continued)

Dimension	Description	Istat Variables
<i>Accessibility</i>	Removal of physical, sensory, and cognitive barriers to ensure the museum is accessible to all, including visitors with disabilities; adaptation of spaces and services to facilitate access for people with different needs; design of inclusive exhibition pathways, provision of accessible informational materials, and staff training to meet the specific needs of visitors	– In 2022, the following services were available to the public: clear and legible external and/or internal signage, with large characters and accompanied by pictograms. [ACCESS_SERV4 37.4 binary] – In 2022, the following services were available to the public: tactile maps, both fixed and/or portable, of the physical spaces within the structure. [ACCESS_SERV5 37.5 binary] – In 2022, the following services were available to the public: tactile or podotactile pathways in exhibition spaces and/or embossed drawings, catalogues and/or explanatory panels in Braille, etc. [ACCESS_SERV6 37.6 binary] – In 2022, the following services were available to the public: videos in LIS (Italian Sign Language), also with Italian subtitles and a voiceover, within the structure. [ACCESS_SERV7 37.7 binary]
<i>Public relations</i>	Establishing clear and direct communication with visitors, providing timely and useful information before, during, and after their visit; offering high-quality reception and assistance services; carefully managing requests, feedback, and complaints to improve the visitor experience and meet their expectations	– In 2022, the following digital resources were available to the public for the visit: smartphone and tablet applications. [SUPPORT1 29.1 binary] – In 2022, the following digital resources were available to the public for the visit: videos and/or touch screens. [SUPPORT2 29.2 binary] – In 2022, the following digital resources were available to the public for the visit: multimedia resources (interactive displays, virtual reconstructions, augmented reality, etc.). [SUPPORT3 29.3 binary] – In 2022, the following digital resources were available to the public for the visit: QR codes and/or proximity systems (bluetooth, wi-fi, etc.). [SUPPORT4 29.4 binary] – In 2022, the following digital resources were available to the public for the visit: tablets available for public use. [SUPPORT5 29.5 binary] – In 2022, the museum/institution carried out the following in-person activities: guided tours. [ATTIVITA3 30.3 binary]

Table 1 (continued)

Dimension	Description	Istat Variables
<i>Relations with the territory and stakeholders</i>	Building collaborative relationships with local authorities, other cultural institutions, and businesses to develop joint projects that enhance the territory; involving the local community and stakeholders in the museum's planning process, fostering continuous dialogue to address the needs of the social and cultural context	– In 2022, the museum/institution carried out formal collaboration and/or partnership projects with other local cultural institutions (e.g. schools, associations, museums, libraries, universities, etc.)? [PARTNER 33 binary] – In 2022, the museum/institution joined networks and/or museum systems and/or integrated cultural services systems? [RETE 34 binary] – In 2022, it was carried out a formal collaboration and/or partnership projects with associations, organisations, cooperatives, schools, universities, other museums, etc., to implement inclusion projects aimed at the following user categories: people with physical-sensory and/or emotional disabilities and/or cognitive disorders. [PROGDISAB 39.1 binary] – In 2022, it was carried out a formal collaboration and/or partnership projects with associations, organisations, cooperatives, schools, universities, other museums, etc., to implement inclusion projects aimed at the following user categories: people living in economic, educational, or cultural poverty. [PROGECON 39.2 binary] – In 2022, it was carried out a formal collaboration and/or partnership projects with associations, organisations, cooperatives, schools, universities, other museums, etc., to implement inclusion projects aimed at the following user categories: immigrant citizens. [PROGIMMI 39.3 binary] – In 2022, it was carried out a formal collaboration and/or partnership projects with associations, organisations, cooperatives, schools, universities, other museums, etc., to implement inclusion projects aimed at the following user categories: inmates in penitentiary institutions and/or community-based correctional facilities (e.g. rehabilitation centres, family homes, etc.). [PROGDETEN 39.4 binary]

Figure 1 shows the correlation matrix among the 48 indicators used to operationalise the seven dimensions of museums' economic and social sustainability. Indicators within the same dimension tend to exhibit moderate correlations, reflecting their conceptual coherence. For instance, variables related to Accessibility, such as clear and legible signage (ACCESS_SERV4), tactile maps (ACCESS_SERV5), and Braille materials (ACCESS_SERV6), and Inclusivity, such as dedicated assistant during visits (ACCESS_SERV8) and programmes for cognitive disabilities (ACCESS_SERV10), show stronger associations within their respective groups, confirming the alignment between the empirical structure and the ministerial framework. By contrast, correlations across dimensions are generally weak to moderate, indicating that the seven dimensions capture distinct aspects of museum sustainability without problematic redundancy.

Nonetheless, before constructing the composite indicator, we conducted a Confirmatory Factor Analysis (CFA) to validate the adequacy and internal coherence of the defined dimensions. The dataset included mostly binary variables and two categorical variables with a small number of categories (three and four, precisely). Therefore, for the CFA, all variables were included in their original form and analysed using the diagonally weighted least squares (DWLS) estimator with robust standard errors, which is well suited for binary and categorical data (Muthén, 1997). The analysis was conducted with the *lavaan* package in R (Rosseel, 2012).

