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Art of innovating in the arts: Disentangling determinants of technological and symbolic innovations in creative industries— Evidence from Canadian museums

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ABSTRACT

This study investigates the factors driving innovation in museums by incorporating both technological and symbolic innovations. Unlike previous research, it employs a comprehensive set of determinants to examine their impact on technological and symbolic innovations. Based on data from 250 Canadian museums and a multivariate path model, we simultaneously estimate eight types of innovations, four types of technological innovations (product, process, organizational, marketing) and four types of symbolic innovations (artistic, aesthetic, cultural, audience). The findings indicate that innovation appears to emerge through complex interplays between internal capabilities, market responsiveness, and external relationships. Resource-related factors such as technological infrastructure, financial assets, and artistic capabilities show differentiated impacts across types of innovation, suggesting that in museums, innovation is not uniformly resource-driven. Human capital, artistic creativity, and R&D investments demonstrate more limited or selective effects. Market orientation, particularly visitor orientation, emerges as a relevant driver of symbolic innovations, while custodial orientation, collaboration, and co-creation strategies have weaker or isolated impacts. Hence, the determinants differ across types of innovation, with some being specific to particular types thereof. Moreover, the study reveals complementarities between several pairs of types of innovation including Process and Aesthetic innovation, Artistic and Cultural innovation, and Aesthetic and Audience innovation. Finally, the degrees of complementarity between technological innovations are higher than those between symbolic innovations. These findings highlight the complex and contingent nature of innovation in museums, underlining, for museum managers, the importance of resource alignment, market-driven orientation, and external engagement strategies for successful innovation.

Introduction

Museums, as non-profit institutions serving society, fulfill essential educational and leisure functions through the conservation and exhibition of cultural heritage (Etges & Dean, 2022; Pop et al., 2019; Sandahl, 2019). In addition to preserving cultural identity and enhancing the brand image of tourist destinations (Gray & McCall, 2020; Nassef et al., 2023), museums also contribute to local economies (McPherson, 2006; Zhang & Courty, 2021). However, in recent years, numerous museums worldwide have closed, and many others have drastically reduced their activities (Arts Council England, 2017; Unesco, 2020). In Canada, for instance, museums such as the Grévin Museum in Montreal, Natural History Museum in Calgary, and Montreal Fashion Museum have shut down, whereas institutions like the Art Gallery of Ontario have significantly reduced their activities. According to several studies (e.g., Bautista, 2021; Velthuis & Gera, 2024), three factors primarily drive museum closures: lack of financial resources, insufficient public interest, and new strategies for displaying collections. Given the increasing scarcity of financial resources (Camarero et al., 2011; Valeonti et al., 2021), museums must strive for economic viability to ensure their survival (Johnson & Thomas, 1998;). In addition, they must continuously differentiate themselves to remain attractive in a competitive leisure industry (Coblence & Sabatier, 2014; Ekström, 2019). Moreover, museum managers must effectively implement new exhibition

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strategies. Hence, despite being non-profit organizations, museums must operate like business entities, adapting to changing environments to sustain themselves (Eid, 2016).

In this continuous pgrocess of reinvention, museum managers recognize the need for innovation to remain viable (Feldstein, 2009; Jayatissa & Boteju, 2022), as it enhances opportunities for value creation (Coblence & Sabatier, 2014). Over time, innovation has become essential for the economic viability and survival of museums (Damala et al., 2019), making it a necessity rather than choice (Jayatissa & Boteju, 2022). Essentially, museums that fail to innovate risk closure (Damala et al., 2019). Consequently, innovation has become a focal point for museums, materializing through a range of unconventional activities (e.g., Bakhshi & Throsby, 2010; Della Corte et al., 2017; de-Miguel-Molina et al., 2014). For example, in Canada, museums have expanded beyond traditional exhibitions to include art hives, drawing workshops, retail and dining spaces, dance and singing workshops, artist meetings, and film screenings. However, the artistic world's complexity, combined with its creative and symbolic nature (Aubouin et al., 2012), makes museum innovation a challenging process that remains poorly understood (Miles & Green, 2008; Strøm et al., 2020). Thus, despite acknowledging the importance of innovation, museums face significant challenges in its implementation (Cerquetti, 2016; Mansfield et al., 2014; Zamani and Peponis, 2010).

McMaster (2008) argued that most innovations in arts and cultural institutions fail due to a lack of understanding of the requirements for successful implementation, leading to management confusion. This issue is particularly critical for museums given their declining funding (Betzler et al., 2021). Museums also face additional challenges in innovation since they must navigate often conflicting cultural and economic considerations (Rumpel et al., 2010). Furthermore, the museum innovation process is complex, as its implementation relies on multiple interrelated factors (Gohoungodji & Amara, 2023). However, the existing literature does not fully capture this complexity. Previous studies have focused on only a limited set of factors. While some examine resource-related factors (Bernardi & Gilli, 2019; Lazzeretti & Cerquetti, 2021), others focus solely on market dynamics (Camarero & Garrido, 2012; Camarero et al., 2015). As in other creative industries, failed innovation efforts in museums can lead to institutional decline (Carlsen et al., 2010; Hotho & Champion, 2011). Consequently, the arts and leisure sectors have one of the lowest survival rates (Chen et al., 2010; Hotho & Champion, 2011). In Canada, for example, innovation in the arts sector, including museums, faces multiple challenges (Statistics Canada, 2019). Between 2002 and 2014, the survival rate of organizations in this sector was only 42% (Archambault & Song, 2018). Therefore, as Hotho and Champion (2011) argue, effective innovation management grounded in a comprehensive understanding of the factors influencing innovation is critical to preventing failure. However, the literature highlights a gap in studies examining the drivers and barriers of successful museum innovation, calling for further research in this area (Gohoungodji & Amara, 2023; Ostman et al., 2023).

Although the literature on museum innovation has gained interest among researchers and practitioners (e.g., Camarero et al., 2011; Camarero & Garrido, 2012; Clements et al., 2021; Taormina & Baraldi, 2022), most studies focus on technological innovations as defined in the Oslo Manual—product, process, organizational, and marketing innovations (OECD/Eurostat, 2018). These studies often equate museum innovation with innovations in the manufacturing sector (e.g., Cerquetti, 2016; Mansfield et al., 2014). However, museums implement additional forms of innovation, which are often inspired by artistic creativity (Cappetta et al., 2006; Wijngaarden et al., 2019). These, known as "symbolic innovations" (Hirschman, 1982), are not directly linked to technological changes but to symbolic transformations (Cappetta et al., 2006; Hirschman, 1986). As such, their value is more symbolic than economic (Rumpel et al., 2010). Specific to the arts and museum sector (Decelle, 2004), symbolic innovations commonly include cultural, artistic, aesthetic, and audience innovations. However, despite their relevance, they remain underexplored, if not entirely overlooked (Li & Ghirardi, 2019). Moreover, existing studies on symbolic innovation are mostly conceptual or based on case studies, highlighting the lack of large-scale, quantitative research on this subject (Gohoungodji & Amara, 2023; Li & Ghirardi, 2019).

In addition, little is known about the determinants of symbolic innovation. While the factors influencing technological innovation have been extensively studied, research on the drivers of symbolic innovation is limited. For example, compared to resource-related factors, studies examining the effects of visitor or custodial orientation on museum innovation remain scarce, as do investigations on the roles of artistic creativity or co-creation. Wijngaarden et al. (2019) recently highlighted this gap, noting the limited research exploring the determinants of symbolic innovation in museums. However, questions remain, such as whether symbolic innovation shares common determinants with technological innovation or whether they have distinct influencing factors. Furthermore, most studies analyzing the determinants of museum innovation rely on correlation, regression, or structural equation modeling methods, which assess the net (rather than joint) effects of specific factors on innovation, such as the determinants of organizational, marketing, or cultural innovation. Likewise, these studies separately examine the determinants of each type of innovation without considering that museum managers must often implement several types simultaneously, including combinations of symbolic and cultural innovation. In Canada, for example, many museum managers often combine their innovative exhibition activities (e.g., programming, artwork acquisition, exhibition scenography, marketing communication) with other innovative cultural activities such as conferences, drawing workshops, ticketing, painting workshops, and murder mystery nights. However, to our knowledge, no previous studies on museums have examined the potential existence of complementarity, substitution, or independence relationships between these different activities. However, according to Brynjolfsson and Milgrom (2013), knowledge of these relationships among innovative activities is crucial for managers to develop strategies for the optimal management of their innovation portfolios.

