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IMMERSIVE TECHNOLOGIES IN ITALIAN CULTURAL TOURISM: AN EXPLORATORY ANALYSIS OF VISITOR SATISFACTION AND PREDICTIVE MODELING

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ABSTRACT. This study explores the impact of Augmented Reality (AR) and Virtual Reality (VR) on cultural tourism in Italy. The methodology is twofold. By analyzing visitor satisfaction through a comprehensive survey conducted across 18 museums in northern, central and southern Italy, we aim to understand the role of these technologies in enhancing the tourism experience. An agent-based simulation using NetLogo was employed to predict visitor satisfaction based on various demographic and experiential factors, utilizing monthly seasonal data from the Italian National Institute of Statistics (ISTAT).

The findings indicate that immersive technologies significantly influence visitor satisfaction, with higher levels of engagement and positive experiences reported among users familiar with AR and VR. This study highlights the potential of immersive technologies to enhance cultural tourism and provides insights for cultural institutions aiming to adopt these innovations.

Keywords: augmenter reality (AR), virtual reality (VR), Italian heritage, tourism experience, agent-based simulation

JEL Classification: O39, R19, Z39

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Introduction

Cultural tourism is a significant segment of the tourism industry in Italy, renowned for its rich historical and cultural heritage. Italy's museums, galleries, and heritage sites attract millions of tourists annually, contributing substantially to the national economy. However, the sector faces challenges such as maintaining visitor engagement and adapting to technological advancements (Angeloni, 2013). Interest in immersive experiences in museums and heritage sites has grown in recent years, driven by sectoral challenges and the opportunities presented by emerging technologies. Arts and heritage institutions expect that immersive experiences will enhance visibility, foster innovation, attract new audiences, increase engagement, social sharing and generate additional revenue. Cultural institutions have served as early testing grounds for immersive approaches, benefiting from investment through various funding bodies (Dal Falco & Vassos, 2017; Jelinčić *et al.,* 2022; Kidd & Nieto McAvoy, 2019).

This work is part of a broader project focused on cultural tourism and the impact of immersive technologies on visitors, analyzing not only the immersive experience itself but also the pre-visit and post-visit experiences (Casais *et al.,* 2025, Trunfio *et al*., 2022). Currently, the project concentrates on Italian museums and cultural sites, as Italy boasts the highest concentration of cultural offerings globally[5]. This richness is due to its complex historical evolution, marked by successive dominations that have shaped its archaeological and artistic heritage. The southern regions and islands were part of Magna Graecia from the 8th century BCE, with Greek settlers establishing thriving colonies that profoundly influenced local culture, architecture, and governance. The rise of Rome led to the unification of the Italian peninsula under the Roman Republic and later the Roman Empire, which dominated for centuries, leaving an unparalleled legacy in law, infrastructure, and the arts. Following the fall of the Western Roman Empire, Italy became a battleground for various powers: the Ostrogoths, Byzantines, Lombards, and later the Franks under Charlemagne, each contributing to the cultural mosaic of the region. The Middle Ages saw the emergence of powerful maritime republics like Venice, Genoa, and Pisa, alongside the Papal States, while southern Italy was successively ruled by the Normans, Swabians, Angevins, and

[5] Italy has the highest number of cultural sites in the world listed in the UNESCO World Heritage List, accounting for 54 out of 952 (5.67%), followed by Germany with 51 sites and France with 49.

Aragonesi. The Renaissance period, particularly strong in Florence and Rome, further enriched Italy's artistic and intellectual heritage. This layered history has endowed Italy with an unparalleled cultural legacy, making it a prime location for studies on cultural tourism.

By analyzing immersive experiences across all visitor journey phases, this study provides a more holistic perspective on how AR/VR influences engagement and satisfaction, adding originality to this study. Furthermore, the study also uses data from 18 museums across northern, central, southern Italy and the islands, bringing together a wide spectrum of institutions, from small regional sites to nationally significant museums.

This study aims to analyze the satisfaction of tourists with immersive experiences in Italian museums. A survey was conducted and agent-based modeling (ABM) was employed to understand the socio-demographic factors influencing satisfaction and predict future trends based on seasonal data. ABM has been increasingly recognized for its ability to simulate complex systems and predict outcomes based on individual behaviors and interactions (Wallinger *et al.,* 2023). Its application in tourism research provides valuable insights into visitor behaviors and the potential impacts of technological innovations (Ferreira *et al.,* 2015). For instance, Tieskens *et al.* (2017) utilized ABM to study landscape management scenarios, while Piliponyte *et al*. (2024) applied simulation models to analyze tourism promotion campaigns in South Tyrol, revealing significative insights into visitor distribution and sustainable tourism management. Other works, such as Brodeala (2020) and Capocchi *et al.* (2019), have explored recommender systems and overtourism dynamics, emphasizing the importance of predictive modeling in tourism strategies.

The paper is organized as follows: this section provides a literature review, including an overview of existing research on cultural tourism in Italy, the application of agent-based models in cultural tourism, and an analysis of cultural tourism in Italy based on ISTAT[6] data from 2015 to 2023. Section 2 details the methodology, including the survey and data collection process and the NetLogo simulation setup and parameters. Section 3 presents the results, followed by a discussion. Finally, Section 4 concludes the paper with key findings and recommendations for future research.

Literature review

The study of cultural tourism in Italy is extensive and interdisciplinary, covering historical, socio-economic (Vita, 2018), and technological perspectives (Guccio *et al*., 2016). This subsection reviews key studies and theoretical frameworks

[6] ISTAT stands for "Istituto Nazionale di Statistica," the Italian National Institute of Statistics.

relevant to our analysis. First, an overview of existing research on cultural tourism is provided, outlining its evolution and significance in Italy. Then, the application of agent-based models (ABM) in tourism research is examined, with particular attention to their role in simulating visitor behavior and predicting trends. Finally, cultural tourism trends in Italy from 2015 to 2023 are analyzed, using data from Federculture and ISTAT to explore regional and municipal variations in tourist flows.

Overview of Existing Research

Cultural tourism in Italy is a multifaceted phenomenon that encompasses a wide range of elements and perspectives (among other see Santoro *et al.* 2024). It is analyzed from various angles, including demand and supply, theoretical and operational approaches, and numerous study models (Csapo, 2012). The intrinsic link between tourism and culture is evident, as cultural sites, attractions, and events provide significant motivation for travel, while travel itself can generate and enhance cultural experiences (Petrotta 1957, Morazzoni 2003). Cultural tourism holds substantial potential for local development by attracting tourists and positively impacting income and employment. This perspective has driven numerous studies since the early 1980s, highlighting the role of culture in local development (OECD, 2005). Cultural and creative industries have been increasingly utilized to promote destinations and enhance their competitiveness and attractiveness. Many tourist destinations in Italy have leveraged cultural assets to develop comparative advantages in a competitive market and create distinctive local traits in the face of globalization (OECD, 2009). Recent research highlights the significant impact of cultural tourism in Italy. Cultural tourism is returning to and exceeding pre-pandemic levels, with culture and major events being the main drivers of growth. Santoro *et al.* (2024) proposes definitions, analysis indicators, and data integration methods to better understand and measure cultural tourism in Italy. Market research also indicates that Italy remains a top destination for its cultural heritage, attracting millions of visitors to both major cities and smaller villages.

Immersive experiences, such as Virtual Reality (VR) and Augmented Reality (AR), offer visitors a more interactive and engaging way to experience cultural artifacts and historical narratives. These technologies can enhance visitor satisfaction, increase museum attendance, and create new revenue streams. However, establishing direct links between investment in immersive technologies and measurable outcomes has been challenging, with inconclusive or contested findings (Dogan & Kan, 2020).

Institutions are increasingly focused on understanding the psychological responses of users to immersive programming. A common assumption is that immersive experiences enhance empathy, but this remains an area requiring further

research. Iterative rounds of user testing, including qualitative investigations, can offer insights into their potential impact, though these effects are unlikely to be universal (Sterling, 2020).

The adoption of immersive technologies affects tourists' perceived value and engagement, leading to higher satisfaction and loyalty (Abou-Shouk *et al.,* 2024). Smart Tourism Technology has reshaped the tourism landscape by enhancing convenience, personalization, and engagement. However, the role of cultural value in shaping traveler satisfaction and destination loyalty remains underexplored. Research suggests that Smart Tourism Technology significantly influences traveler satisfaction, which subsequently enhances destination loyalty. However, its direct impact on loyalty appears weaker, indicating that satisfaction serves as a key mediating factor (Lemy *et al.,* 2025).