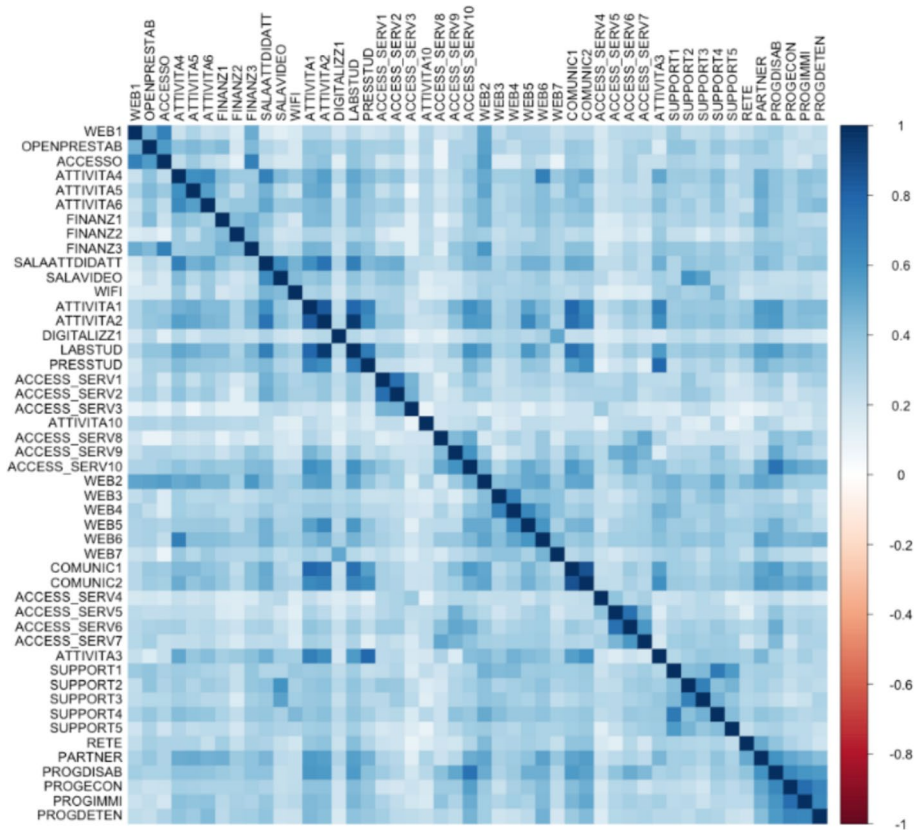


Fig. 1 Correlation matrix of the variables used to construct the seven dimensions of museums' social and economic sustainability

Table 2 CFA goodness-of-fit results for the hypothesised model of museum quality dimensions. Fit indices demonstrate strong alignment with the data, confirming the robustness of the model for assessing the relationship between museum quality attributes and their economic and social sustainability outcomes

χ^2	df	CFI	TLI	RMSEA	SRMR
11491.38	1073	0.944	0.941	0.049	0.053

The CFA assessed several goodness-of-fit measures (Goretzko et al., 2024; Xia & Yang, 2019), all shown in Table 2. The Comparative Fit Index (CFI; Bentler, 1990) and Tucker-Lewis Index (TLI; Bentler & Bonett, 1980; Tucker & Lewis, 1973) both exceeded the recommended threshold of 0.9, indicating strong relative model fit. The Root Mean Square Error of Approximation (RMSEA; Steiger, 1990; Steiger & Lind, 1980) was below the 0.08 cut-off, with a value of 0.049, suggesting a good absolute fit; values equal or below 0.05, as in this case, are generally considered indicative of a close fit to the construct. Similarly, the Standardised Root Mean Square Residual (SRMR; Bentler, 1995) was well below the 0.08 threshold, with a value of 0.053, reflecting minimal residual discrepancies.

Therefore, all fit indices meet or exceed their respective thresholds, indicating that the hypothesised model aligns well with the observed data. This suggests that the dimensions defined in the model effectively capture the quality of museum services and their link to economic and social sustainability. Consequently, the model provides a robust foundation for constructing a composite indicator to evaluate museums' performance (Hu & Bentler, 1999).

In addition to the fit indices, the Confirmatory Factor Analysis provided further evidence of the model's validity through the examination of standardised factor loadings. All loadings were statistically significant ($p < 0.001$), with values ranging from 0.21 to 0.82 and an average loading of 0.47 across the seven dimensions. These results, presented in Table 3, indicate moderate to strong associations between the observed variables and their respective latent constructs, supporting the convergent validity of the measurement model.

2.3 Steps for Building the MESS Composite Indicator

Having confirmed the validity of the identified dimensions, we aggregated the indicator values by province. To compute province-level scores, we calculated the arithmetic mean of each elementary indicator across all museums within each province. This step allowed us to summarise museum performance at a provincial (and, subsequently, regional) level, capturing potential geographical disparities while ensuring a manageable dataset for further analysis. The final dataset consisted of 106 rows (provinces) and 52 columns, including the 48 variables drawn from the Istat survey (grouped into the seven dimensions of museum quality) and 4 additional variables (ID, province, region, and macro-area) that described contextual and geographic information.

Following the guidelines of the OECD and JRC handbook (2008), we constructed the MESS composite indicator. The first step involved normalising each indicator using the min–max normalisation method. This technique scales data to a range between 0 and 1 by subtracting the minimum value and then dividing by the range (multiplying by 100 to ensure the scale ranges from 0 to 100). For the weighting step, we opted for equal weights, as there was no compelling evidence to justify assigning greater importance to any specific indicator. This approach ensures that all dimensions contribute equally to the composite indicator, thereby avoiding subjective bias. The weights were assigned proportionally to the number of simple indicators constituting each identified dimension. Finally, we aggregated the dimensions using the weighted arithmetic mean. This method assumes “perfect compensability”, meaning that a high score in one indicator can fully compensate for a low score in another. While this assumption may oversimplify the relationships between indicators, it allows for straightforward interpretation and comparability of results.

To ensure the robustness of our composite indicator and assess its sensitivity to methodological choices, we tested alternative approaches for normalisation, weighting, and aggregation. For normalisation, we compared the min–max method with standardisation, ranking, and distance from the maximum. Regarding weighting, we explored equal weights, weights derived from Principal Component Analysis (PCA), and the Benefit of the Doubt (BOD) method. The BOD approach assigns weights based on the uncertainty associated with each indicator's influence: indicators with higher uncertainty receive lower weights, while those with greater reliability are assigned higher weights. This method strikes a balance between subjective judgment and data reliability. Lastly, for aggregation, we tested the arithmetic

Table 3 Standardised factor loadings for each observed variable within its corresponding dimension