In light of the foregoing, this study aims to fill these gaps by pursuing two objectives. First, it investigates the complementarities, independence, and substitutions between eight types of innovation in museums: four technological innovations (product, process, organizational, and marketing innovation) and four symbolic innovations (artistic, cultural, aesthetic and audience). Second, it attempts to explore the heterogeneity of the determinants of these types of innovation. To address these aims, we conducted a survey to collect data from Canadian museums and employed a multivariate path modeling approach for the analysis. The theoretical framework integrates three complementary perspectives, namely the resource-based view (Rumelt, 1984; Barney, 1996), market orientation framework (Narver & Slater, 1990), and vicarious learning perspective (Dyer & Singh, 1998; von Hippel, 1988). The results showed that the determinants vary between types of innovation, and certain determinants are specific to some types. While resource factors such as technological resources and R&D almost exclusively impact technological innovations, visitor orientation, heritage orientation, and co-creation affect only symbolic innovations. Finally, the degrees of complementarity between technological innovations are higher than those between symbolic innovations, whereas complementarities exist between several pairs including process and aesthetic innovation, as well as artistic and cultural innovation.

The study offers several contributions. First, we respond to recent calls to better understand the factors impacting innovation in museums (Gohoungodji & Amara, 2023; Ostman et al., 2023). We advance research from an empirical perspective by using a new database that encompasses both technological and symbolic innovations, which are rarely studied jointly in the extant literature on museums. Indeed, contrary to previous studies that considered mainly the technological types of innovation proposed by the Oslo Manual (OECD, 2018), our

research also includes four types of symbolic innovation that take into account the peculiarities of art organizations. Second, this study draws on three theoretical perspectives, enabling the integration of several types of factors likely to impact innovation within museums. Indeed, contrary to other studies that focus solely on resource factors, this one also mobilizes market-related factors and those related to networking activities. This consideration illuminates a theoretical understanding of the complex nature of innovation in museums, as called for by several researchers (e.g., Li & Ghirardi, 2019; Wijngaarden et al., 2019). Finally, the use of a multivariate path model, which enables the simultaneous estimation of eight equations corresponding to the eight types of innovation (four technological and four symbolic), also allows us to elucidate the synergy effects among the various types. In the context of the rarefaction of resources, knowledge of the determinants by type of innovation and the complementarities between them will assist museum managers in knowing which resources to deploy first for which type of innovation. Consequently, this study provides useful insights for museum managers in developing appropriate and efficient strategies to promote innovation in museums.

The remainder of this article is structured as follows. In section 2, we review the relevant literature and outline the theoretical perspectives that underpin the study. Section 3 details the methodological approach employed, and Section 4 presents our findings. In Section 5, we discuss the results in light of the existing literature and outline theoretical and practical implications. Section 6 presents the conclusion and implications, and provides suggestions for future research.

Literature review

Innovations in museums

Innovation as an activity is omnipresent in all organizations (Fagerberg et al., 2013) including non-profit ones (Zimmermann, 1999). Indeed, since Schumpeter's (1934) work on innovation theory, it is increasingly viewed as an activity essential to the vitality of all organizations, whatever the field of activities (Hall & Rosenberg, 2010). The cultural sector, led by the cultural and creative industries, is no exception. Innovation is present and its potential impacts the vitality of the sector's organizations (Landoni et al., 2020; McDonald et al., 2021). As part of these artistic organizations, museums have been living for several decades to the rhythm of the innovations within them. Certainly, faced with changing public tastes and the emergence of new technological and socio-cultural contexts, museums are deploying a wide range of new activities to further attract the public (Mulgan et al., 2007). These new activities are needed for cultural heritage institutions to maintain or increase their market position (Bakhshi & Throsby, 2012; Radbourne, 2005). Specifically, this means developing new managerial activities to engage the public in a more meaningful way; improve understanding and appreciation of art, history, or culture; and make museums more accessible and relevant to visitors (Sundbo et al., 2022; Zbuchea, 2015). Essentially, these activities have led to the implementation of innovative practices in museums.

Similar to innovation in manufacturing, these practices can be understood as the introduction of new ideas and methods created and adopted by museums at the product, process, organizational, or commercial level. This ties in not only with the definition of the concept of innovation proposed by the Oslo Manual (OECD, 2018), but also with that proposed by Miles & Green (2008). The latter define innovation as a process found in the form of products, services, or processes that affects technological, organizational, market, and user behavior dimensions. Applying the definition, innovation in museums refers to the introduction of new artwork, new working methods, new management styles, or marketing novelties (Camarero and Garrido, 2012). This corresponds to a conceptualization that renders innovation in museums similar to that in factories without considering the specificities of museums. Here, innovation in museums is viewed as a microeconomic activity whose process is characterized by a technological push. However, according to Decelle (2004), it would be inappropriate to apply to museums definitions of innovation that focus almost exclusively on invention or new technologies. Indeed, although museums cannot avoid the presence of new technologies in their day-to-day operations, many of their innovations are linked to strategic activities specific to them, including conservation and restoration, exhibition, digitization, and visitor services. This conception considers the museum a component of artistic and cultural frameworks, emphasizing their particularity as artistic and cultural organizations distinct from factories. Such innovation is culture-centric, focusing on the conservation and dissemination of museographic works. It integrates only the artistic and cultural dimensions, focusing on features such as the creation of artistic value, extension of art forms, addition of new works of art, and new cultural programs. This vision restricts innovation in museums to innovations with artistic and cultural dimensions (Ostman et al., 2023).

However, according to a systematic review by Gohoungodji and Amara (2023), a better understanding of the concept of innovation in the creative industries to which museums belong requires considering an element that integrates the technological dimension of innovation and specific features of museums and their activities. This approach is aligned with the definition proposed by Camarero and Garido (2011), according to which innovations in museums are linked to both novelties in the basic service (temporary exhibitions, educational programs, friends' programs, etc.) and to those in the additional services provided, such as advances in the technology used to enhance visitors' experience (exhibitions and screens, virtual tours, or web publishing). This conceptualization regards innovation as a tendency to incorporate new systems, technologies, or processes that change both the way the museum operates and how it presents its exhibits to visitors (Vicente et al., 2012). This vision calls on managers to not only focus their efforts on renewing or improving their heritage collections, but also to seek to increase the value perceived by the customer to maintain public interest and enthusiasm (Eid, 2016). As a result, over time, museums have developed diverse activities (Falk & Sheppard 2006) and innovations in relation to their collections and visitor expectations, in addition to their original functions of conserving and disseminating cultural heritage (Peacock, 2008). Consequently, while some museums may have stronger capabilities and experience in one type of innovation than others, museum managers often implement various types of innovation that can be technological (see Camarero et al., 2011; Camarero & Garrido, 2012) or symbolic (Abernathy & Clark, 1985; Cappetta et al., 2006). Table 1 below shows the current types of museum innovation noted in the literature based on the nature thereof.

Complementarities between type of innovations

Recent research has found that firms tend to simultaneously undertake several innovative practices (Zhang, 2022). Many examples have been provided to show that combining various types of innovation can benefit firm performance. Hence, although each type of innovation may contribute to firm performance in isolation, simultaneously introducing different types of innovation provides extra benefits and generates multiplier effects (Ballot et al., 2015; Hullova et al., 2019). This knowledge has given rise to the study of complementarity between various types of innovation in several areas such as technology (Zhang et al., 2017), energy (Nahm & Steinfeld, 2014), manufacturing (Amara et al., 2008; Zhang, 2022), and knowledge transfer (Landry et al., 2010). The leisure industry is no exception. As Della Corte et al. (2017) argue, museum managers need to orient their activities in various dimensions including the technological, organizational, and marketing arenas to align with current changes in the sector. In this sense, Baujard and Lagier (2020) contend that beyond their traditional curatorial functions, museum managers also implement managerial functions that lead them to intensify the application of innovative practices. For example, they are now introducing new managerial activities such as that pertaining to

Table 1
Potential types of innovation in museums.