The integration of emerging technologies presents unique opportunities and challenges for cultural tourism in Italy (Duguleana *et al.,* 2016). Academic literature distinguishes between online and on-site applications of AR and VR in cultural heritage. Online initiatives enhance digital engagement, while on-site applications augment physical visits (Di Pietro *et al.,* 2018). While Italian cultural institutions have begun adopting these innovations, implementation remains inconsistent. Museums, galleries, and archaeological sites across the country are increasingly integrating immersive experiences to attract and engage audiences. Notable projects include the Hidden Florence app and the Smart City Living Lab in Syracuse, which demonstrate AR's potential to enhance visitor experiences while addressing concerns like overtourism and heritage conservation. However, financial constraints have hindered the long-term sustainability of such initiatives, as evidenced by the deactivation of AR totems in Syracuse due to funding shortages (Graziano & Privitera, 2020). Yet, as Nevola *et al.* (2022) observe, AR adoption in Italy has been gradual and requires long-term commitment from stakeholders.

Agent-Based Models in Cultural Tourism

Agent-based modeling (ABM) is a computational approach that simulates the interactions of autonomous agents to assess their effects on the system as a whole. This method is particularly useful in tourism research due to its ability to represent complex, dynamic systems and capture the heterogeneity of individual behaviors (among others see Baktash *et al.,* 2022; Johnson *et al.,* 2016). ABM has been applied in various tourism contexts, including visitor flow management, sustainable tourism development, and the analysis of tourist decision-making processes. For instance, Wallinger *et al.* (2023) discuss the potential of ABM to simulate visitor flows in urban and rural destinations, providing insights for policy makers to enhance economic, social, and environmental resilience in tourism development. Similarly, Boavida-Portugal *et al.,* (2015) highlights the use of

ABM to model the decision-making processes of tourists, offering a deeper understanding of the complex relationships within the tourism system. Despite its advantages, ABM has received limited attention in mainstream tourism research Nicholls *et al.* (2017) identifies several challenges to the adoption of ABM, including technical difficulties, communication barriers, and the novelty of the approach. To address these challenges, Nicholls *et al.* (2017) suggest strategies such as education, raising awareness, and forming interdisciplinary teams. In the context of cultural tourism, ABM can be particularly valuable for simulating the adoption and impact of immersive technologies in museums. By modeling the behaviors and interactions of museum visitors, ABM can help researchers and practitioners understand how different factors, such as socio-demographic characteristics and familiarity with technology, influence visitor satisfaction and engagement.

Applications of Agent-Based Models Based on Survey Data

ABMs have been increasingly used in various fields, including economics and psychology, to analyze complex systems and behaviors based on survey data. In economics, ABMs are employed to simulate market dynamics, consumer behavior, and policy impacts. For example, Pangallo & del Rio-Chanona (2024) discuss how data-driven economic ABMs, initialized from real-world micro-data, can track empirical time series and provide valuable insights for economic research and policymaking. In psychology, ABMs are used to study social interactions, cognitive processes, and behavioral patterns. Canessa *et al.* (2023) highlight the use of ABMs in psychological research to simulate cognitive dynamics and social phenomena, providing a bottom-up approach to understanding complex psychological systems. Eberlen *et al.* (2017) emphasize the potential of ABMs to complement traditional research practices in social psychology, particularly in addressing issues related to the replication crisis. By incorporating survey data, ABMs can enhance the accuracy and relevance of simulations, making them powerful tools for analyzing and predicting behaviors in various contexts. In your study, ABMs can be used to simulate the adoption and impact of immersive technologies in museums, based on survey data collected from visitors.

Analysis on cultural tourism in Italy

This subsection analyzes cultural tourism trends in Italy during the period 2015–2023, drawing on ISTAT data to examine regional and municipal patterns.

Particular emphasis is placed on the year 2019, considered the last full year before the COVID-19 pandemic, which significantly affected tourism in 2020 and most of 2021. The data highlights shifts in tourist distribution, the impact

of the pandemic, and the subsequent recovery, offering valuable insights into the resilience and transformation of the cultural tourism sector in Italy.

Based on ISTAT data, in 2019, cultural tourism in Italy accounted for about two-thirds of the total tourist presence (61.8%). This segment is mainly concentrated in three categories of municipalities:

- Municipalities with a cultural, historical, artistic, and landscape vocation: 431 municipalities.
- Municipalities with multiple vocations, including cultural: 583 municipalities.
- Large cities with multidimensional tourism: 12 municipalities.

The most significant category in terms of absolute presence is that of municipalities with multiple vocations (34.3%), followed by large cities (19.7%) and municipalities with an exclusively cultural vocation (7.8%). Among the municipalities with multiple vocations, those with both cultural and maritime vocations represent 57.7% of the presence, followed by municipalities with cultural and mountain vocations (24.2%). Large cities record the highest average presence per municipality, with over 7 million presences per municipality, highlighting a strong concentration of tourist flows in major centers.

In terms of presence per inhabitant, municipalities with a mountain vocation are in the first place with just over 26 presences per inhabitant, followed by lake tourism municipalities (23.7) and maritime vocation municipalities (19).

An analysis of data from 2015 to 2022 reveals that large cities experienced a notable increase in their share of presence, peaking at 19.7% in 2019. However, they also endured the steepest declines during the pandemic. By 2022, their share had nearly returned to pre-pandemic levels, reaching 16.9%. In contrast, municipalities with an exclusively cultural focus maintained a steady share of approximately 8% throughout the period. The recovery trend continued into 2023, with large cities regaining 18.5% of the total presence—signaling a strong rebound (Laratta, 2024).

Between 2015 and 2023, large cities experienced notable fluctuations in their share of tourist presence. This share grew steadily, reaching 19.7% in 2019, just before the COVID-19 pandemic. However, during the pandemic years, large cities experienced the sharpest decline. A gradual recovery began in the following years, with the share rising to 16.9% in 2022, approaching pre-pandemic levels. The rebound continued into 2023, when large cities accounted for 18.5% of total tourist presence, confirming a strong upward trend (Laratta, 2024). Throughout the period, municipalities with an exclusively cultural vocation maintained a stable presence share of around 8%

Tourist Trends from 2015 to 2023

From 2015 to 2019, all categories characterized by cultural tourism saw positive variations in tourist presence. The largest increases were observed in large cities (+21.7%), followed by municipalities with a mountain vocation (+14.6%) and those with a cultural, historical, artistic, and landscape vocation (+13.7%), all exceeding the national average (+11.2%). Municipalities with multiple vocations, including cultural, saw a slightly lower increase (+8.7%).

In 2020, during the pandemic, large cities experienced the most significant decline in tourist presence, far exceeding the national average (-74.2% in large cities vs. -52.3% nationally). Municipalities with an exclusively cultural vocation saw a decline almost equal to the national average (-52.9%), while those with multiple vocations, including cultural, had a smaller decline (-44.1%). In 2021, there was a recovery in tourist flows across all categories, with some variations significantly exceeding the national average (+38.7%). Large cities saw a positive variation of 49.8% (+11.1 points above the national average), and municipalities with an exclusively cultural vocation saw a variation of 44.1% (+5.4 points above the national average). Municipalities with multiple vocations, including cultural and landscape, had a more contained variation (+29.4%), 9.4 points below the national average. During the same period, other types of municipalities also saw growth in tourist flows: lake municipalities (+82.3%), thermal municipalities (+65.8%), and maritime municipalities (+46.9%), all exceeding the national average. Mountain municipalities, although growing, recorded the lowest increase (+3.5%).

In 2022, the growth in tourist flows continued for all categories, with large cities showing a particularly notable increase (+104.4%), almost three times the national average (+39.3%). However, compared to 2019, the levels had not yet fully recovered (-21.0%). Municipalities with an exclusively cultural vocation and those with multiple vocations, including cultural and landscape, had variations in line with the national average (+39.3% and +33.3%, respectively), but still had not recovered pre-pandemic volumes (-5.4% and -3.7% vs. -7.8% nationally).

In 2023, tourism in Italy reached record levels, with over 134 million arrivals and 451 million presences. Large cities continued their recovery, achieving an 18.5% share of total presence, while municipalities with multiple vocations, including cultural, saw a 35.1% share. Municipalities with an exclusively cultural vocation maintained a stable share of around 8.2%. The data indicates a robust recovery and growth in cultural tourism, surpassing pre-pandemic levels in several categories.

Cultural Tourism Trends in 2023

The year 2023 marked a significant recovery for cultural tourism in Italy, consolidating the positive trends observed in 2022 and leaving behind the crisis years. The following key insights highlight the main trends in cultural participation and tourism for 2023.