<i>Dimension</i>	<i>Variable</i>	<i>Standardised factor loading</i>
<i>Finances and accounting</i>	Online ticketing (WEB1)	0.38
	Set opening schedule (OPENPRESTAB)	0.41
	Free or paid access (ACCESSO)	0.45
	Conferences, lectures, seminars (ATTIVITA4)	0.62
	Live performances/cultural events (ATTIVITA5)	0.56
	Exhibitions/temporary displays (ATTIVITA6)	0.56
	Public contributions/funding (FINANZ1)	0.49
	Private funding (FINANZ2)	0.39
	Other income from services (FINANZ3)	0.55
<i>Educational activities</i>	Classroom/laboratory for education (SALAATTDIDATT)	0.64
	Video/multimedia room (SALAVIDEO)	0.47
	Wi-fi connection (WIFI)	0.40
	Educational paths for children (ATTIVITA1)	0.73
	Educational workshops (ATTIVITA2)	0.82
	Digitised collections (DIGITALIZZ1)	0.38
	Workshops for schools (LABSTUD)	0.80
	Guided tours for schools (PRESSTUD)	0.48
<i>Inclusivity</i>	Ramps/slopes/lifts (ACCESS_SERV1)	0.49
	Accessible toilets (ACCESS_SERV2)	0.47
	Non-slip/anti-reflective floors (ACCESS_SERV3)	0.32
	Renovation/expansion (ATTIVITA10)	0.35
	Dedicated assistant during visit (ACCESS_SERV8)	0.27
	Augmentative/alternative communication maps (ACCESS_SERV9)	0.21
	Programmes for cognitive disabilities (ACCESS_SERV10)	0.48
<i>Communication and promotion</i>	Social media presence (WEB2)	0.57
	Online virtual tours (WEB3)	0.36
	Online guided tours (WEB4)	0.35
	Online educational workshops (WEB5)	0.36
	Online conferences/seminars (WEB6)	0.46
	Digital catalogues (WEB7)	0.39
	Campaigns for children (COMUNIC1)	0.66
	Campaigns for students (COMUNIC2)	0.63
<i>Accessibility</i>	Clear and legible signage (ACCESS_SERV4)	0.45
	Tactile maps (ACCESS_SERV5)	0.39
	Braille materials/podotactile paths (ACCESS_SERV6)	0.50
	LIS videos/subtitles (ACCESS_SERV7)	0.37
<i>Public relations</i>	Guided tours (ATTIVITA3)	0.35
	Apps for smartphones/tablets (SUPPORT1)	0.48
	Touch screens/videos (SUPPORT2)	0.56
	Multimedia resources (SUPPORT3)	0.48
	QR codes/proximity systems (SUPPORT4)	0.57
	Tablets available (SUPPORT5)	0.34

Table 3 (continued)

<i>Dimension</i>	<i>Variable</i>	<i>Standardised factor loading</i>
<i>Relations with the territory and stakeholders</i>	Networks/museum systems (RETE)	0.46
	Collaboration projects (PARTNER)	0.63
	Inclusion projects for disabilities (PROGDISAB)	0.55
	Inclusion projects for disadvantaged groups (PROGECON)	0.38
	Inclusion projects for immigrants (PROGIMMI)	0.35
	Inclusion projects for inmates (PROGDETEN)	0.25

mean, the weighted median, and the Copeland method. The weighted median offers greater robustness to outliers compared to the mean, as it reflects the central tendency of the data without being skewed by extreme values. The Copeland method, on the other hand, is based on pairwise comparisons between units and is particularly effective in handling dominance pairs, ensuring that rankings remain stable even when methodological variations occur.

As regards the sensitivity analysis, a global perturbation approach was adopted to test alternative modelling choices for normalisation, weighting, and aggregation. By exploring all specified combinations, we were able to quantify their influence on the composite indicator scores and identify the most influential modelling assumptions (Becker et al., 2022).

By applying these diverse methods, we were able to evaluate the sensitivity of the composite indicator to changes in assumptions, ensuring its validity and robustness. All analyses were performed using the *COINr6* R package, a comprehensive tool designed for the development, evaluation, and visualisation of composite indicators (Becker et al., 2022).

3 Results

In this section, we present the results of the MESS composite indicator, developed to assess the economic and social sustainability of museums in Italy. The analysis is structured to explore how different museums perform across various quality dimensions and how these factors correlate with their overall sustainability. By examining the geographical distribution of scores and comparing the contributions of each dimension, we aim to identify key patterns and insights that can guide museums in enhancing their services and achieving a greater societal impact. Additionally, we assess the robustness and sensitivity of the composite indicator, testing different methodologies for normalisation, weighting, and aggregation to ensure the reliability of the results.

3.1 Overall Performance of the MESS Composite Indicator

The geographical distribution of the sustainability scores for Italian museums provides valuable insights into provincial disparities and trends. By aggregating the MESS composite indicator at the provincial level, we can examine how museums across different parts of Italy contribute to economic and social sustainability. This distribution highlights the varying degrees of sustainability across the national territory, allowing us to identify areas of excellence as well as areas that may face challenges in achieving high sustainability scores.

The provincial distribution of the MESS composite indicator scores reveals significant variation in the performance of museums across Italy. The scores (ranging from 0 to 100) span from 15.96 to 62.81, with a mean of 42.15 and a standard deviation of 9.5. This suggests that while many museums maintain a reasonable level of economic and social sustainability, there are clear differences in performance between institutions. In Table 4, the summary of the score distribution is presented.

The distribution pattern highlights a tendency for museums to perform relatively well. However, it also highlights a significant proportion that may require additional support or strategic interventions to enhance their sustainability and service quality. That is, the presence of museums with lower scores emphasises the need for targeted efforts to improve practices, particularly in those museums that are facing challenges related to resource limitations or engagement with their local communities.

Figure 2 provides a visual representation of the MESS composite indicator across Italian provinces, highlighting significant geographical variations in museum sustainability. Higher MESS scores, depicted in darker shades, are predominantly concentrated in certain provinces of northern and central Italy, reflecting robust governance, financial resources, and community engagement in these regions. Conversely, lower scores, represented by lighter shades, are more prevalent in southern Italy and the Islands, indicating challenges such as limited funding, operational inefficiencies, and lower levels of inclusivity.

The cartogram also underscores the disparities within individual regions, where adjacent provinces may exhibit markedly different scores. For instance, while certain provinces in Sicilia or Campania achieve high sustainability scores, others within the same regions show room for improvement, suggesting that local factors, such as municipal investment in cultural heritage and the quality of partnerships with stakeholders, play a critical role.

The province of Bolzano, shaded in grey due to missing data, represents an exception in the map and highlights the need for complete datasets to ensure comprehensive regional analyses. This geographical distribution emphasises the importance of targeted interventions and tailored policies to bridge the sustainability gaps between provinces and regions.

To facilitate the interpretation of the results, we aggregated the MESS composite indicator scores and their dimensions by mean at both the regional and macro-regional levels. These summaries are presented in Tables 5 and 6, respectively.