Nature of innovation	Type of innovation	Definition and examples	Authors
Technological innovation	Product innovation	Introduction of new creative products or services (e.g., new exhibitions, new artwork, new training for artists, etc.)	Garrido and Camarero (2010); De-Miguel-Molina, Hervás-Oliver, De-Miguel-Molina and Boix (2014); Dawson (2008).
	Process innovation	Using new processes (e.g., new processes in artists' programming, sponsor or financing searches, ticketing, etc.)	
	Organizational innovation	Changes in organizational structure (e.g., museum chart reorganization, creation or deletion of positions, personal training, etc.)	Garrido and Camarero (2010); Camarero and Garrido (2008); Camarero, Garrido, and Vicente (2011); Camarero and Garrido (2012); Vicente, Camarero and Garrido (2012).
	Marketing innovation	Introduction of novelties in marketing strategies (e.g., changes in entry prices, changes in advertising, segmentation in audience age, etc.)	Heilbrun (1993); Camarero and Garrido (2008); Peacock (2008); Garrido and Camarero (2010); Camarero, Garrido, and Vicente, (2011); Vicente, Camarero, and Garrido, (2012); Camarero and Garrido (2012); Dawson (2008)
Symbolic innovation	Artistic innovation	Introduction of new artwork, artists, or novelty in the content or form of the artwork during exhibitions (e.g., new artworks, specific on-site-artworks, augmented reality-infused artworks, trendy interactive artworks)	Heilbrun (1993); Castañer and Campos (2002); Bakhshi and Throsby (2010).
	Cultural innovation	Occurs through the execution of temporary exhibitions, educational programs, and activities, as well as through academic and professional articles written by museum staff (e.g., conferences, drawing workshops, painting workshops, murder mystery nights)	Castañer (2014); Li and Ghirardi (2019); Søndergaard and Veirum (2012).
	Aesthetic innovation	Occurs when aesthetic novelty is conferred on artworks or exhibition scenography in terms of visual (broadly, sensory) attributes (e.g., walls covered in mirrors, soundscapes, scent diffusion, dynamic lighting, digital visual effects, thematic color environments)	Thoelen and Zanoni (2016).
	Audience innovation	Generation of new audiences through use of digital technologies such as online collections and by interacting with audiences on social networks (e.g., social media campaigns targeting new demographic groups, virtual guided tours for non-traditional audiences)	Bakhshi and Throsby (2010).

visitor experience, staff recruitment, training, and exhibition programming (Griffin, 2008). They also develop innovative technological activities to leave a lasting impression in visitors' memories and differentiate their services from competitors (Passebois-Ducros, 2019). For instance, to adapt to technology-induced changes, museums have introduced technological novelties to attract new audiences (Bakhshi & Throsby, 2009) and implemented cultural or aesthetic innovations to enhance their appeal (Boix et al., 2013). Therefore, following Stang Våland et al. (2021), we contend that museum managers engage daily in several types of technological and symbolic innovations (see Table 2 later in the paper). They must often combine innovative exhibition activities with other types such as drawing workshops, conferences, and digital projects. Under these conditions, museum managers must continuously manage a portfolio of various types of innovation (Vicente et al., 2012). Unfortunately, little is known about the interplay between these various types of innovation, and whether they are complementary, substitutive, or independent. Thus, we hypothesize that complementary relationships exist between the eight types of innovation (see Table 2).

Theoretical perspectives and determinants of innovation in museums

Based on a systematic review by Gohoungodji and Amara (2023), which edified an integrated conceptual framework linking innovation in creative industries with various sets of explanatory variables, and the results of a Reference Publication Year Spectroscopy identifying the historical roots of innovation in creative industries (Gohoungodji & Amara, 2022), we draw on three theoretical perspectives. There are the resource-based view (Rumelt 1984; Barney, 1996), market orientation approach (Narver & Slater, 1990), and vicarious learning perspective of

Table 2
Descriptive statistics.

Dependent variables					
Description: Measurement scale					
Dependent variable: Product innovation	70% of museums introduced new creative products or services				
Dependent variable: Process innovation	61,2% of museums have used new processes				
Dependent variable: Organizational innovation	48% of museums implemented changes in organizational structure				
Dependent variable: Marketing innovation	58% of museums introduced novelty in marketing strategies				
Dependent variable: Artistic innovation					
				Mean	Standard deviation
				2.28	1.30
Dependent variable: Aesthetic innovation					
				Mean	Standard deviation
				2.55	1.10
Dependent variable: Cultural innovation					
				Mean	Standard deviation
				3.58	1.04
Dependent variable: Audience innovation					
				Mean	Standard deviation
				3.47	1.00
Independent Variables	Type of variable	Minimum	Maximum	Mean	Standard deviation
Continuous variables:					
Human capital	Continuous: number	1.00	5.00	3.85	0.91
Financial resources	Continuous: number	1.00	5.00	2.37	0.77
Infrastructural capability	Continuous: number	1.00	5.00	2.83	0.91
Visitors' orientation	Continuous: number	1.00	5.00	4.09	0.60
Custodial orientation	Continuous: number	1.00	5.00	4.20	0.57
Technological resources	Continuous: number	1.00	5.00	3.35	0.90
Artistic capability	Continuous: number	1.00	5.00	2.36	1.41
Artistic creativity	Continuous: number	1.00	5.00	3.20	1.08
Co-creation	Continuous: number	1.00	5.00	3.09	0.75
Collaboration	Continuous: number	1.00	5.00	3.67	0.94
Size	Continuous: number	1.00	185.00	4.62	13.96
Age	Continuous: number	4.00	163.00	46.16	21.67
Categorical variables:					
Knowledge resources [R&D]	24.8% of museums engaged in R&D activities to innovate *over the last 3 years*				
Ownership	84.4% of museums are publicly owned				
Museum vocation	56.4% of museums exhibit artwork by artists				

Dyer and Singh (1998). Accordingly, museums' likelihood of innovating might be enhanced or hampered by various determinants rooted in one or more of these theoretical approaches. These determinants are presented in the following section.

Resources

Relying on the resource-based view (Rumelt, 1984; Barney, 1996), we assume that like any manager, museum managers control a set of idiosyncratic resources that are deployed and mobilized in their innovative activities. The systematic review by Gohoungodji and Amara (2023) identified seven factors relevant to the types of resources available to museums, namely use of technological resources, availability of financial resources, infrastructural capability, human capital, artistic creativity, artistic capability, and investment in R&D.

First, museums deploy various technological resources (Li & Ghirardi, 2019), which influence their innovation-related activities (Lazzeretti & Cerquetti, 2021; Taormina & Baraldi, 2022). Specifically, several studies highlighted the key role of the use of technological resources in deploying marketing strategies to attract visitors (Bernardi & Gilli, 2019; Guccio et al., 2020). Technology use is also considered a driver for the digitization of cultural heritage, which has provided an important way to safeguard and promote heritage (Kostadinova, 2020). In addition, technological resources are regarded as essential for organizational (Kostadinova, 2020), product (Camarero & Garrido, 2012b), and audience innovation (Bakhshi & Throsby, 2009) in the museum. However, little is known about the influence of technology use on artistic, aesthetic, and cultural innovation. Moreover, previous studies concluded that infrastructural capabilities influence innovation in museums (Camarero & Garrido, 2012). However, these have not examined whether the infrastructural capabilities of museums are important for all types of innovation. Based on this rationale, we hypothesize the following:

Hypothesis 1: Technological resource use increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Hypothesis 2: Infrastructural capabilities increase the likelihood of a) technological innovations and b) symbolic innovations in museums.

Second, much research has focused on the influence of financial resources on innovation in museums (Camarero, Garrido et al. 2011). Essentially, the availability thereof is considered to promote innovative activities in the creative industries including museums (Protogerou et al., 2017; Zhou et al., 2020). Furthermore, in their systematic review, Gohoungodji and Amara (2023) confirmed the significant and positive impact of technological resources on innovation. Nevertheless, the real impact of financial resources, especially on symbolic innovations, has not yet been investigated, despite the importance of knowing whether financial resources are also necessary for all types of technological innovation. Therefore, we propose the following hypothesis:

Hypothesis 3: The availability of financial resources increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Third, the literature on innovation in creative industries indicates that personal factors may affect innovation. According to Protogerou et al. (2017), the quality of funders' human capital influences innovative activities in these industries. This is aligned with Sica et al., (2025), who emphasized that creative industries need to acquire new leadership skills and competencies to ensure sustainability and resilience. However, the existence of this effect has yet to be examined for museums. In our study, we suppose that human capital impacts both technological and symbolic innovations. Based on this rationale, we postulate the following:

Hypothesis 4: The quality of human capital increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Furthermore, studies have noted the importance of artistic creativity (Camarero et al., 2019; Wilson & Stokes, 2005) and artistic capability (García-Muiña et al., 2019; Voss et al., 2006) for innovation in creative industries. In this regard, Gohoungodji and Amara (2023) conclude that the artistic dimension, embodied by artistic creativity and capability, is a fundamental factor in implementing symbolic innovations in creative industries. However, it could be useful to know whether technological innovation also requires the presence of creativity or artistic talent.