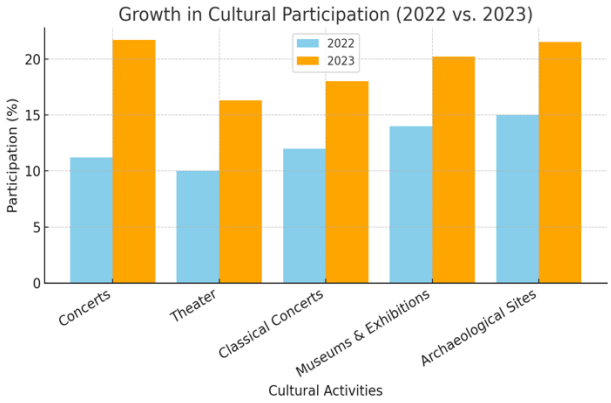

Figure 1. Growth in cultural participation in Italy (2022-2023).
Source: Authors' elaboration based on ISTAT data.

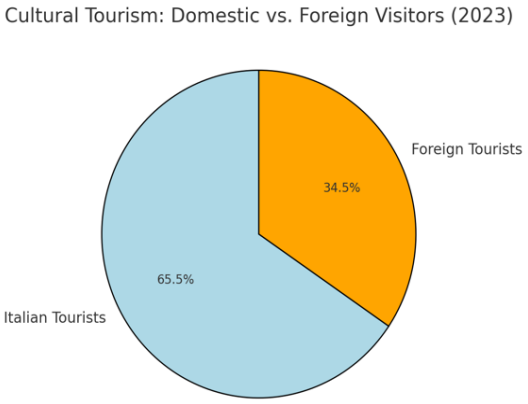

Figure 2. Domestic vs foreign visitors in Italy (2023).
Source: Authors' elaboration based on ISTAT data.

Regarding cultural participation, engagement in cultural activities outside the home increased substantially, with 35.2% of citizens participating in cultural events, reflecting a 12% rise compared to 2022. Notable growth was recorded

in concert attendance (from 11.2% to 21.7%), theater visits (+63%), classical concerts (+50%), museum and exhibition attendance (+44%), and visits to archaeological sites and monuments (+43%).

There was a substantial growth of cultural tourism: 34.5% increase in foreign tourists visiting Italy's cities of art was recorded, reinforcing the crucial role of cultural heritage in the country's tourism sector. This segment accounted for over 50% of the total tourism market, underlining the economic significance of cultural tourism.

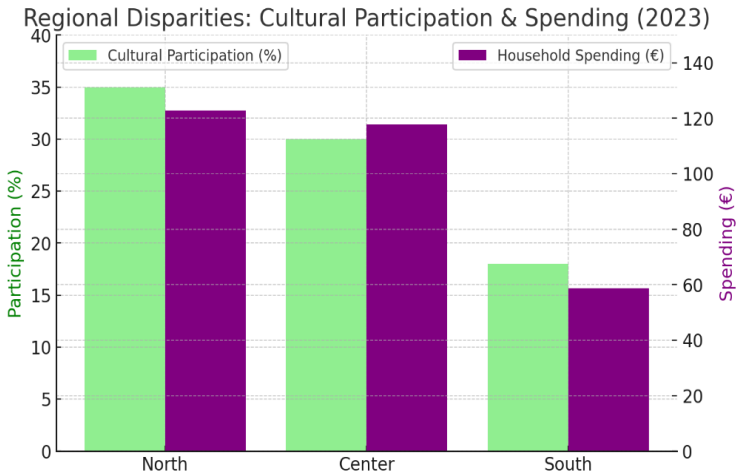

Figure 3. Italian regional disparities in cultural participation and spending (2023). Source: Authors' elaboration based on survey data.

Despite the overall positive trends, significant regional disparities persisted in cultural participation and spending. The North and Center reported higher engagement compared to the South. For instance, in Trentino Alto Adige, 30-40% of residents attended cultural events, whereas in Calabria, Sicily, and Basilicata, participation ranged from 15-20%. Similarly, household spending on culture remained higher in the North (€122.8) and Center (€117.8) compared to the South (€58.7), reflecting a continued geographical divide in cultural accessibility and investment.

These findings reinforce the resilience and ongoing transformation of cultural tourism in Italy, positioning it as a key driver of economic and social revitalization in the post-pandemic era.

Methodology

Survey and Data Collection Process

This study is among the first to combine large-scale survey data on immersive museum experiences in Italy with agent-based modeling (ABM). While both methods have been used independently in tourism research, their integration to model visitor satisfaction in the context of AR/VR in cultural heritage is innovative.

The survey was designed to collect data on visitors' immersive experiences in Italian museums and cultural sites. It consists of two sections: a socio-demographic section and a section evaluating the one-time immersive experience of the visitor. The survey is completed immediately after the physical visit to the museum or cultural site. The survey is anonymous and voluntary, with assistance provided by museum staff if needed. Visitors access the survey by scanning a QR code displayed on a bilingual (Italian and English) poster. The questions, although consistent across all surveys, were tailored to the specific offerings of each cultural site (e.g., whether both VR and AR were available or only one of the two). Data collection is ongoing, and this study is based on survey responses collected from 18 museums across northern, central, and southern Italy. A total of 216 responses were gathered between late November 2024 and early March 2025, during the low seasonal period.

The cultural sites from which responses have been collected so far are:

- Northern Italy: Lumen Museum, Cles Palace, SASS, Rodari Museum, Forte Bard
- Central Italy: Villae, Appia Park
- Southern Italy: Villa Frigerj, La Civitella Museum, Castello Svevo, Castel del Monte, Castello Melfi, Siritide Archaeological Museum, Sannio Caudino Archaeological Museum, Libero d'Orsi Archaelogical Museum, G. Vallet Museum
- Islands: Turritano Archaeological Museum, Bellini Museum

The survey collects information on the following variables:

- Age
- Gender
- Level of education
- Country of origin
- Familiarity with immersive technologies (e.g., VR, AR, virtual tours)
- Overall satisfaction with the visit

The familiarity with immersive technologies and the satisfaction with the immersive experience are measured using a Likert scale from 1 (strongly disagree) to 5 (strongly agree), with 3 indicating a neutral opinion. The satisfaction with the immersive experience is assessed through a total of 9 questions, as follows:

Pre-visit experience:

- "Before the visit, the virtual tour sparked my surprise and interest in the museum."

During the visit (5 questions):

- "The use of augmented/virtual reality has improved my visit to the museum."
- "The information provided through augmented/virtual reality was clear and useful."
- "I found the use of AR/VR technology at the museum interesting."
- "Virtual reality has enriched my geographical and cultural understanding."
- "I experienced positive emotions and a sense of connection during the AR/VR experience."

Post-visit experience:

- "After the visit, augmented/virtual reality helps me better understand the museum's information."

Expectations:

- "I would like to use AR/VR again during future visits."

Concluding question:

- "I would recommend using AR/VR to other visitors."

NetLogo Simulation Setup and Parameters

The agent-based simulation conducted using NetLogo is designed to predict visitor satisfaction based on various demographic and experiential factors. The simulation utilizes monthly seasonal data from ISTAT and analyzes the following variables:

- Age range
- Gender

- Provenance (Italian or foreign)
- Education level: Categorized as Low, Medium, and High.
- Familiarity with immersive technologies: Categorized as Low, Medium, and High.
- Satisfaction with the immersive experience: Categorized as Low, Medium, and High.

The simulation models the interactions and behaviors of visitors within the museum environment, taking into account these factors to reflect the actual conditions observed in the participating museums. The parameters were set based on the survey data collected, and the model was calibrated to ensure accuracy in predicting visitor satisfaction.

Simulation Code Analysis

The simulation setup involves the following key steps:

Global Variables

- season: Represents the current season, initially set to "spring".
- adoption-rate: Represents the adoption rate of immersive technology, set to 0.15.

Turtle Variables

- age: Age of the visitor.
- gender: Gender of the visitor ("male" or "female").
- education: Education level of the visitor ("low", "medium", "high").
- origin: Origin of the visitor ("Italy" or "Outside").
- tech-familiarity: Familiarity with immersive technology, measured on a Likert scale from 1 to 5.
- satisfaction: Satisfaction with the immersive experience, measured on a Likert scale from 1 to 5.

Setup Procedure

Clears the environment and sets initial values for season and adoption-rate.
Creates 290 turtles (representing tourists) and assigns random positions.
Assigns demographic and experiential attributes to each turtle based on weighted distributions.
Sets visual attributes (color and size) based on technological familiarity and satisfaction levels.

Helper Functions

- weighted-age: Assigns age based on a weighted distribution.
- weighted-education: Assigns education level based on a weighted distribution.
- weighted-tech-familiarity: Assigns technology familiarity based on a weighted distribution.
- weighted-satisfaction: Assigns satisfaction level based on a weighted distribution.