Table 5 provides the ranking of Italian regions based on their sustainability performance. Generally, results show that Lombardia emerges as the top-performing region, achieving the highest overall MESS score and demonstrating strengths across multiple dimensions, particularly in *educational activities* and *public relations*. This reflects the region's significant investment in cultural infrastructure and its ability to foster strong community engagement.

More specifically, for the *finances and accounting* dimension, museums in northern regions, such as Lombardia and Emilia-Romagna, tend to achieve higher scores, reflecting stronger revenue diversification and more consistent financial planning. Conversely, museums in southern regions tend to exhibit lower scores, likely due to limited autonomy in financial management and fewer additional revenue streams.

Table 4 Summary statistics for the distribution of MESS composite indicator scores. The table presents the minimum, first quartile, median, mean, third quartile, and maximum scores, providing a comprehensive overview of the variability in museums' economic and social sustainability performance

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
15.96	36.29	41.43	42.15	48.69	62.81

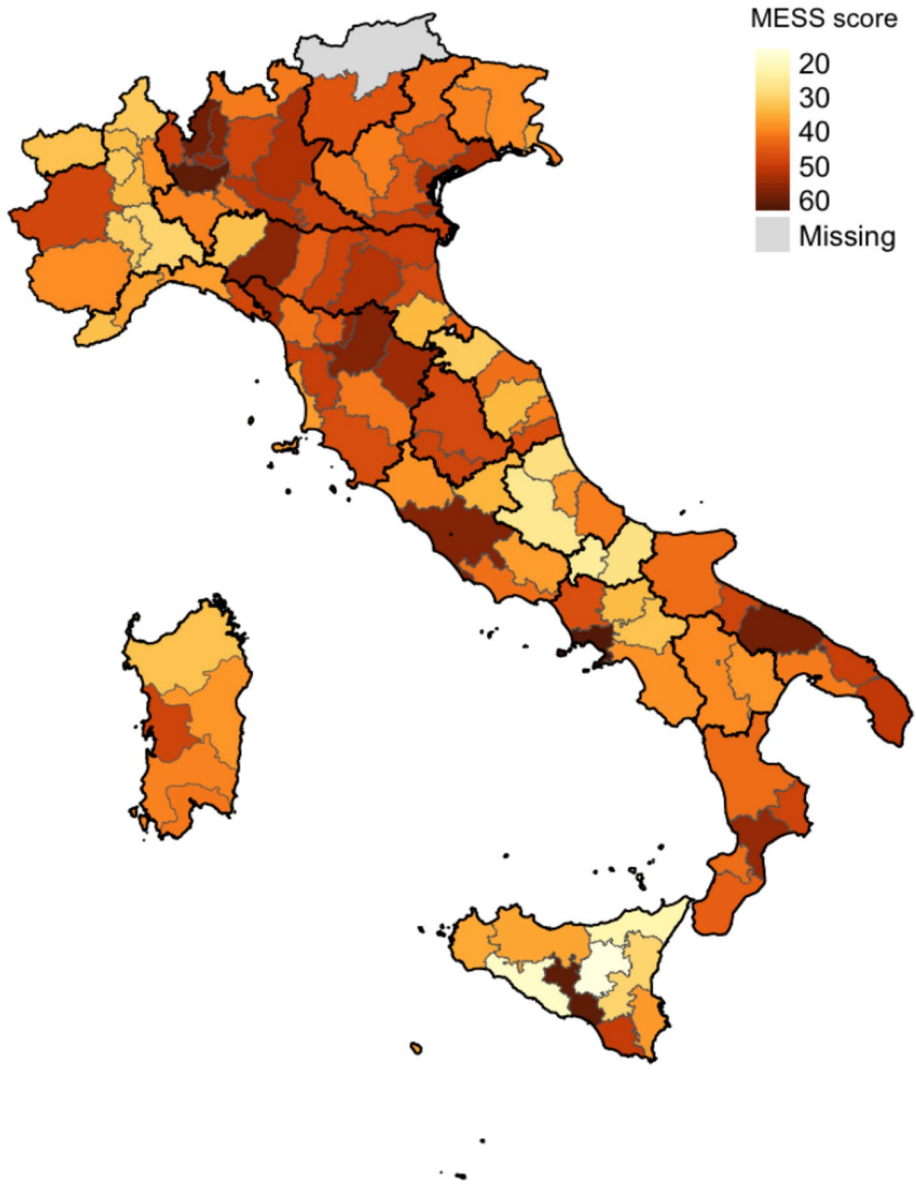


Fig. 2 Cartogram of MESS scores by province in Italy, with regional boundaries highlighted for interpretative clarity. Darker shades represent higher MESS scores, indicating stronger economic and social sustainability. The province of Bolzano, in Trentino-Alto Adige, is shaded in grey due to missing data

Regions in the top quartile, such as Puglia, Umbria, and Toscana, stand out for their relatively balanced performance across dimensions, showcasing effective governance and active engagement with their local communities. For example, in the *educational activities* dimension, central regions such as Toscana and Umbria perform slightly better, with a higher proportion of museums offering workshops and guided tours for school groups.

Table 5 Regional ranking of the Italian regions based on their performance in the MESS composite indicator. It also provides detailed scores for each contributing dimension, highlighting regional strengths and areas for improvement in museum sustainability