Thus, we hypothesize the following:

Hypothesis 5: Artistic creativity increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Hypothesis 6: Artistic capability increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Finally, although several studies have shown that R&D capability influences innovation in the creative industries (Benghozi et al., 2015; Lee & Drever, 2013), the role thereof in museums has not yet been established. Thus, researchers such as Protogerou et al. (2017) called for more investigation to better understand the place of R&D in art organizations including museums. Consequently, we hypothesize the following:

Hypothesis 7: Investment in R&D increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Market orientation

Next, regarding the role of market orientation in innovation in museums, we mobilize the Narver and Slater (1990) framework. According to this approach, market orientation is a philosophy in which an organization prioritizes the profitable creation and maintenance of superior customer value. Applied to museums, the market orientation stresses visitors' satisfaction in managing museums. According to Camarero and Garrido (2012), market orientation positively impacts organizational innovation in museums. However, those authors did not investigate the impact of market orientation on other types of technological or symbolic innovation. As in previous research on museums (e.g., Camarero & Garrido, 2012), we consider two basic dimensions of market orientation, namely visitor and custodial orientation. These two dimensions enable the museum to adopt a strategy based on aspects that can create value for visitors or maintain the perennial nature of custodial orientation (Camarero & Garrido, 2012; García-Muiña et al., 2019). Consequently, we hypothesize that:

Hypothesis 8: Visitor orientation increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Hypothesis 9: Custodial orientation increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Vicarious learning perspective

Regarding the vicarious learning perspective, our approach focuses on the acquisition of innovative skills and knowledge through learning during networking activities, namely collaboration and co-creation. Organizations often learn by collaborating with other companies (Dyer & Singh, 1998), and according to Von Hippel (1988), innovative knowledge could emerge from customer suggestions or ideas. First, regarding museums operating with several partners (e.g., other museums, crafts, festivals), previous studies revealed that collaboration with others influences innovation (Pauget & Tobelem, 2019). Li and Ghirardi (2019), for example, confirmed the positive impacts of cooperation with other partners such as universities or technology firms on innovation within museums. Nevertheless, the question is whether this is the case for all types of innovation in museums. Thus, we propose the following hypothesis:

Hypothesis 10: In museums, increasing collaboration with art organizations increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Second, as cultural organizations such as museums are driven to adopt entrepreneurial approaches (Rentschler & Gilmore, 2002), they implement a co-creation orientation to adopt a more visitor-centric culture. This manifests by co-producing experiences with visitors (García-Muiña et al., 2019; Minkiewicz et al., 2016) and involving them in innovative activities (Camarero & Garrido, 2012; Pine & Gilmore, 1998). However, according to Gohoungodji and Amara (2023), the effects of co-creation on innovation in museums must be consolidated, as it is not yet known whether it influences both technological and symbolic innovations these organizations. In this study, we suppose that an increase in co-creation increases the likelihood of all eight types of innovation noted in our study. Thus:

Hypothesis 11: An increase in co-creation with visitors increases the likelihood of a) technological innovations and b) symbolic innovations in museums.

Control variables

To consider the heterogeneity and peculiarities of museums, we considered four control variables, namely size, age, ownership, and museum advocation. Previous research highlighted that size and ownership impact museums' capability to innovate and that larger museums have more resources to do so (Camarero et al., 2011). In addition, Rodriguez-Gulias et al. (2020) concluded that age has a negative effect on the probability of patenting activity in creative industries including museums. This aligns with Müller et al. (2009), who showed that younger firms have a higher probability of introducing product imitations in creative industries. However, little is known about the impact of age on innovative activities, especially in museums. The influence of these characteristics on both technological and symbolic innovations in museums remains to be established in the literature (Gohoungodji & Amara, 2023). We also consider museum ownership, especially whether being a private or public museum impacts innovation. As Ju and Gao, (2024) state, ownership type affects innovation strategies. Finally, for the model estimation, we include another control variable, namely museum advocation. We also distinguish between museums that exhibit artwork by artists and those that do not. Finally, Fig. 1 delineates the conceptual model of the study, while the operational definitions of all explanatory and control variables are presented in Appendix 1.

Methodology

Units of observation

In this study, the units of observation are museums. As one category of the creative industries, museums encompass several types of establishments such as those catering to archaeology, contemporary art, modern art, decorative art, fine art, science and technology, natural science, historic sites and houses, ethnography and anthropology, and interpretation centers. These non-profit organizations are at the service of society and acquire, conserve, communicate, and exhibit humanity's tangible and intangible heritage (Sandahl, 2019). Furthermore, the choice of museums as the units of observation is justified by the fact that since the beginning of the 21st century, they have been implementing various innovations (see e.g., Landoni et al., 2020; McDonald et al., 2021). The quest for novelty has become an important topic of interest for these organizations (Damala et al., 2019). In fact, facing the perpetual need for novelty induced by changing visitor preferences, museums have no choice but to innovate to satisfy their audiences and better fulfill their missions in a more effective, efficient, and sustainable way (Eid, 2016).

Population of the study

The individuals composing the population of this study are the museums' executives, managers, or directors in Canada. These people are the most likely to understand innovation in these organizations. They are considered key informers who provide us with information to achieve the aims of this study. Although the data comes from a single

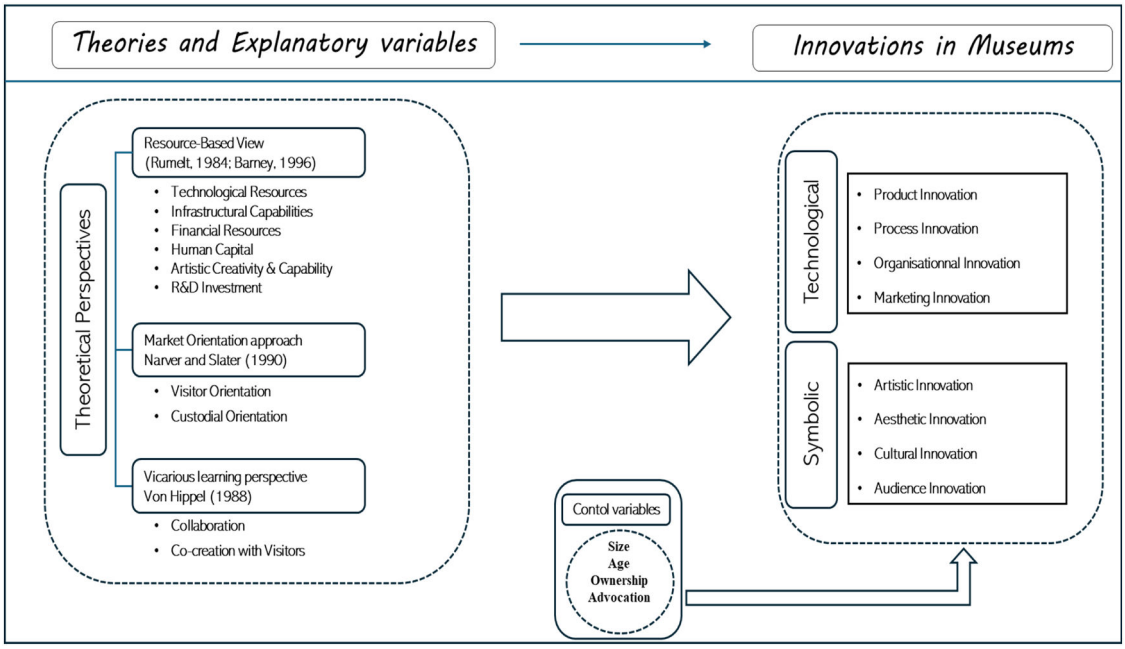

Fig. 1. Conceptual model.

source, according to Camarero and Garrido (2012), museum managers have a global view of the prevailing philosophy of museum management and the innovations implemented. To identify this population, first, during winter 2023, we found on the website of the Association of Canadian Museums (AMC) (www.museums.ca) all affiliated Canadian museums and their complete addresses. The total population listed thereon is 2,712 museums and related institutions. Second, following the advice of an expert museologist, we excluded museum-related institutions, namely libraries, archive houses, culture houses, interpretation centers, and historical sites. The reason is because these institutions do not face the same innovation realities as other museums, as they do not need to continually renew their offers. Through this process, we eliminated 1621 institutions, retaining a sample of 1091 museums located across Canada.