The simulation uses these weighted distributions to create a realistic representation of the visitor population and their interactions with immersive technologies. The model is calibrated to reflect the actual survey data, ensuring accurate predictions of visitor satisfaction. The detailed code for the NetLogo simulation is provided in the appendix.

Results

This section presents the key findings of our study. First, the results of a visitor survey conducted in 18 Italian museums are analyzed, focusing on demographic characteristics, familiarity with immersive technologies, and satisfaction levels during the low-season period. Then, based on the survey data, an agent-based model (ABM) is implemented in NetLogo to simulate and predict visitor behaviors during the spring season.

Survey Findings

Southern Italy hosts the highest number of museums in the survey (50%), while Central Italy, despite having only 11% of the museums, records a disproportionately high number of visitors. This reflects national trends, where Lazio—particularly Rome—attracts the largest share of cultural tourists. Northern Italy (22%) and the Islands (11%) form distinct museum clusters, with visitor numbers varying significantly, indicating different regional tourism dynamics.

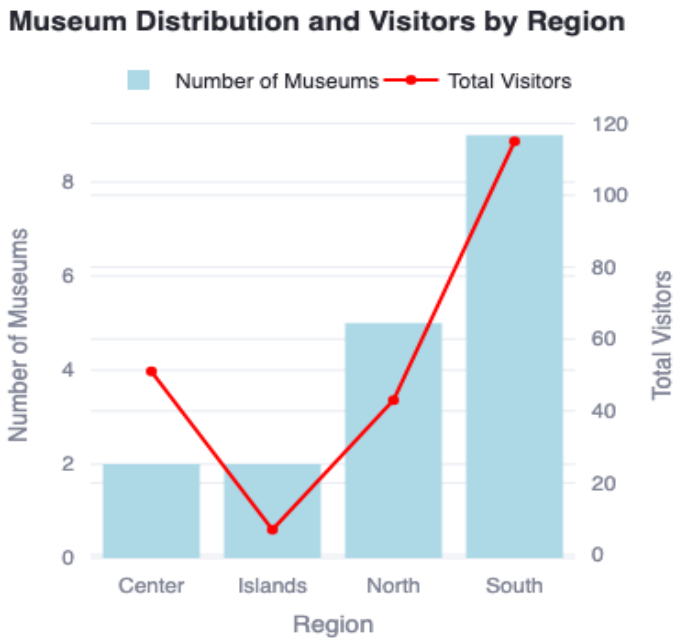

Figure 4. Museum Distribution and Visitors by Region (2025).
Source: Authors' elaboration based on survey data.

The vast majority of visitors (82.1%) were Italian, while 17.9% were international tourists. Gender distribution follows general museum trends (Hill, 2016; Lacoe et al., 2020), with female visitors predominating (57.4%) over male visitors (42.6%) in most institutions. However, exceptions include Villae and Vallet museums, where male visitors were more frequent. The most balanced gender distribution was observed in medium-sized museums.

Visitor demographics per Museum

The highest visitor counts were recorded at Villae (14.8% of total visitors) and Montesarchio (14.4%). Several museums showed moderate attendance (7-11.6%), while smaller institutions such as SASS and Bellini had minimal attendance (0.5-0.9%). These variations suggest significant differences in museum popularity and accessibility.

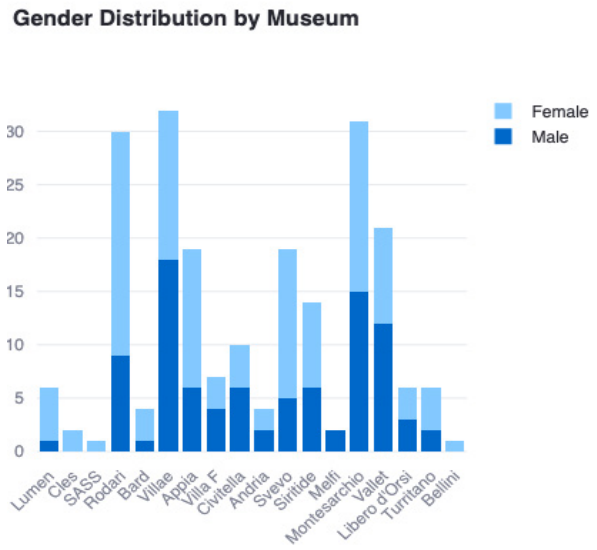

Figure 5. Gender Distribution by Museum.
Source: Authors' elaboration based on survey data.

Figure 6. Number of Visitors per Museum.
Source: Authors' elaboration based on survey data.

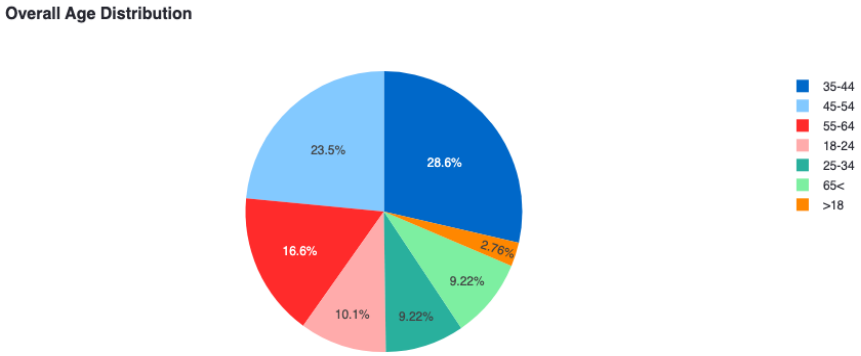

Figure 7. Overall Age Distribution of Visitors.
Source: Authors' elaboration based on survey data.

The most represented age groups were middle-aged visitors: 35-44 (28.6%) and 45-54 (23.5%), making up a substantial proportion of the total. Young adults (18-24: 10.1%) and seniors (65+: 9.2%) accounted for smaller but notable shares, while visitors under 18 constituted the smallest segment (2.8%). These trends suggest that museums primarily attract adult audiences, indicating opportunities to enhance engagement with younger visitors.

Higher education levels were dominant among visitors, with 63.7% holding complete university degrees. Medium education levels represented a substantial secondary segment (25.9%), while lower education levels had minimal representation (10.5%). These findings suggest that museums primarily attract individuals with higher educational backgrounds.

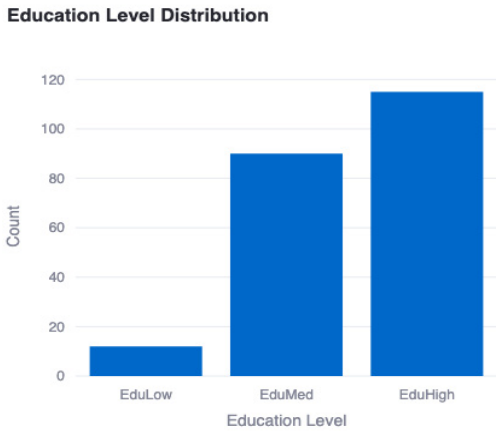

Figure 8. Education Level Distribution of Visitors
Source: Authors' elaboration based on survey data.

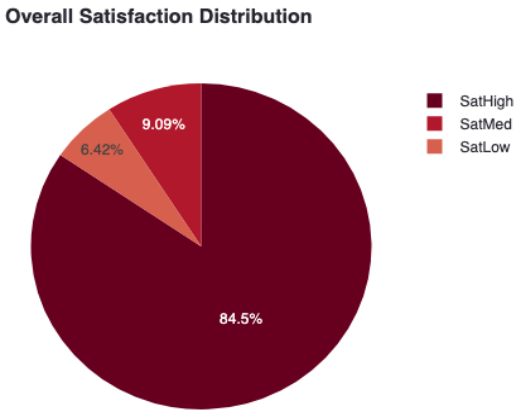

Figure 9. Overall Visitor Satisfaction Distribution
Source: Authors' elaboration based on survey data.

Visitor Satisfaction

Overall, visitor satisfaction levels were high across all surveyed museums. A significant portion (84.5%) of visitors reported high satisfaction, while medium satisfaction was noted in 9.1% of cases. Only 6.4% of visitors expressed low satisfaction, suggesting generally positive visitor experiences.

Visitors with high technology familiarity (62.2% of respondents) tended to report higher satisfaction levels, with 80.7% of respondents in this group reporting high satisfaction. In contrast, visitors with medium technology familiarity (16.2%) showed a more balanced satisfaction distribution, with 53.6% reporting high satisfaction and 26.8% medium satisfaction. Those with lower technology familiarity (21.6%) exhibited more varied satisfaction ratings, with 62.5% high satisfaction, 23.4% medium satisfaction, and 14.1% low satisfaction. This pattern suggests that comfort with technology may influence overall museum experience satisfaction (see figure 10).