Region	Rank	MESS	Communication and promotion	Public relations	Accessibility	Relations with the territory and stakeholders	Inclusivity	Finances and accounting	Educational activities
<i>Lombardia</i>	1	50.17	45.47	53.60	33.13	38.66	46.58	56.78	69.52
<i>Puglia</i>	2	48.42	41.25	54.32	27.75	46.35	47.23	48.78	67.25
<i>Umbria</i>	3	48.11	47.04	59.66	26.96	41.73	35.81	59.13	62.16
<i>Toscana</i>	4	48.02	48.09	49.32	30.03	40.25	40.42	59.17	62.77
<i>Calabria</i>	5	46.57	39.58	48.41	40.39	38.49	43.91	44.93	65.45
<i>Trentino-Alto Adige</i>	6	45.62	42.21	48.15	29.39	32.51	44.85	58.19	56.46
<i>Emilia-Romagna</i>	7	45.25	46.76	49.83	24.65	33.21	37.54	54.49	63.63
<i>Veneto</i>	8	45.22	41.84	48.59	28.30	30.93	44.93	56.62	57.55
<i>Campania</i>	9	42.57	40.07	43.13	26.36	41.80	40.29	47.59	54.00
<i>Lazio</i>	10	41.70	39.81	38.10	33.54	32.02	42.97	45.60	54.05
<i>Sardegna</i>	11	39.76	35.07	45.48	27.31	27.28	32.88	52.54	51.80
<i>Marche</i>	12	38.62	33.94	39.22	27.65	33.20	36.77	43.03	51.43
<i>Basilicata</i>	13	38.52	33.73	37.64	32.45	31.68	32.55	45.98	50.97
<i>Liguria</i>	14	38.36	36.54	38.63	31.11	25.72	33.49	46.60	51.09
<i>Friuli-Venezia Giulia</i>	15	38.23	31.92	42.75	23.38	21.85	42.43	45.67	51.33
<i>Piemonte</i>	16	35.11	30.84	37.62	19.84	30.35	30.56	41.41	49.67
<i>Sicilia</i>	17	33.95	29.81	30.79	28.91	23.98	36.49	44.82	37.30
<i>Abruzzo</i>	18	32.63	33.72	31.26	17.09	21.77	31.23	37.74	48.94
<i>Valle d'Aosta</i>	19	31.90	25.93	39.21	34.80	26.17	28.80	32.01	36.01
<i>Molise</i>	20	25.51	17.30	30.68	16.05	17.46	29.75	22.64	39.54

In contrast, Molise ranks lowest, with consistently lower scores across most dimensions, likely due to structural challenges such as limited financial resources and underdeveloped promotional strategies. Similarly, regions like Sicilia and Abruzzo, which fall in the lower quartile, face persistent difficulties in areas such as *accessibility* and *relations with the territory and stakeholders*.

In the *inclusivity* dimension, notable disparities emerge between regions: museums in Trentino-Alto Adige and Piemonte exhibit strong commitments to accessibility initiatives and programmes for disadvantaged groups, while museums in Calabria and Sicilia are left behind, supposedly due to infrastructural constraints. The dimension of *communication and promotion* highlights the growing use of social media and digital tools among museums in large urban centres in northern and central regions. However, smaller and more rural regions show a digital divide that limits their capacity to engage broader audiences. *Accessibility*, which considers physical and cognitive access, remains a challenge for many museums (in historic buildings, for example). Nevertheless, some northern regions have pioneered innovative solutions, such as virtual tours and tactile maps, to improve inclusivity.

Finally, the *public relations* and *relations with the territory and stakeholders*' dimensions reveal the importance of networks and partnerships. Regions such as Piemonte and Emilia-Romagna stand out for their active participation in local cultural networks and collaborations with community organisations. In contrast, museums in more peripheral regions often operate in isolation, limiting their integration with local development initiatives.

These results reflect the complex interplay between regional policies, resource availability, and local socio-economic contexts. Regions with higher MESS scores typically benefit from robust public–private partnerships, sustained investments in cultural heritage, and strategic use of tourism as a driver for sustainability. On the other hand, regions with lower scores would greatly benefit from targeted interventions aimed at enhancing inclusivity, accessibility, and operational efficiency.

When aggregated at the macro-regional level (Table 6), the data reveal notable patterns. Museums in the North generally exhibit higher scores, likely due to their more developed infrastructure, diversified funding sources, and stronger governance frameworks. Central Italy also performs well, driven by regions such as Tuscany and Umbria, which leverage their rich cultural heritage and well-established networks for community engagement. In contrast, the South and Islands exhibit more varied performances, with Puglia representing an outlier of excellence. At the same time, other regions in these macro-areas struggle with lower scores in dimensions such as *communication and promotion* and *finances and accounting*.

Overall, the findings illustrate the diversity of museum performance across Italy, emphasising the importance of tailored strategies that address regional strengths and weaknesses to foster economic and social sustainability.

3.2 MESS Indicator's Robustness and Sensitivity Analysis

To evaluate the reliability of the MESS composite indicator, we conducted robustness and sensitivity analyses focusing on key methodological choices: normalisation, weighting, and aggregation. These analyses provide insights into the stability of provincial and regional rankings under different methodological assumptions.

Table 6 Macro-regional ranking of the Italian macro-regions based on their performance in the MESS composite indicator. It also provides detailed scores for each contributing dimension, highlighting macro-regional strengths and areas for improvement in museum sustainability

Macro-region	Rank	MESS	Communication and promotion	Public relations	Accessibility	Relations with the territory and stakeholders	Inclusivity	Finances and accounting	Educational activities
<i>Centre</i>	1	42.90	45.41	30.01	36.91	39.75	52.42	58.15	44.46
<i>North-East</i>	2	42.08	47.99	25.85	30.25	41.28	53.70	58.92	43.92
<i>North-West</i>	3	38.58	45.51	28.62	33.43	38.65	49.25	58.88	42.73
<i>South</i>	4	36.78	43.55	27.73	36.04	39.75	43.48	57.40	41.45
<i>Islands</i>	5	31.69	36.03	28.34	25.16	35.20	47.58	42.48	36.03

The stability of rankings was assessed using the Spearman correlation coefficient, which measures the correlation between baseline rankings and those generated from alternative scenarios (comprising 36 different rankings in total). Results indicated high robustness, with 78.4% of rankings achieving a correlation coefficient of at least 0.9 (96.3% with a correlation of 0.8 or higher).

Fluctuations at the provincial level primarily occurred among provinces in the mid-range of the distribution (see Fig. 3). More specifically, the results illustrated in Fig. 3 highlight the stability and variability of provincial rankings in the MESS composite indicator under uncertainty analysis. The majority of the provinces demonstrate relatively narrow confidence intervals, indicating a high degree of robustness in their rank placement despite variations in methodological assumptions. This suggests that their performance relative to other provinces remains consistent across different analytical scenarios.

However, some provinces exhibit wider confidence intervals, particularly those in the middle of the rank distribution, such as Vibo Valentia, Taranto, and Brindisi. This increased variability may be due to their intermediate performance, where minor methodological adjustments can cause significant shifts in ranking. Provinces with wider intervals could benefit from targeted improvements in specific dimensions of the indicator to strengthen their position.