Questionnaire development and data collection

Based on Gohoungodji and Amara's (2023) systematic literature review on innovation in the creative industries, we developed a survey questionnaire comprising six sections. The first includes questions pertaining to general information on museums. The second probes the types of innovation, while sections three to six focus on the determinants thereof in museums. For the types of innovation in museums, apart from that related to technology (product, process, marketing, and organizational), we considered four other types specific to museums, namely artistic, aesthetic, cultural, and audience innovation. These four types are the most common in the literature. Furthermore, following Gohoungodji and Amara (2023), we employed four groups of determinants, namely those related to resources, market orientation, networking activities, and general museum information (size, age, localization, advocation, etc.).

For data collection, the retained list of museums and their addresses, as well as the questionnaires (English and French versions) were sent to a survey company specializing in innovation surveys. Thereafter, first, the respondents (museum executives, managers or directors) were contacted by e-mail to complete the online survey. Second, respondents who did not respond to the questionnaire by e-mail were contacted via telephone using ITAO, a computer-assisted telephone interviewing technology that simultaneously integrates coding and data capture into the data collection step. Before launching the survey, we obtained a certificate of ethics approval from the ethics committee for research at our university of affiliation. The survey was conducted between August and October 2023. Among the 1,091 museums selected, 506 were removed from the sample for the following reasons: (1) invalid phone numbers (n = 94), (2) out of sample numbers (n=64), and (3) no answer after 10 attempts (n = 348). Therefore, the final sample comprised 585 museums. From these, we received 13 incomplete questionnaires, 21 refusals after agreeing to participate, and 40 deferrals requesting to be interviewed later but who we could not reach. Therefore, the final sample comprised 250 museums across Canada for a response rate of 48,92% (250/511).

A power analysis for a linear regression was also conducted using G* Power 3.1 software (Faul et al., 2009) to assess the likelihood of committing Type I and II errors. Specifically, with a significance level of 0.05 and small effect size of 0.12, the minimum sample size needed for having 15 explanatory variables and a very high power of 0.95 is 245 observations. As our sample included 250 observations, we believed we would be able to minimize the effect of sample size (Lipsey, 1990; Portney & Watkins, 2008) (see Appendix 2).

Findings

Sample characteristics

The upper part of Table 2 reports the descriptive statistics of the eight dependent variables considered in this study: product, process, organizational, marketing, artistic, aesthetic, cultural, and audience innovation. The first four dependent variables refer to the types of technological innovation as defined by the Oslo Manual (2018). These four are dichotomous variables. Of the 250 respondents, 70% reported that their museums introduced new creative products or services, 61% have used new processes, 48% implemented changes in their organizational structure, and 58% introduced novelty in their marketing strategies. The last four types are symbolic innovations. As shown in the upper part of Table 2, on average, the means of the weighted five-item index referring to artistic, aesthetic, cultural, and audience innovation are 2.28 out of 5 (SD=1.30), 2.55 out of 5 (SD=1.10), 3.58 out of 5 (SD=1.04), and 3.47 out of 5 (SD=1.00), respectively.

The lower part of Table 2 reports the summary statistics of the explanatory variables included in this study. Likewise, for the explanatory variables referring to the resources available to museums, on average, museums ranked at 3.85 (SD=0.91), 2.37 (SD=0.77), and 2.83 (SD=0.91) out of a maximum of 5 on the weighted scales of human capital, financial resources, and infrastructure capability, respectively. Moreover, almost a quarter of the museums have engaged in R&D activities to innovate over the last three years. Regarding market factors, on average, museums ranked at 4.09 (SD=0.60) and 4.20 (SD=0.57) out of 5 on the weighted scales of visitors' and custodial orientation, respectively. For creativity factors, on average, museums ranked at 2.36 (SD=1.41) and 3.20 (SD=1.08) out of 5 on the weighted scales of artistic capability and artistic creativity, respectively. Likewise, for relational factors, on average, museums ranked at 3.09 (SD=0.75) and 3.67 (SD=0.94) out of 5 on the weighted scales of co-creation and collaboration, respectively. Finally, for the control variables, overall, the average museum had 4.62 employees (SD=13.96) and an age of 46.16 years (SD= 21.67). Moreover, almost 85% are publicly owned and 56% exhibit artwork by artists.

Econometric models specification

A first saturated path model was used to simultaneously estimate eight regressions where the dependent variables are the types of innovation in museums: four technological and four symbolic innovations. The estimation was performed via Mplus 8.6—a structural equation-modeling package by Muthén and Muthén (1998-2017)—to control for the mutual correlations between the error terms of the eight dependent variables (Amara & Rhaiem, 2024; D'Este et al., 2016; Galia & Legros, 2004). Specifically, the estimation of such models provides two types of results. First, it permits exploring the correlations between the eight dependent variables considered in the study, namely product (PROD), process (PROC), organizational (ORGA), marketing (MARK), artistic (ARTI), aesthetic (AESTH), cultural (CULT), and audience innovation (AUDIE). A positive and significant correlation between the error terms of a pair of dependent variables is interpreted as indicating complementarity between the two variables forming the pair, while negative and significant correlation is interpreted as substitution. Furthermore, for us, a non-significant correlation means independency between the two dependent variables forming the pair (Amara & Rhaiem, 2024: Jaureguy et al., 2023; Landry et al., 2010). Second, the model enables identifying the influential explanatory variables on each of the eight types of innovation. We considered 15 explanatory variables of innovation in museums, namely human capital (HUMK), financial resources (FINRES), infrastructural capability (INFRACAP), technological resources (TECHRES), knowledge resources (R&D), visitors' orientation (VISITOR), custodial orientation (CUSTOD), artistic creativity (ARTCREA), artistic capability (ARTCAP), collaboration (COLLAB), co-creation (COCREA), size (LnSIZE), age (SQRTAGE), ownership (OWNER), and museum vocation (VOCAT).

The first four dependent variables are dichotomous variables (PROD, PROC, ORGA, MARK), and the last four are measured on a multi-item index encompassing several activities of ARTI, AESTH, CULT, and AUDIE. Thus, for each of the binary-dependent variables, the following binary logistic regression model was estimated: $\log (P_i /1 - P_i) = \beta X_i + \varepsilon_i$

Where X_i is the vector of K explanatory variables for museum i, β_i (i=0,….,15) is the coefficient, and $\log (P_i/1 - P_i)$ represents the probability of a museum adopting a given type of innovation.

Similarly, for the dependent variables measured with a multi-item indices (ARTI, AESTH, CULT, AUDIE), an ordinary least squares (OLS) regression model was performed:

$Y_i = \beta X_i + \varepsilon_i$

Where Y_i denotes the dependent variable for museum i, X_i represents the explanatory variables, β is a vector of parameters to be estimated for museum i (i=0,…15), and ε_i is the error term for museum i.

As the estimated saturated path model does not enable a direct assessment of fit, an unsaturated path model was estimated by constraining insignificant parameters (i.e., those with $p > 0.10$, two-tailed) at 0 (Golob & Regan, 2002). Specifically, we removed non-significant coefficients to improve interpretability, mitigate multicollinearity effects, and have a non-zero degree of freedom. This unsaturated model enables an assessment of overall model fit (Amara & Rhaiem, 2024; D'Este et al., 2016).

Furthermore, to test the suitability of performing a joint estimation of the eight regressions rather than separate regressions, a second unsaturated model was estimated by fixing all the error term covariances at 0. The comparison of this constrained model with the fully saturated one (where error terms are freely estimated) allows us to determine whether estimating the eight regressions simultaneously is more appropriate than modeling them separately. In this regard, the computed value of the likelihood ratio index (LR index), which compares the log likelihood values related to the unsaturated model and the one forcing the covariances between the error terms of the equations to equal zero, is significant at the 1% level (Chi-square = 281.94; p-value = 0.000). This suggests that the null hypothesis, namely that all the error term covariances are zero, is strongly rejected. Therefore, the use of a model with free error term covariances better reflects the data than a model with error term covariances fixed at zero. The results of this comparison confirmed, at least for our data, that using the separate models to identify the determinants of museums' portfolio of innovations is inappropriate.