Relationship between technology familiarity and visitor satisfaction

This relationship is depicted by Figure 10, below.

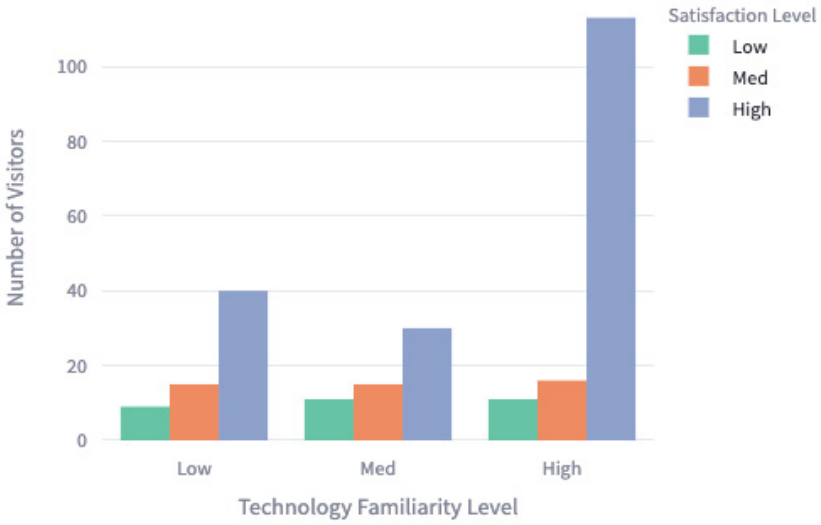

Figure 10. Relationship between technology familiarity and visitor satisfaction. Source: Authors' elaboration based on survey data.

Correlation Analysis

There is a statistically significant positive correlation (0.62) between higher education levels (EduHigh) and overall visitor numbers, suggesting that museums with educational content attract more educated visitors. Visitor demographics exhibit interesting patterns: museums with higher male attendance also tend to have higher international visitors (correlation 0.58), indicating potential gender differences in international tourism. The 35-44 age group shows the strongest correlation (0.71) with high technology familiarity (FamHigh), suggesting this demographic is most comfortable with digital museum technologies. Museums with visitors reporting high satisfaction (SatHigh) show positive correlation with both high education levels (0.57) and high technology familiarity (0.49), highlighting the potential influence of these factors on visitor experience quality.

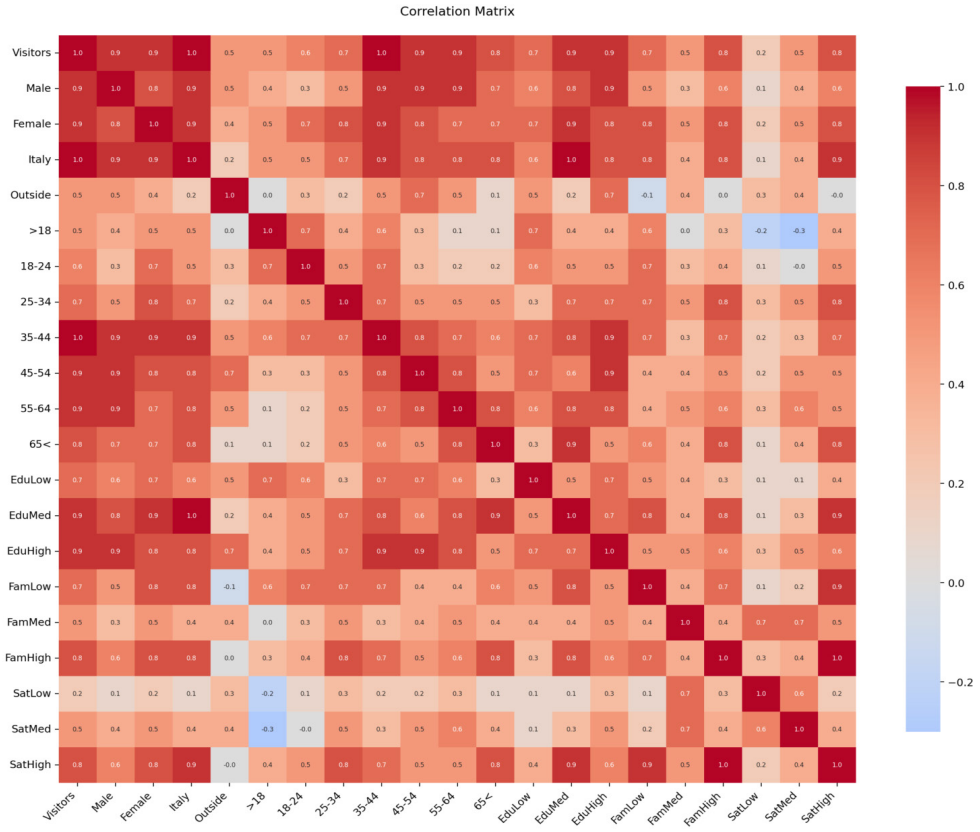

Figure 11. Correlation matrix of visitor characteristics and museum experience. Source: Authors' elaboration based on survey data.

Statistical Insights

Mean visitor counts vary significantly across museums, with a high standard deviation reflecting attendance variability. Demographic distributions confirm clear patterns across different visitor segments, reinforcing the trends observed in graphical representations.

The summary statistics reveal significant variations in museum visitation patterns, with a mean of 12.0 visitors per museum but a substantial standard deviation of 10.5, indicating a highly uneven distribution of visitors across institutions. Demographic analysis shows that Italian visitors (mean: 9.9) substantially outnumber international visitors (mean: 2.1), with an 82.5% to 17.5% split, suggesting primarily domestic interest in these cultural institutions.

Gender distribution analysis shows a slight female predominance (mean: 6.6) compared to male visitors (mean: 5.4), representing a 55% to 45% split, consistent with broader cultural visitation patterns. Education level statistics confirm the prominence of visitors with high educational attainment (mean: 6.4), representing 53.3% of all visitors, compared to medium (mean: 5.0, 41.7%) and low education levels (mean: 0.7, 5.0%), highlighting museums' appeal to educated audiences. For details see Table 1 in Appendix.

Agent-Based Model (ABM) Simulation Results

The NetLogo simulation was used to analyze visitor satisfaction under different conditions, considering seasonal trends, demographics, and familiarity with immersive technologies. The simulation complements our survey data by modeling potential changes in visitor satisfaction under different technology adoption scenarios, providing predictive insights that cannot be directly derived from static survey responses.

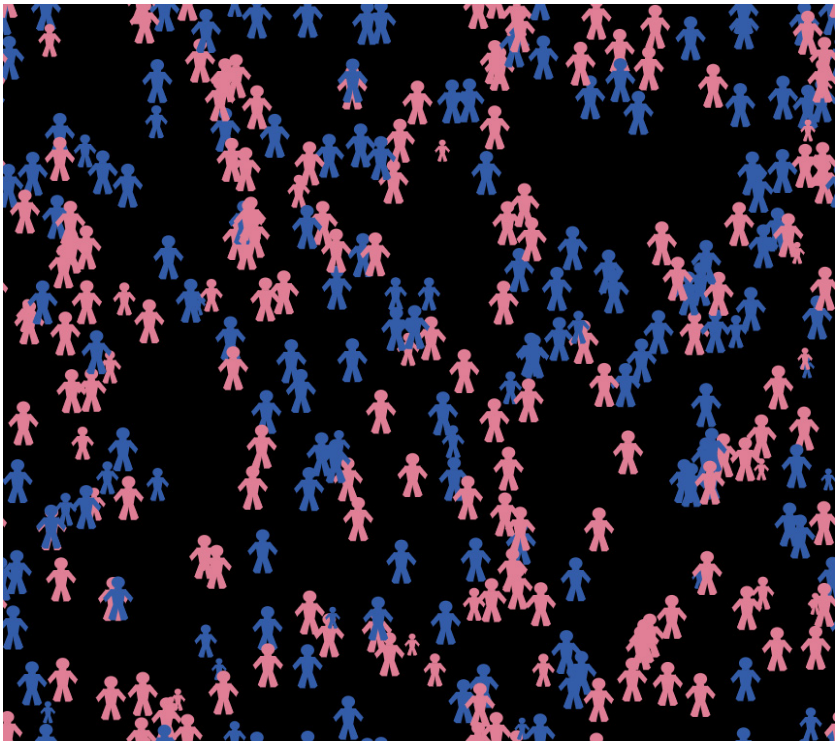

Figure 12. Netlogo Simulation: Spring 2025.
Source: Authors' elaboration based on simulation data.