Despite that, the figure confirms that the MESS indicator is robust in identifying the top and bottom-performing provinces, while also providing insights into areas where methodological sensitivity could influence rankings, particularly for those in the mid-range.

Regarding the regional levels, Fig. 4 illustrates how regional rankings change under alternative modelling assumptions. As can be observed, the analysis confirms a general stability also in the regional ranking structure, with some regions exhibiting minimal variability. For example, Lombardia consistently ranks first across nearly all scenarios, highlighting its strong and balanced performance across the seven dimensions of sustainability. Similarly, Lazio, Calabria, and Toscana demonstrate stable rankings within the top quartile, suggesting that their positions are robust to methodological changes. In contrast, regions such as Molise and Abruzzo, which occupy the lowest positions in the baseline ranking, also remain in the lower ranks across alternative configurations. Notably, regions in the middle of the ranking, such as Veneto, Campania, and Umbria, show slightly more variability in their positions, reflecting a greater sensitivity to the methodological choices.

When comparing these results with the analysis at the provincial level (Fig. 3), a similar pattern of stability emerges, particularly for territories at the extremes of the ranking. However, the regional aggregation tends to reduce some of the variability observed at the provincial level. This is because regional scores represent the combined performance of multiple provinces, which can smooth out the influence of individual outlier museums. Despite this aggregation effect, regions with highly heterogeneous provinces, such as Sicilia and Piemonte, still show modest variability in their ranks, indicating internal disparities that may require targeted interventions.

Sensitivity indices provided further insights into the uncertainty associated with methodological variations. More specifically, Fig. 5 provides a detailed breakdown of the uncertainty associated with each methodological input.

More specifically, as illustrated in the left pane of Fig. 5, among the tested factors, the weighting scheme proved to be the primary source of variability, followed by the aggregation method. Variations in weight allocation, such as using PCA-derived weights or the

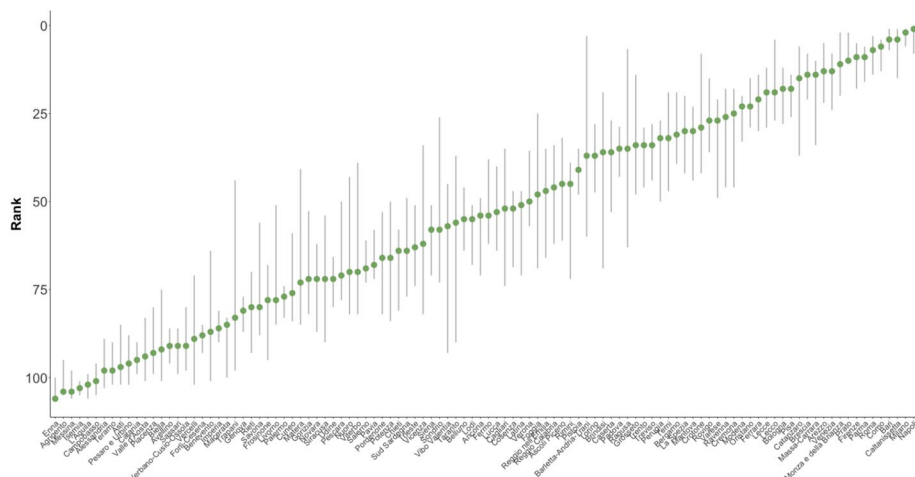


Fig. 3 Median provincial ranks across all replications of the uncertainty analysis, with vertical lines representing the 5th and 95th percentiles of rank variation. The green dots indicate the median rank for each province, providing an overview of ranking stability and variability across the uncertainty analysis. This visualisation highlights the reliability of rankings while identifying provinces with higher uncertainty

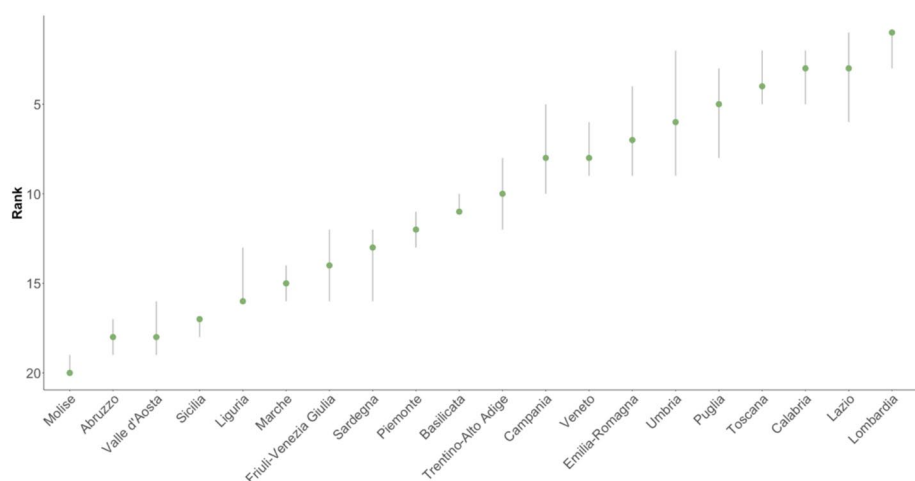


Fig. 4 Median provincial ranks across all replications of the uncertainty analysis, with vertical lines representing the 5th and 95th percentiles of rank variation. The green dots indicate the median rank for each region, providing an overview of ranking stability and variability across the uncertainty analysis. This visualisation highlights the reliability of rankings while identifying regions with higher uncertainty

BoD approach, led to moderate shifts in rankings. These changes were more pronounced for provinces with less consistent performance across dimensions, reflecting the influence of dimension-specific strengths. Switching from the arithmetic mean to alternative aggregation methods, such as the weighted median or the Copeland method, introduced minor adjustments, particularly in the middle of the ranking distribution. The weighted median reduced the impact of outliers, whereas the Copeland method highlighted dominance relationships