A key strength of adopting this econometric model is its capacity to capture the association between the different dependent variables, which in our case, are the eight types of innovation. This not only improves estimation efficiency, but also provides valuable insight into potential complementarities, substitution, or independence among innovation types. These insights would have been missed had we used separate models. In contrast, separate estimations cannot uncover the interplay between the dependent variables. However, a limitation of this modeling approach is its complexity in estimation and interpretation, and the need for a sufficiently large sample size to obtain stable and reliable estimates.

Noteworthy is that for the four symbolic innovations operationalized with multi-item scales, an exploratory factor analysis (EFA) was conducted to identify their underlying dimensions. Appendix 3 presents the results of the EFA and exact wording of the entire set of items (14 items). Each item was measured on a five-point Likert scale to qualify the level of agreement with 14 statements regarding symbolic innovations in museums (1=*Strongly disagree,* 5=*Strongly agree*). This resulted in a four-factor solution with eigenvalues greater than 1 (variance explained = 69.63%). The results presented in Appendix 2 show that of the total 14 items, 5 loaded onto the first, 2 onto the second, 3 onto the third, and 2 onto the fourth factor. The reliability scores (Cronbach's alphas) for each factor were .887, .908, .684, and .690, respectively, indicating that the items forming each factor are reliable (Nunnally & Bernstein, 1994).

Appendix 3 also shows that aesthetic innovation contributes most to the explained variance of the phenomenon under study (24.39%), followed respectively by artistic innovation (19.28%), cultural innovation (16.09%), and audience innovation (9.87%). We consider each of these four factors to comprise the underlying dimensions of symbolic innovations in museums. Thus, these factors will be used as the four dependent variables referring to symbolic innovations in our econometric models. In particular, we used the weighted mean of items corresponding to each factor to construct an index. Therefore, the mean scores of a particular factor of symbolic innovations (artistic, aesthetic, cultural, and audience) can take on non-integer values from 1 to 5 (Thornhill & White, 2007).

We also assessed the unidimensionality and reliability of the ten independent variables based on multiple-item scales, respectively human capital (HUMK), financial resources (FINRES), infrastructural capability (INFRACAP), technological resources (TECHRES), visitors' orientation (VISITOR), custodial orientation (CUSTOD), artistic

creativity (ARTCREA), artistic capability (ARTCAP), collaboration (COLLAB), and co-creation (COCREA). For all variables measured with multiple-item scales, we conducted a principal components factor analysis (PCFA) on the construct scales to assess their unidimensionality (Ahire & Devaraj, 2001). The results of the PCFA of the ten independent variables indicate that they are unidimensional. Moreover, the values of Cronbach's alpha indicate that the items forming each index are reliable. Finally, the tolerance statistic values for the independent variables used in the regression models, which are all much higher than 0.2, confirm that there are no concerns regarding multicollinearity (Field, 2013; Menard, 2002). Appendix 1 provides an overview of the operationalization of the dependent and explanatory variables that may be associated with innovation in museums. The wording of all questions and assertions used to operationalize the dependent and independent variables of this study are detailed in Appendix 1.

Regression results

The regression results, presented in Table 3, summarize the final unsaturated path models, which include only significant coefficients. This table also reports the covariance effects between different innovation types and compares the constrained unsaturated model (with fixed error term covariances at 0) to the unconstrained version.

Overall model fit and R-squares

The unsaturated path model demonstrated strong fit indicators, with 72 degrees of freedom and a non-significant chi-square statistic of 69.88 ($p = 0.549$), suggesting an excellent fit. The R^2 values show that artistic (ARTI: $R^2 = 0.626$), process (PROC: $R^2 = 0.520$), cultural (CULT: $R^2 = 0.378$), and aesthetic innovation (AESTH: $R^2 = 0.349$) were the most effectively explained in the model.

Last, the appropriateness of the path modeling approach was reaffirmed through an LR index test comparing the unconstrained and constrained unsaturated models. The result (Chi-square = 281.94, $p = 0.000$) strongly rejected the null hypothesis that all error term covariances are zero, validating the simultaneous estimation of multiple regressions over separate models.

Complementarities among types of innovation in museums

The estimates of the error term covariances of the eight regression equations are reported at the bottom of Table 3. All significant covariances are positive. Specifically, the results suggest complementarities between the four types of technological innovation (product, process, organizational, and marketing innovation). Thus, none of these innovations substitute one another. The results also show complementarities between product innovation and three of the four types of symbolic innovations—aesthetic, cultural, and audience innovation—and between marketing and all symbolic innovations (artistic, aesthetic, cultural, and audience). Likewise, complementarities are found between the pairs process–aesthetic innovation, process–cultural innovation, artistic–aesthetic innovation, artistic–cultural innovation, aesthetic–cultural innovation, aesthetic–audience innovation, and cultural–audience innovation.

The remaining statistically insignificant covariances between the estimated disturbances suggest that:

- Product innovation is independent from artistic innovation.
- Process innovation is independent from artistic and audience innovation.
- Organizational innovation is independent from the four types of symbolic innovations.
- Artistic innovation is independent from audience innovation.

Noteworthy is that some covariances between the innovation pairs are higher, in absolute terms, than others, suggesting the presence of higher complementarities between some pairs than others. This is notable between the following pairs: product and marketing innovation (0.427), product and process innovation (0.391), process and organizational innovation (0.388), and aesthetic and cultural innovation (0.334).

Effects of explanatory variables on types of museum innovation

The results in Table 3 indicate that between five and seven explanatory variables significantly influence each of the eight innovation types with significance levels ranging from 1% to 10%. Examining the role of resources, certain predictors strongly determine the likelihood of adopting different innovation strategies in museums. Considering the effects of the different variables to explain the variations of the eight dependent variables (different types of museum innovations), regarding the explanatory variables related to the resources available to museums, the results do not fully support any of our hypotheses. First, our findings reveal that the use of technological resources is significant and positively correlated with only process, organizational, marketing, and audience innovation. It has no impact on product, artistic, aesthetic, and cultural innovation. These results partially support Hypotheses 1a and 1b. Moreover, the results show that infrastructural capability is significant and positively associated with process, organizational, aesthetic, cultural, and audience innovation. Hence, it has no impact on product, marketing, and artistic. These results partially support Hypotheses 2a and 2b. Furthermore, financial resources are significant and positively associated with five types of innovation, namely product, organizational, marketing, artistic, and aesthetic innovation. Hence, these have no impact on process, cultural, and audience innovation. This result partially supports Hypotheses 3a and 3b. In addition, human capital is significant and positively associated with only two types of innovation: product and cultural innovation. This means human capital has no effect on process, organizational, marketing, artistic, aesthetic, and audience innovation. Consequently, Hypotheses 4a and 4b are partially confirmed.

Likewise, regarding creativity factors, artistic creativity is significant and positively associated with product, process, artistic, and aesthetic innovation. Therefore, it has no impact on organizational, marketing, cultural, and audience innovation. As such, Hypotheses 5a and 5b are partially supported. As for artistic capability, it is significant and positively associated with only three types of innovation: organizational, marketing, and artistic innovation. It therefore has no impact on the other types of innovation, namely product, process, aesthetic, cultural, and audience innovation. These results partially confirm Hypotheses 6a and 6b. Finally, knowledge resources (R&D) are significant and positively correlated with product and process innovation, and significantly and negatively associated with organizational innovation. Thus, R&D has no effect on marketing innovation or on the four symbolic innovations: artistic, aesthetic, cultural, and audience innovation. This result partially confirms Hypothesis 7a, but does not support Hypothesis 7b.

As for the explanatory variables related to the market, Table 3 shows that visitors' orientation is significant and positively associated with marketing, cultural, and audience innovation. In terms of technological innovations, it impacts product, process, and organizational innovation. However, regarding symbolic innovation, visitors' orientation has no effect on artistic or aesthetic innovation. Therefore, Hypotheses 8a and 8b are partially confirmed. Concerning custodial orientation, it is significant and positively associated with only artistic and audience innovation, and has no impact on technological innovations. It also has no impact on aesthetic or cultural innovation. In this case, Hypothesis 9a is partially confirmed, while Hypothesis 9b is not supported.