Visual Representation of Agents

Tourists are visually encoded within the simulation for intuitive observation:

- *Shape*: Each agent is depicted as a "person" shape.
- *Color Coding*: Gender is differentiated through color—blue for male, pink for female.
- *Size Encoding*: Satisfaction levels are visually emphasized through size: agents with high satisfaction are largest, followed by medium, and then low satisfaction levels.

The simulation replicates the behaviors and demographic characteristics of 290 tourists visiting a diverse set of museums during the spring season. The initial adoption rate for immersive technologies among tourists is set at 15%, in alignment with empirical estimations from preliminary survey data.

Tourist Demographics

The virtual population was constructed to mirror real-world distributions based on survey inputs:

- *Age Distribution*: The tourists' ages span from under 18 to over 65, with the most significant concentration found within the 35–54 age range. This segment comprises a pivotal demographic for cultural engagement and technology adoption.
- *Gender Distribution*: A slight majority of tourists are female (57.4%), compared to 42.6% male, indicating a gendered nuance in museum visitation patterns.
- *Educational Attainment*: High educational levels predominate among the tourists, suggesting a correlation between academic background and cultural tourism.
- *Geographic Origin*: Most tourists originate from Italy (82.1%), with the remaining portion representing international visitors. This underscores the domestic appeal of the museum network in the analyzed region.

Museum Allocation

Tourists are algorithmically distributed across various museums based on historical attendance data. The simulation includes diverse institutional types—such as Villae, Montesarchio, Medium-sized museum, Small museum, SASS, and Bellini—thereby allowing for the observation of heterogeneous visitor dynamics across museum typologies.

Familiarity with Immersive Technology

Familiarity levels with immersive technologies were also integrated into the simulation. Most tourists exhibit a high level of familiarity, followed by medium and low levels, reflecting the growing pervasiveness of digital interfaces in cultural experiences.

Tourist Satisfaction

The simulation reveals notable satisfaction outcomes:

- *High Satisfaction*: 84.5% of tourists report high satisfaction, reflecting strong engagement levels with the museum offerings.
- *Medium Satisfaction*: 9.1% of tourists express a moderate level of satisfaction.
- *Low Satisfaction*: Only 6.4% of tourists report low satisfaction, indicating a marginal discontent that warrants further investigation, particularly in relation to museum assignment and technological familiarity.

Discussion

Cultural tourism trends from ISTAT are examined to assess their alignment with visitor demographics and behaviors identified through the survey and the simulation.

Domestic tourism remains prevalent in both our data and ISTAT trends, with a growing portion of international tourism, particularly in the post-pandemic period. Our simulation also predicts a slight increase in foreign tourists in the coming months. Considering the location of museums, those centrally situated in Lazio and the Museo Rodari in Lombardia recorded the highest levels of responses. This is partially consistent with Figure 3, which highlights greater cultural engagement in central-northern Italy compared to the south. However, the situation in the north is still evolving; for example, museums in Trentino currently show low participation rates, likely due to closures affecting some of these institutions, a part of which was therefore not included in this initial survey. Significant deviations or emerging patterns may indicate shifts in visitor preferences, such as increased interest in immersive and interactive experiences. Similar studies have highlighted the growing role of immersive technologies in enhancing visitor experiences and promoting cultural heritage (Pratisto *et al.,* 2022; Colamatteo *et al.,* 2024)

According to De Luca *et al.* (2022), VR technology can significantly enhance visitor engagement with cultural heritage, as demonstrated by their VR360 application for the city of Bari. Their user experience (UX) evaluation revealed high satisfaction levels in terms of usability, immersion, and the sense of presence. Similarly, Li & Huang (2022) emphasize how the virtual Palace Museum leverages immersive storytelling, interactive learning, and peer sharing to transform passive tourists into active explorers. These findings align with Guttentag's (2010) argument that VR can provide alternative heritage experiences, supporting both visitor engagement and heritage preservation. Furthermore, Bekele *et al.* (2018) highlight the role of augmented reality (AR) in enhancing historical education and cultural visualization. Our findings contribute to this ongoing discussion, examining the nuanced impact of digital tools in cultural heritage settings, including both their benefits and potential drawbacks.

Immersive technologies present significant potential benefits, as they can greatly enhance visitor engagement, learning, and overall satisfaction. By offering interactive and multisensory experiences, they appeal to a broader audience, particularly younger generations and international visitors, which is essential for the future of cultural tourism. Additionally, the ability to virtually recreate historical settings and artifacts provides new opportunities for education and accessibility, allowing a wider range of users to engage with cultural heritage in innovative ways.

The findings from the NetLogo simulation reinforce these theoretical considerations. The simulated population, calibrated on the demographic characteristics from survey data, showed high levels of satisfaction among tourists—especially those with a high familiarity with immersive technologies. Notably, 84.5% of virtual visitors reported high satisfaction, with only 6.4% expressing dissatisfaction. This suggests a strong alignment between technological familiarity and positive user experience. Moreover, the simulation revealed that increasing the adoption rate of immersive technologies (from 15% to 30%) can potentially amplify satisfaction levels across the visitor base. The visual encoding of agents in the simulation further supports this pattern: tourists with higher technological familiarity appeared larger and were more prevalent in high-satisfaction categories. This outcome highlights not only the importance of increasing access to immersive experiences but also the value of digital literacy initiatives in museums to reduce exclusionary effects. In terms of museum typologies, the simulation allowed for comparative analysis across different institutions (e.g., Villae, SASS, Bellini, Montesarchio), suggesting heterogeneous responses that could be further investigated in future research to assess context-specific effects of immersive technology deployment.

However, these advancements also introduce challenges and critical reflections. The increasing reliance on digital content raises concerns about the potential dilution of authenticity in traditional museum experiences. While virtual environments can offer deeper engagement, they might also shift the focus away from the tangible, physical aspects of heritage. Furthermore, the integration of these technologies requires substantial investment, not only in digital infrastructure but also in staff training to ensure effective implementation. Museum management must carefully balance technological innovation with heritage conservation, ensuring that digital enhancements complement rather than overshadow traditional cultural narratives.

Despite these insights, it is important to acknowledge the survey's limitations. As the study is still ongoing, the findings remain preliminary and subject to updates as data collection progresses. The voluntary nature of participation may introduce selection bias, as some visitors may have opted not to take part. Additionally, while the use of a QR code aimed to facilitate quick and easy access to the survey, it may have inadvertently discouraged participation among visitors with lower digital literacy. Regarding representation and data scope, the participating museums are geographically distributed across northern, central, and southern Italy. However, they may not fully capture the diversity of immersive technology applications nationwide. Some major museums with high tourist flows have yet to join the study, potentially limiting the generalizability of the findings. Looking ahead, future improvements and research directions will focus on expanding the dataset to enhance the accuracy of predictive models, such as the NetLogo simulation. As data collection continues, a more comprehensive analysis will provide deeper insights into the evolving role of immersive technologies in cultural heritage. Integrating longitudinal data and cross-institutional comparisons could also help refine strategic planning in museum management, ensuring inclusive, impactful, and sustainable adoption of immersive tools.

Conclusions

This study highlights the continued predominance of domestic tourism in Italy, with a gradual increase in international visitors, particularly in the post-pandemic period. The findings underscore significant regional disparities in museum participation, with central institutions experiencing higher engagement than their northern and southern counterparts. Moreover, immersive technologies are emerging as powerful tools for enhancing visitor engagement, learning, and satisfaction, aligning with trends observed in ISTAT data and existing academic research.

While immersive and interactive experiences hold great potential for attracting diverse audiences, including younger and international visitors, their implementation requires careful consideration. The integration of digital tools must strike a balance between innovation and heritage conservation, ensuring that technological advancements enhance rather than diminish the authenticity of museum experiences. In our project, the survey is still ongoing; therefore, we aim to verify the ABM predictions and refine our findings after the conclusion of the spring 2025.

Additionally, future research should explore the differential impact of immersive technologies across various demographic groups, particularly focusing on their influence on younger visitors and international tourists. We are specifically aiming to focus on student groups.

Finally, future studies should investigate the long-term effects of digital tools on visitor engagement, retention, and museum attendance. Given that immersive and interactive experiences are still in their early stages, further data collection is needed. More specifically, museums should leverage immersive technologies to enhance visitor experiences, making cultural heritage more accessible and engaging. This can only be achieved after the allocation of PNRR funds in Italy, which are currently enabling the digitalization of many museums, so the work is still ongoing. It could also be valuable to disseminate surveys and other data-driven strategies in museums to optimize marketing efforts and tailor exhibits to meet evolving visitor expectations. Museums must ensure that technological innovations complement traditional museum narratives, preserving the authenticity and integrity of cultural heritage.