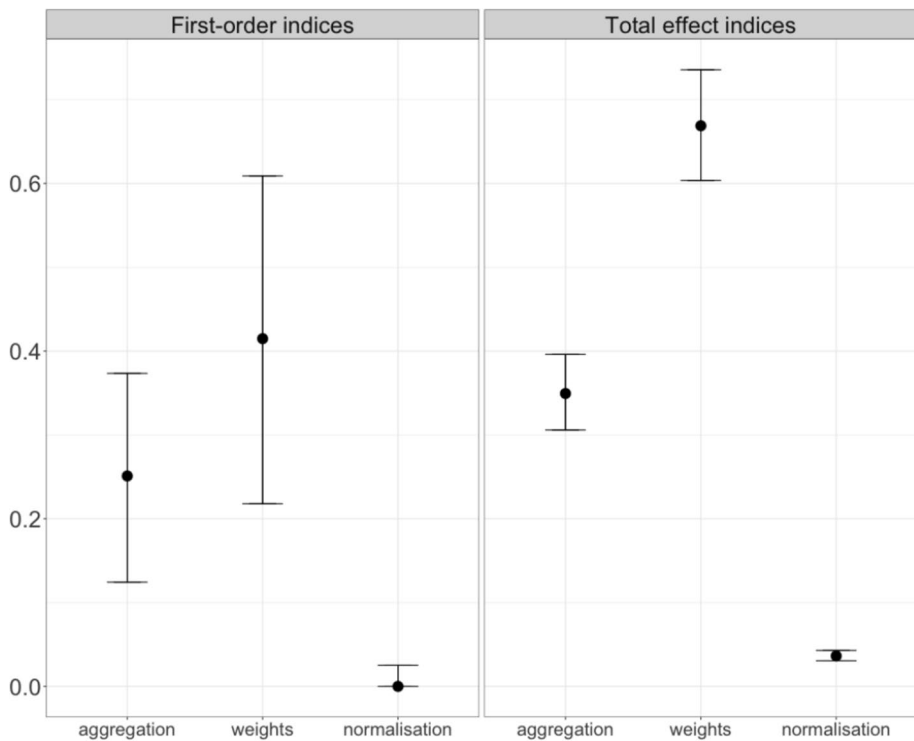


Fig. 5 The first order sensitivity index (left panel) can be interpreted as the uncertainty caused by the effect of the i -th uncertain parameter/assumption on its own. The total order sensitivity index (right panel) is the uncertainty caused by the effect of the i -th uncertain parameter/assumption, including its interactions with other inputs. The y-axis represents the standard deviation of composite scores across alternative modelling choices for normalisation, weighting, and aggregation methods. This figure illustrates the sensitivity of rankings to different methodological choices, highlighting the impact of weighting schemes

among provinces. In contrast, the choice of normalisation method, including min–max scaling, z-scores, ranking, and distance to the maximum, had a negligible impact on rankings, suggesting that this methodological decision does not significantly influence the results.

The interaction effects between weighting and aggregation methods, as shown in the right panel of Fig. 5, further emphasise the complexity of methodological choices. While weighting schemes exerted the strongest influence, their interaction with aggregation methods occasionally amplified rank changes, highlighting the importance of carefully aligning these steps during indicator construction.

However, overall, the findings validate the robustness of the MESS composite indicator. Despite minor variations, the core ranking structure remains stable across methodological scenarios, ensuring that the indicator reliably captures provincial disparities in museum sustainability. These results also emphasise the importance of transparent methodological choices and robust sensitivity analyses in the development of composite indicators.

4 Conclusion

This study provides a framework for assessing the economic and social sustainability performance of museums, highlighting their potential contribution to fostering sustainable development in their local contexts. By evaluating governance practices, community engagement, and service quality, the proposed MESS composite indicator offers a tool to monitor and support museums in aligning with sustainability standards and enhancing their societal impact over time.

Museum sustainability is not uniformly distributed across Italy, with distinct performance patterns at both the regional and provincial levels. While many museums excel in specific dimensions, such as educational activities or public relations, others struggle with inclusivity and accessibility. For example, regions like Lombardia and Toscana emerged as leaders in overall sustainability, driven by robust governance, active community engagement, and consistent investment in cultural heritage. Conversely, regions such as Molise and Abruzzo face structural challenges, including limited financial resources and underdeveloped inclusivity and promotional strategies.

On a policy level, the disparities revealed by the MESS scores necessitate targeted interventions to bridge the gap between high- and low-performing regions (Richards, 2018). Policies encouraging public–private partnerships, fostering collaborations between museums and local stakeholders, and prioritising investments in cultural infrastructure can significantly enhance overall sustainability (Holden, 2015). Special attention should be given to southern regions and smaller institutions, which often face resource constraints and operational inefficiencies (Cracolici & Nijkamp, 2009). Policymakers, therefore, could leverage these insights to design targeted funding strategies, incentivising regions to improve inclusivity, accessibility, and operational efficiency.

The findings, therefore, have significant theoretical and practical implications. From a theoretical perspective, integrating economic and social dimensions into a single composite indicator offers a holistic framework for evaluating museum sustainability performance. This approach aligns with contemporary discussions on sustainability, where cultural institutions are increasingly viewed as agents of societal and economic development (Duxbury & Jeannotte, 2012; Duxbury et al., 2019). Practically, the results provide actionable insights for museum administrators and policymakers. High-performing regions can serve as benchmarks, offering models of best practices that can be adapted to other contexts (Scott (2016). Conversely, for lower-performing regions, targeted investments in governance, accessibility, and community engagement appear critical. Policymakers should consider allocating resources to underperforming areas and fostering public–private partnerships to enhance the sustainability of museums.

From a methodological perspective, the robustness and sensitivity analyses confirmed the reliability of the MESS composite indicator. Despite minor variations in rank, the core ranking structure remained stable across different methodological scenarios, reinforcing the validity of the results. This robustness provides confidence in the MESS indicator as a tool for evaluating museum sustainability and guiding policy decisions.

The sensitivity analysis revealed that the choice of weighting method has the most significant influence on the composite indicator scores compared to the normalisation and aggregation methods (see Fig. 5). This is consistent with findings in the literature, as weighting schemes often determine the relative contribution of each dimension to the overall index. In

this study, we applied proportional weights to the indicators within each dimension, ensuring that all seven dimensions contributed equally to the composite indicator regardless of the number of indicators used to operationalise them. This approach was chosen for its simplicity, transparency, and alignment with the exploratory nature of the analysis.

While this weighting method effectively balances the dimensions, we acknowledge that alternative approaches, such as PCA-derived weights or the Benefit of the Doubt method, could provide additional robustness by incorporating the correlation structure among indicators or optimising weights based on data variability. Exploring such methods represents a valuable avenue for future research aimed at refining the composite indicator further.