Regarding networking-related factors, collaboration is significant and positively associated with only one type of technological innovation, namely process innovation, and two types of symbolic innovation: aesthetic and cultural innovation. Thus, collaboration does not significantly impact product, organizational, marketing, or the two symbolic innovations of artistic and audience innovation. These results partially

Table 3
Results of the unsaturated multivariate path model explaining innovations in museums.

	Product innovation [PROD]		Process innovation [PROC]		Organizational innovation [ORGA]		Marketing innovation [MARK]		Artistic innovation [ARTI]		Aesthetic innovation [AESTH]		Cultural innovation [CULT]		Audience innovation [AUDIE]	
	Coeff. (β)	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*	*Coeff. (β)*	*P-value*
Independent variables																
Intercept	2.542	.002	7.167	.000	1.562	.020	2.817	.012	.728	.004	.087	.750	.119	.746	.766	.132
RESOURCES																
Human capital [HUMK]	.287*	.062											.090*	.055		
Financial resources [FINRES]	.169**	.037			.249**	.035	.306**	.039	.010**	.039	.129**	.032				
Infrastructural capability [INFRACAP]			.346*	.068	.455**	.01					.304***	.000	.292***	.000	.117**	.067
Technological resources [TECHRES]			1.173***	.000	.466*	.007	.669***	.000							.243***	.002
Knowledge resources [R&D]	.315***	.004	.401**	.032	-.900**	.004										
MARKET FACTORS																
Visitors' orientation [VISITOR]							.120***	.001					.219*	.060	.119***	.004
Custodial orientation [CUSTOD]									.099**	.046					.201**	.036
CREATIVITY FACTORS																
Artistic creativity [ARTCREA]	.392***	.007	.451***	.006					.094***	.004	.139*	.070				
Artistic capability [ARTCAP]					.221**	.014	.301***	.002	.445***	.000					.052**	.049
RELATIONAL FACTORS																
Collaboration [COLLAB]			.447***	.014							.132**	.022	.165***	.003		
Co-creation [COCREA]													.172***	.004		
CONTROL VARIABLES																
Size [LN SIZE][a]	.668***	.002	.654***	.002	.417**	.004	.734***	.000			.104**	.044	.142***	.006		
Age [SQRTAGE][b]			.180*	.062												
Ownership [OWNER]															.155**	.020
Museum vocation [VOCAT]	.648**	.021							1.147***	.000	.521***	.000	.256***	.007		

Covariances between disturbances	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7
ε_1							
ε_2	.391***						
ε_3	.204**	.388***					
ε_4	.427***	.305***	.307***				
ε_5	.028	.082	.060	.086**			
ε_6	.143**	.131**	.055	.140**	.135***		
ε_7	.112**	.180***	.074	.172**	.102***	.334***	
ε_8	.106***	.107	.063	.101*	.028	.082**	.127***

	Product innovation [PROD]	Process innovation [PROC]	Organizational innovation [ORGA]	Marketing innovation [MARK]	Artistic innovation [ARTI]	Aesthetic innovation [AESTH]	Cultural innovation [CULT]	Audience innovation [AUDIE]
R-Square	0.298	0.520	0.137	0.321	0.626	0.349	0.378	0.160
Number of observations	250							
Unsaturated path model with free error terms	$\chi^2(72) = 69.88$, *p-value* $= 0.549$							
Constrained unsaturated path model with error terms fixed at 0	$\chi^2(100) = 281.94$, *p-value* $= 0.000$							

*, **, and *** indicate that the coefficient is significant, respectively, at the 10%, 5%, and 1% thresholds.
a LN indicates a logarithmic transformation.
b SQRT indicates square root transformation.

confirm Hypotheses 10a and 10b. With respect to co-creation, it is significant and positively associated only with cultural innovation. Therefore, the co-creation strategy has no impact on any type of technological innovation including process, product, organizational, and marketing innovation. This result does not support Hypothesis 11a, but partially supports Hypothesis 11b.

For control factors, the results show that museum size is significant and positively associated with the four types of technological innovation: product, process, organizational, and marketing innovation, and with two types of symbolic innovation: aesthetic and cultural innovation. Museum age is significant and positively associated only with process innovation. Ownership is significant and positively associated only with audience innovation. Finally, museum vocation is significant and positively associated with four types of innovation: product, artistic, aesthetic, and cultural innovation.

Discussion

Complementarity and independence

The results suggest the presence of complementarities and independence effects between several types of innovation, partially confirming our hypothesis regarding the existence of complementary relationships between the eight types of innovation. These results offer several important insights into how innovation strategies interact in the museum context:

- First, the analyses indicate that complementarities are more pronounced among technological innovations than among symbolic ones. This is probably because technological innovations share more common determinants than symbolic innovations. This conclusion is aligned with Castañer and Campos' (2002) analysis, which shows that in art organizations, innovations such as artistic ones have their own specific determinants.
- Second, marketing innovation emerges as the most complementary type of technological innovation, showing strong linkages with nearly all other types except organizational innovation. This could be attributed to the importance of marketing in museums (Hausmann & Poellmann, 2013). Through marketing functions, and especially marketing communication, museum managers communicate their innovations to audiences (Lukáč et al., 2021, Zbuchea, 2015). To achieve this aim, marketing communication must complement all types of innovation in museums to make them known to visitors (Nechita, 2014). However, organizational innovation, for example organizational chart changes, does not need to be communicated to visitors.
- Third, almost all types of innovations considered in this study go alongside product and process innovations. This result is justified by the fact that product or process innovation create the framework in which other types take place. For example, symbolic innovations are often implemented in the context of museum exhibitions that induced both product and process innovations.
- Fourth, all symbolic innovations are independent from organizational innovations. In museums, organizational innovations often refer to replacing curators who are art experts by those are experts in both art and business (Camarero & Garrido 2012). Consequently, organizational innovations are evidenced in the adoption of a business rather than custodial approach, while symbolic innovations showcase mainly a custodial approach (Rumpel et al., 2010). In this sense, it would not be effective to simultaneously implement organizational and symbolic innovations, because they pursue conflicting goals. However, this result needs to be further investigated, since the technical-administrative dichotomy is the focus of museums, which aim to achieve business and custodial aims.
- Fifth, cultural innovation appears to be the most integrative type, demonstrating complementarities with nearly all other innovations except audience and organizational innovation. In fact, other types of innovation can be implemented during cultural innovations, which manifest as the organization of temporary exhibitions, drawings, painting workshops, or live performances (Li & Ghirardi, 2019).

In summary, the results suggest complex interactions between several types of innovation in museums that are mutually reinforcing and lead to better innovation performance. Furthermore, synergy effects are evident between the types of innovation. Here, the performance of certain types of innovation can become a resource base on which to implement other innovations.

Determinants of innovations in museums

The results show that financial resources, artistic creativity, artistic capacity, and infrastructural capability have a positive and significant impact on almost all types of innovation. Technological resources impact only technological innovations. These results only partially confirm our hypothesis regarding the positive impact of technology on innovation in museums (Hypothesis 1), and may be due to our conceptualization, which assimilated technological innovation to those in manufacturing, where innovations are mainly associated with the intensive use of technology (Mongo, 2013). Nevertheless, our results are aligned with the literature of innovation in museums that highlights technological resources as key drivers for many technological types of innovation (see, e.g., Camarero et al., 2019; García-Muiña et al., 2019). However, according to Camarero et al. (2015), museums must be careful in their use of technology, as overusing it might harm their essence and compromise the integrity of visitors' museum experiences. Thus, technology overuse can have the opposite effect to that expected.

In addition, as previous findings regarding the importance of infrastructure for innovation in art organizations show (Camarero & Garrido, 2012; Colapinto & Porlezza, 2012), and as per Hypothesis 2, we found that infrastructural capability has a significant and positive impact on almost all types of innovation. However, apart from the impact of infrastructure, it will be useful to identify the influence of various types of museum infrastructure. Previous studies distinguish hard and soft infrastructure. Hard infrastructure refers to physical elements like the museum's building (Ing, 1999), while soft infrastructure is related to new forms of digital networking, advanced and innovative artwork exhibition rooms (Colapinto & Porlezza, 2012), and commodity installations for high-quality sound or highly visual productions. Moreover, regarding the positive impact of the availability of financial resources, our results, which confirm Hypothesis 3 that financial resources increase the likelihood of innovation in museums, are consistent with previous studies (see, e.g., Li & Ghirardi, 2019; Vicente et al., 2012). The availability of financial resources enables museums to acquire the inputs they need to innovate. However, while this availability is crucial for innovation, as Geiger and Cashen (2002) pointed out, too high a level thereof can create a relaxed environment inhibiting managers' motivation to engage in innovative activities.