As digital transformations continue to reshape cultural tourism, museums must adopt a strategic approach that embraces innovation while preserving the richness of historical and artistic heritage. Ongoing research will be essential in guiding these developments and ensuring that immersive technologies serve as a bridge—rather than a barrier—to cultural appreciation.

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REFERENCES

Abou-Shouk, M., Zouair, N., Abdelhakim, A., Roshdy, H. & Abdel-Jalil, M. (2024), The effect of immersive technologies on tourist satisfaction and loyalty: the mediating role of customer engagement and customer perceived value. *International Journal of Contemporary Hospitality Management*, *36* (11), 3587-3606. https://doi.org/10.1108/IJCHM-09-2023-1496

Angeloni, S. (2013). The Strategic Plan for Tourism Development in Italy. *Economia. Seria Management*, *16*(1), 106–120. Available at: https://ideas.repec.org/a/rom/econmn/v16y2013i1p106-120.html

Bekele, M.K., Pierdicca, R., Frontoni, E., Malinverni, E.S. & Gain, J. (2018) A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. *Journal on Computing and Cultural Heritage*, *11*(2), 1-36. https://doi.rog/10.1145/3145534

Brodeala, L.C. (2020). Online Recommender system for Accessible Tourism Destinations. In Proceedings of the RecSys '20: 14th ACM Conference on Recommender Systems, Virtual, 22–26 September 2020; Association for Computing Machinery: New York, NY, USA, 2020; 787–791. https://doi.org/10.1145/3383313.341145

Baktash, A., Huang, A., de la Mora Velasco, E., Jahromi, M.F. & Bahja, F. (2022). Agent-based modelling for tourism research. *Current Issues in Tourism*, *26*(13) 2115–2127. https://doi.org/10.1080/13683500.2022.2080648

Boavida-Portugal, I., Ferreira, C. C. & Rocha, J. (2015). Where to vacation? An agent-based approach to modelling tourist decision-making process. *Current Issues in Tourism*, *20*(15), 1557–1574. https://doi.org/10.1080/13683500.2015.1041880

Canessa, E., Chaigneau, S.E. & Marchant, N. (2023). Use of Agent-Based Modeling (ABM) in Psychological Research. In *Trends and Challenges in Cognitive Modeling* (Early Access, 7–20). https://doi.org.10.1007/978-3-031-41862-4_2

Capocchi, A., Vallone, C., Pierotti, M. & Amaduzzi, A. (2019). Overtourism: A literature review to assess implications and future perspectives. *Sustainability*, *11*(12), 3303. https://doi.org/10.3390/su11123303

Casais, B., Coelho, T., & Escadas, M. (2025). Sensory marketing in the metaverse for tourism preview and tourism pre-experience: the effect on the intention to visit tourist destinations. *Tourism Review*. https://doi.org/10.1108/TR-06-2024-0540

Colamatteo, A., Sansone, M., Pagnanelli, M.A. & Bruni, R. (2024), The role of immersive technologies in cultural contexts: future challenges from the literature, *Italian Journal of Marketing,* 113–142. https://doi.org/10.1007/s43039-024-00089-4

Csapó, J. (2012). The Role and Importance of Cultural Tourism in Modern Tourism Industry. In Kasimoglu, M. (*Ed.*). *Strategies for Tourism Industry. Micro and Macro Perspectives*: pp. 202-232. London, UK: IntechOpen. https://doi.org/10.5772/2685

Dal Falco, F. & Vassos, S. (2017). Museum experience design: A modern storytelling methodology. *The Design Journal*, *20*(sup1), S3975-S3983. https://doi.org/10.1080/14606925.2017.1352900

De Luca, V., Marcantonio, G., Barba, M.C. & De Paolis, L.T. (2022). A virtual tour for the promotion of tourism of the city of Bari, *Information*, *13*(7), 339. https://doi.org/10.3390/info13070339

Di Pietro, L., Guglielmetti Mugion, R. & Renzi, M.F. (2018). Heritage and identity: Technology, values and visitor experiences. *Journal of Heritage Tourism, 13*(2), 97–103. https://doi.org/10.1080/1743873X.2017.1384478

Dogan, E. & Kan, M.H. (2020). Bringing heritage sites to life for visitors: towards a conceptual framework for immersive experience. *Advances in Hospitality and Tourism Research*, *8*(1), 76-99. https://doi.org/10.30519/ahtr.630783

Duguleana, M., Brodi, R., Girbacia, F., Postelnicu, C., Machidon, O. & Carrozzino, M. (2016). Time-travelling with mobile augmented reality: A case study on the Piazza dei Miracoli, In M. Ioannides et al. (Eds.), *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. EuroMed 2016, Lecture Notes in Computer Science*, *10058*, 73–84). Springer, Cham. https://doi.org/10.1007/978-3-319-48496-9_73

Eberlen, J., Scholz, G. & Gagliolo, M. (2017). Simulate this! an introduction to agent-based models and their power to improve your research practice. *International Review of Social Psychology*, *30*(1),149-160. https://doi.org/10.5334/irsp.115

Federazione nazionale delle Imprese della Cultura, Regioni, Enti Locali, Federculture, (2024), IMPRESA CULTURA, 20° Rapporto Annuale. https://www.federculture.it/attivita/studi-ricerche-e-pubblicazioni/

Ferreira, A.R., Mendes, R. & Vareiro, L. (2015). Residents' perceptions of film-induced tourism. 55th Congress of the European Regional Science Association: "World Renaissance: Changing roles for people and places", Lisbon, Portugal, 25–28 August. https://hdl.handle.net/10419/124821

Graziano, T. & Privitera, D. (2020). Cultural heritage, tourist attractiveness and augmented reality: insights from Italy. *Journal of Heritage Tourism*, *15*, 6, 666-679. https://doi.org/10.1080/1743873X.2020.1719116

Guccio, C., Martorana, M.F., Mazza, I. & Rizzo, I. (2016). Technology and Public Access to Cultural Heritage: The Italian Experience on ICT for Public Historical Archives. In: Borowiecki, K., Forbes, N., Fresa, A. (eds), *Cultural Heritage in a Changing World*. Springer, Cham., 55-75. https://doi.org/10.1007/978-3-319-29544-2_4

Guttentag, D.A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management*, *31*(5), 637–651. https://doi.org/10.1016/j.tourman.2009.07.003

Jelinčić, D.A., Šveb, M., & Stewart, A.E. (2022), Designing sensory museum experiences for visitors' emotional responses. *Museum management and curatorship*, 37(5), 513-530. https://doi.org/10.1080/09647775.2021.1954985

Johnson, P., Nicholls, S., Student, J., Amelung, B., Baggio, R., Balbi, S., Boavida-Portugal, I., de Jong, E., Hofstede, J.G., Lamers, M., Pons, M. & Steiger, R. (2016). Easing the adoption of agent-based modelling (ABM) in tourism research, *Current Issues in Tourism*, *20* (8), 801–808. https://doi.org/10.1080/13683500.2016.1209165

Kidd, J., Nieto McAvoy, E. (2019). Immersive experiences in museums, galleries and heritage sites: a review of research findings and issues. Discussion paper. Creative Industries Policies and Evidence Centre, Newcastle University Business School. Available at: https://pec.ac.uk/discussion_paper_/immersive-experiences-in-museums-galleries-and-heritage-sites-a-review-of-research-findings-and-issues/

Laratta, A. (2024), In Italia mai così tanti turisti come nel 2023, un anno record. *Finestre sull'Arte online*. Available at: https://www.finestresullarte.info/turismo/in-italia-mai-cosi-tanti-turisti-come-nel-2023

Lemy, D.M., Juliana, J. & Pramezwary, A. (2025). Cultural value in the digital age: Combining Smart Travel Technology with traveler satisfaction and loyalty. *International Journal of Sustainable Development and Planning*, *20*(2), 607-621. https://doi.org/10.18280/ijsdp.200212

Li, W. & Huang, X. (2022). The Interactive Design and User Experience of Virtual Museums: Case Study of the Virtual Palace Museum. In: Rau, PL.P. (eds) Cross-Cultural Design. Applications in Learning, Arts, Cultural Heritage, Creative Industries, and Virtual Reality. HCII 2022. *Lecture Notes in Computer Science*, *13312*. Springer, Cham. https://doi.org/10.1007/978-3-031-06047-2_29

Morazzoni, M. (2003), *Turismo, territorio e cultura*, De Agostini, Milano, Italia.