In this vein, while the framework proposed in this study reflects the key principles of the *Carta dei Servizi e Standard di Qualità*, it should be acknowledged that the operationalisation of some criteria was constrained by data availability. In particular, the detailed ministerial datasets used for museum accreditation were not accessible for this analysis. Although the Istat survey provides a valuable census perspective on Italian museums, some aspects of quality and sustainability identified in the decree could not be directly measured. This limitation underscores the need for improved data integration between national surveys and accreditation systems to facilitate more comprehensive evaluations in the future.

Another possible limitation is the potential bias due to missing data or the exclusion of smaller museums with lower response rates, as well as the limited number of observations available for some provinces. Since the composite indicator relies on averaging elementary indicators across museums, provinces represented by a limited number of institutions may produce scores that are more sensitive to the characteristics of individual museums rather than reflecting an aggregate provincial condition. Consequently, these provinces may exhibit larger fluctuations and reduced robustness of indicator values, which limits the interpretability and generalisability of their results. Furthermore, in provinces with a large number of museums, the strong performance of a few large, well-resourced institutions can elevate the overall provincial score, potentially overshadowing smaller, underperforming museums. These smaller institutions, which could benefit most from targeted support, may remain invisible in aggregated assessments.

Nonetheless, the robustness of the MESS indicator ensures its applicability in various contexts, making it a valuable tool for continuous monitoring and evaluation. Future research could, on the one hand, integrate qualitative assessments or extend the framework to include additional variables, such as visitor satisfaction or environmental sustainability measures, to enrich the understanding of museum performance, and, on the other hand, address this issue by applying methods tailored explicitly for small-sample contexts or by integrating additional data sources to increase the representativeness of such provincial analyses.

Acknowledgements We acknowledge funding from Next Generation EU, in the context of the project PE5 CHANGES—Spoke9 “Cultural Heritage Active Innovation for Sustainable Society” (CUP B53C22004010006).

Funding Open access funding provided by Università degli Studi di Firenze within the CRUI-CARE Agreement.

Data Availability The datasets analysed during the current study are available at the following link: <https://www.istat.it/en/microdata/survey-on-museums-and-other-cultural-institutions/>.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Andridge, R. R., & Little, R. J. (2010). A review of hot deck imputation for survey non-response. *International Statistical Review*, 78(1), 40–64.
- Becker, W., Caperna, G., Del Sorbo, M., Norlén, H., Papadimitriou, E., & Saisana, M. (2022). COINr: An R package for developing composite indicators. *Journal of Open Source Software*, 7(78), Article 4567.
- Bentler, P. M. (1995). *EQS structural equations program manual*. Multivariate software.
- Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, 107(2), 238–246.
- Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88(3), 588–606.
- Brown, K. (2019). Museums and local development: An introduction to museums, sustainability and well-being. *Museum International*, 71(3–4), 1–13.
- Cracolici, M. F., & Nijkamp, P. (2009). The attractiveness and competitiveness of tourist destinations: A study of Southern Italian regions. *Tourism Management*, 30(3), 336–344.
- Di Fazio, S., & Modica, G. (2018). Historic rural landscapes: Sustainable planning strategies and action criteria. The Italian experience in the global and European context. *Sustainability*, 10(11), 3834–3861.
- Duxbury, N., Kangas, A., & De Beukelaer, C. (2019). Cultural policies for sustainable development: Four strategic paths. In A. Kangas, N. Duxbury, & C. De Beukelaer (Eds.), *Cultural Policies for Sustainable Development* (1st ed., pp. 86–102). Routledge.
- Duxbury, N., & Jeannotte, M. S. (2012). Including culture in sustainability: An assessment of Canada's Integrated Community Sustainability Plans. *International Journal of Urban Sustainable Development*, 4(1), 1–19.
- Goretzko, D., Siemund, K., & Sterner, P. (2024). Evaluating model fit of measurement models in confirmatory factor analysis. *Educational and Psychological Measurement*, 84(1), 123–144.
- Holden, J. (2015). The ecology of culture: A report commissioned by the Arts and Humanities Research Council's Cultural Value Project. AHRC.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55.
- Joint Research Centre. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. OECD publishing.
- Muthén, B. O. (1997). Robust inference using weighted least squares and quadratic estimating equations in latent variable modeling with categorical and continuous outcomes. *Psychometrika*.
- Orea-Giner, A., De-Pablos-Herederó, C., & Vacas Guerrero, T. (2021). Sustainability, economic value and socio-cultural impacts of museums: A theoretical proposition of a research method. *Museum Management and Curatorship*, 36(1), 48–61.
- Pencarelli, T., Cerqueti, M., & Splendiani, S. (2016). The sustainable management of museums: An Italian perspective. *Tourism and Hospitality Management*, 22(1), 29–46.
- Pop, I. L., & Borza, A. (2014). Increasing the sustainability of museums through international strategy. *Economia. Seria Management*, 17(2), 248–264.
- Pop, I. L., & Borza, A. (2016). Quality in museums as a way to increase sustainability. *European Journal of Sustainable Development*, 5(3), 217–228.
- Pop, I. L., Borza, A., Buiga, A., Ighian, D., & Toader, R. (2019). Achieving cultural sustainability in museums: A step toward sustainable development. *Sustainability*, 11(4), 970–992.

- Richards, G. (2018). Cultural tourism: A review of recent research and trends. *Journal of Hospitality and Tourism Management*, 36, 12–21.
- Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48, 1–36.
- Scott, C. A. (2016). *Museums and public value: Creating sustainable futures*. Routledge.
- Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research*, 25(2), 173–180.
- Steiger, J. H., & Lind, J. C. (1980). *Statistically based tests for the number of common factors*. Paper presented at the Annual Meeting of the Psychometric Society.
- Stylianou-Lambert, T., Boukas, N., & Christodoulou-Yerali, M. (2014). Museums and cultural sustainability: Stakeholders, forces, and cultural policies. *International Journal of Cultural Policy*, 20(5), 566–587.
- Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika*, 38(1), 1–10.
- Ursache, M. (2015). Tourism—significant driver shaping a destinations heritage. *Procedia - Social and Behavioral Sciences*, 188, 130–137.
- Xia, Y., & Yang, Y. (2019). RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. *Behavior Research Methods*, 51, 409–428.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.