Nevola, F., Coles, T. & Mosconi, C. (2022). Hidden Florence revealed? Critical insights from the operation of an augmented reality app in a World Heritage City. *Journal of Heritage Tourism*, *17*(4), 371-390. https://doi.org/10.1080/1743873X.2022.2036165

Nicholls, S., Amelung, B. & Student, J. (2017). Agent-based modeling: A powerful tool for tourism researchers. Journal of Travel Research, *56*(1), 3–15. https://doi.org/10.1177/0047287515620490

Organisation for Economic Co-operation and Development - OECD. 2009. *The Impact of Culture on Tourism*. Paris, France: OECD Publishing. https://doi.org/10.1787/9789264040731-en

Organisation for Economic Co-operation and Development - OECD. 2005. *Local Governance and the Drivers of Growth (Local Economic and Employment Development Programme - LEED*). Paris, France: OECD Publishing. https://doi.org/10.1787/9789264013308-en

Pangallo, M. & del Rio-Chanona, R.M. (2024) Data-driven economic Agent-Based Models. Available at SSRN: https://ssrn.com/abstract=5066965

Petrotta, S. (1957), *Turismo e cultura,* Zangara Editore, Palermo, Italia.

Piliponyte, G., Massimo, D. & Ricci, F. (2024). Simulation of recommender systems driven tourism promotion campaigns. *Information Technology & Tourism*, *26*, 407–448. https://doi.org/10.1007/s40558-024-00283-2

Pratisto, E.H., Thompson, N. & Potdar, V. (2022). Immersive technologies for tourism: A systematic review. *Information Technology & Tourism, 24*, 181–219. https://doi.org/10.1007/s40558-022-00228-7

Santoro, M.T., Cavallo, L., Di Sante, S. & Petrei, F. (2024). Cultural Tourism in Italy: A Proposal for Definitions, Analysis Indicators and Data Integration. In: *Calabrò, F., Madureira, L., Morabito, F.C., Piñeira Mantiñán, M.J. (eds) Networks, Markets & People. NMP 2024. Lecture Notes in Networks and Systems*, *1184*. Springer, Cham. https://doi.org/10.1007/978-3-031-74608-6_21

Sterling, C. (2020). Designing 'critical'heritage experiences: Immersion, enchantment and autonomy. *Archaeology International*, *22*(1), 100-113. https://doi.org/10.5334/ai-401

Tieskens, K.F., Shaw, B.J., Haer, T., Schulp, C.J.E. & Verburg, P.H. (2017). Cultural landscapes of the future: using agent-based modeling to discuss and develop the use and management of the cultural landscape of South West Devon. *Landscape Ecology, 32*, 2113–2132. https://doi.org/10.1007/s10980-017-0502-2

Trunfio, M., Jung, T. & Campana, S. (2022). Mixed reality experiences in museums: Exploring the impact of functional elements of the devices on visitors' immersive experiences and post-experience behaviours. *Information & Management*, *59*(8), 103698. https://doi.org/10.1016/j.im.2022.103698

UNESCO, World Heritage List. Available at: https://whc.unesco.org/en/list/

Wallinger, S., Grundner, L., Majic, I. & Lampoltshammer, T.J. (2023). Agent-Based Modelling for Sustainable Tourism. In: Ferrer-Rosell, B., Massimo, D., Berezina, K. (eds) *Information and Communication Technologies in Tourism 2023*. ENTER 2023. Springer Proceedings in Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-031-25752-0_40

Vita, C. (2018). Cultural tourism: the "minor" art center in Italy. *African Journal of Hospitality, Tourism and Leisure*, *7*(6). https://www.ajhtl.com/uploads/7/1/6/3/7163688/article_7_vol_7_6__2018.pdf

Table 1. Statistical insights. Descriptive statistics per museum (n = 18 museums, total respondents = 216)
Note: ***Each row summarizes per-museum visitor distributions (mean, std dev, etc.) based on survey data.***

Statistic	Visitors	Male	Female	Italy	Foreign	>18	18-24	25-34	35-44	45-54	55-64	65<	EduLow	EduMed	EduHigh	FamLow	FamMed	FamHigh	SatLow	SatMed	SatHigh
Count	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Mean	12	5.11	6.83	9.89	2.11	0.33	1.22	1.11	3.44	2.83	2	1.11	0.67	5	6.39	2.22	1.67	6.39	0.67	0.94	8.78
Std Dev	10.82	5.29	6.21	9.71	3.07	0.69	1.06	1.28	3.42	2.33	2.54	1.97	0.97	5.48	5.62	2.41	1.85	6.49	1.03	0.99	9.05
Min	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25%	4	1.25	2.25	2	0	0	1	0	1	1.25	0	0	0	2	2.25	0	0	2	0	0	2
50%	6.5	3.5	4	6	1	0	1	1	2.5	2	1	0	0	2	4	2	1	4	0	1	5
75%	19.75	6	12	14.75	2.75	0	1.75	2	5.75	4.75	3	1.75	1	6.75	11	3	2.75	9	1	1	13.75
Max	32	18	21	31	11	2	4	4	11	9	9	8	3	19	19	8	7	20	4	3	30

Source: Authors' calculation

NetLogo code

```
globals [season adoption-rate]

turtles-own [
  age
  gender   ;; “male” or “female”
  education-level ;; “low”, “medium”, “high”
  origin   ;; “Italy”, “Outside”
  tech-familiarity-level ;; “low”, “medium”, “high”
  satisfaction-level  ;; “low”, “medium”, “high”
  museum ;; Museum assignment based on attendance data
]

;; SETUP PROCEDURE

to setup
  clear-all
  set season “spring”  ;; Seasonal setting
  set adoption-rate 0.15 ;; Initial adoption rate of immersive technology

  create-turtles 290 [  ;; Number of tourists
    setxy random-xcor random-ycor  ;; Random positioning
    set age weighted-age  ;; Assign age based on survey data
    set gender weighted-gender  ;; Assign gender distribution
    set education-level weighted-education ;; Assign education level
    set origin weighted-origin  ;; Assign visitor origin
    set museum weighted-museum ;; Assign museum based on attendance
    set tech-familiarity-level weighted-tech-familiarity ;; Assign familiarity level
    set satisfaction-level weighted-satisfaction ;; Assign satisfaction level
    set shape “person” ;; Default shape
    ;; Debug print per controllare i valori assegnati
    show (word “Satisfaction: “ satisfaction-level)

    set shape “person” ;; Default shape


    ;; Assign colors based on satisfaction level
    ifelse satisfaction-level = “low” [set color red]
      [ ifelse satisfaction-level = “medium” [set color yellow]
        [set color green] ]
```

```
    ;; Adjust colors for gender to prevent overlap
    if gender = "male" [set color blue]
    if gender = "female" [set color pink]

    ;; Set size based on satisfaction level
    ifelse satisfaction-level = "high" [set size 2]
      [ ifelse satisfaction-level = "medium" [set size 1.5]
        [set size 1] ]
  ]
  reset-ticks
end

;; Function to assign age based on survey data
to-report weighted-age
  let r random-float 1
  if r < 0.028 [report 17]  ;; Under 18 (2.8%)
  if r < 0.129 [report random 7 + 18]  ;; 18-24 (10.1%)
  if r < 0.415 [report random 10 + 35]  ;; 35-44 (28.6%)
  if r < 0.650 [report random 10 + 45]  ;; 45-54 (23.5%)
  if r < 0.742 [report random 10 + 55]  ;; 55-64 (9.2%)
  report random 10 + 65  ;; 65+ (9.2%)
end

;; Function to assign gender based on survey data
to-report weighted-gender
  let r random-float 1
  if r < 0.574 [report "female"]
  report "male"
end

;; Function to assign visitor origin
to-report weighted-origin
  let r random-float 1
  if r < 0.821 [report "Italy"]
  report "Outside"
end

;; Function to assign museum based on attendance distribution
to-report weighted-museum
  let r random-float 1
  if r < 0.148 [report "Villae"]
  if r < 0.292 [report "Montesarchio"]
  if r < 0.408 [report "Medium-sized museum"]
  if r < 0.524 [report "Small museum"]
```

```
  if r < 0.633 [report "SASS"]
  report "Bellini"
end

;; Function to assign education level based on survey data
to-report weighted-education
  let r random-float 1
  if r < 0.105 [report "low"]
  if r < 0.364 [report "medium"]
  report "high"
end

;; Function to assign technology familiarity level
to-report weighted-tech-familiarity
  let r random-float 1
  if r < 0.10 [report "low"]   ;; Likert 1-2
  if r < 0.50 [report "medium"]   ;; Likert 3
  report "high"   ;; Likert 4-5
end

;; Function to assign satisfaction level based on survey data
to-report weighted-satisfaction
  let r random-float 1
  if r < 0.064 [report "low"]  ;; 6.4% Likert 1-2
  if r < 0.155 [report "medium"]  ;; 9.1% Likert 3
  report "high"  ;; 84.5% Likert 4-5
end
```