Furthermore, except for cultural innovation, the pairing of artistic creativity and artistic ability impacts all types of innovation, partially confirming Hypotheses 5 and 6, in which these two factors increase the likelihood of technological and symbolic innovations. However, according to Li and Ghirardi (2019), cultural innovation is positively and significantly impacted by collaboration with arts organizations that draw on artistic creativity or capability. Thus, the artistic dimension impacts both technological and symbolic innovations. This is aligned with previous studies that concluded that artistic creativity (Setyanti, 2018) and artistic capability (Akgün et al., 2019) are core antecedents of innovation in creative industries. As per Camarero and Garrid (2011), museums have an artistic, historical, and scientific mission to accomplish by preserving and promoting cultural heritage. This refers to museums attracting a greater number of visitors while focusing on their cultural collection (Camarero et al., 2011). This objective can only be

achieved through attractive innovations that enhance cultural heritage (Camarero et al., 2011). These innovations, according to Gohoungodji and Amara (2023), require artistic creativity or artistic capability, core elements for attractive innovations in creative industries (Hooper-Greenhill, 2013).

Similarly, regarding the use technological resources, our results reveal that R&D in museums impacts only technological innovations, and have no effect on symbolic innovations. This partially confirms Hypothesis 7, which postulated the positive impact of R&D on technological and symbolic innovations in museums. This result is consistent with those of Benghozi et al. (2015), who highlighted the key role of R&D in innovation in creative industries. Contrary to technological innovations, which are based on information from research sources (Amara & Landry, 2005), symbolic innovations stem from artistic inspiration (Arriagada, 2020). Thus, R&D has a limited role in driving symbolic innovation, suggesting a key distinction between technological and cultural forms of innovation. While R&D investments are critical for developing new technologies or materials, symbolic innovation relies more on creative practices and cultural expertise. This implies that innovative strategies in museums should not only focus on formal R&D, but should also foster artistic collaborations, participatory curating, and cross-sector cultural exchange to enable meaningful symbolic change.

From a resource-based perspective, the study showed that no single resource consistently drives all innovation types. While technological resources and infrastructure capabilities positively impact specific innovations, especially those tied to organizational processes and engaging audiences, their effect does not apply uniformly across all innovation types. These findings question the belief that resources always have a universal effect and highlight how their use in cultural organizations can vary depending on the setting. Interestingly, money and experienced workers, typically seen as the key drivers of innovation, showed a more specific and limited influence. This suggests that museums may depend more on unique ways of organizing resources than just having many. Moreover, artistic creativity and skill roles affirm the dual character of innovation in museums, stemming both from artistic creation and institutional management. Artistic creativity encourages advancements in technology and meaningful symbolism, while artistic talent tends to be more specialized. This suggests that fostering innovation might need a blend of artistic imagination and supportive management. Moreover, the minimal and sometimes unfavorable impact of R&D spending raises questions about how museums effectively conceptualize and implement research to support innovation.

Furthermore, the partial validation of Hypotheses 8 and 9, which propose that market factors increase the likelihood of innovations in museums, indicates that while visitor orientation significantly contributes to both technological and symbolic innovations, custodial orientation is less influential. This distinction implies that innovation could be more strongly linked to actively interacting with visitors rather than focusing only on the traditional objective of preserving artifacts in museums. These observations align with broader trends in the cultural field, where connecting with audiences and creating immersive experiences are becoming more central (Chan et al., 2016). Camarero and Garrido (2012), for example, found that visitor orientation positively impacts organizational innovations. Future studies need to consolidate the effect of visitor orientation on technological innovations. Concerning the positive impact of both visitor and custodial orientation on symbolic innovations, these two determinants reflect the dichotomous nature of the museum's mission. Indeed, on the one hand, custodial orientation enables museums to place their heritage mission at the core of their innovative activities by preserving and safeguarding heritage (Camarero et al., 2015). Visitor orientation, on the other hand, pinpoints audience expectations and integrates them into innovative activities to attract high numbers of visitors (Camarero et al., 2015). To achieve these objectives, museums must remain attractive to visitors without losing sight of their primary heritage mission. Thus, heritage base innovations (symbolic innovations) need to integrate visitors' expectations for their attractiveness. However, while some visitors might be excited by attractive novelties, others may be attracted by what a museum has already exhibited and can be discouraged by attractive novelties that can denature museum collections. Like the Mona Lisa in the Louvre, Las Meninas attracts many visitors to Prado every year, even if these museums do not innovate.

Concerning relational factors, the findings suggest a differentiated impact on innovation. Specifically, collaboration emerges as a significant and positive predictor of process, aesthetic, and cultural innovation, but has no significant effect on other types. These results thus only partially support Hypothesis 10, namely that collaboration with art organizations increases the likelihood of innovations in museums. This indicates that collaboration may be particularly conducive to innovative activities that entail procedural improvements and the co-construction of symbolic value rather than those that are product- or market-oriented (Morgan & Castle, 2024). In contrast, co-creation reveals an even more restricted effect, being positively linked only to cultural innovation. This outcome fails to support Hypothesis 11, in which co-creation with visitors increases the likelihood of innovations in museums, thereby challenging the common assumption of the efficacy thereof for all innovation types. One plausible interpretation is that co-creation, which typically involves active stakeholder engagement, may be better aligned with the development of shared meanings and cultural legitimacy than with the quest for technological and organizational novelties (Ko & Liu, 2025).

Regarding size, our results show a positive association between museum size and both technological and symbolic (aesthetic and cultural) innovations. This suggests that larger museums are better equipped to innovate, likely due to greater financial and human resources (Camarero et al., 2011). However, this finding raises important concerns. It implies that larger museums may enjoy a structural advantage in innovation capacity, potentially exacerbating existing resource disparities within the sector. While symbolic innovation is often assumed to emerge from curatorial creativity or the cultural mission, our results suggest it is also associated with organizational size, indicating a growing institutionalization of artistic innovation. This challenges the common assumption that small environments are the primary sites where artistic creativity thrives (Hayes & Roodhouse, 2010). Future research should therefore investigate how small and medium-sized museums innovate despite limited resources, and whether current funding mechanisms unintentionally favor institutional scale over creative diversity. Furthermore, museums' age has almost no influence on all innovative activities. Whatever the age, a museum must innovate to survive. This result partially differs from the findings of Camarero et al. (2011) that museum age plays an important role for innovation. Museum age may have both positive and negative influences on innovation that offset each other, resulting in no net statistical effect. As such, museums' age can both encourage and impede innovation.

For example, legacy constraints and structural inertia may prevent older museums from adapting and changing, even though they may also benefit from the accumulated knowledge, resources, and cultural legitimacy that encourage innovation. This coexistence of opposing forces may neutralize the observable impact of age, rendering it non-significant. This result aligns with prior studies in other nonprofit sectors that found no consistent relationship between organizational age and innovation. Indeed, in studies of nonprofits, some authors (e.g., Damanpour & Schneider, 2006; Chen, 2014) found that organizational age is not a significant predictor of innovation. Actually, innovation in museums may depend more on resources, strategic orientation, and partnership than on how old the institution is.

Likewise, ownership has almost no impact on innovative activities in museums. Both public and private museums need to innovate to remain attractive. Nevertheless, public ownership has a positive impact on audience innovation. For example, during COVID-19, public museums with a high infrastructural and technological capacity more easily digitalized their collections to generate an online audience. This

partially supports the conclusion that public ownership stimulates innovation in museums (Camarero et al., 2011). Finally, the finding that museum vocation, which is whether a museum exhibits artistic artworks, is positively associated with product, artistic, aesthetic, and cultural innovation, highlighting the central role of artistic mission in driving both technological and symbolic innovations. Museums that explicitly focus on exhibiting art are more likely to engage in activities that push creative boundaries, reinterpret collections, or adopt new curatorial formats. This supports the idea that a strong artistic orientation provides not only a mandate for innovation, but also legitimizes experimental practices and risk-taking (Knell & Taylor, 2011). Symbolic innovation, in particular, is deeply connected to a museum's expressive mission and engagement with cultural meaning-making (Weil, 2002). In contrast, museums with non-artistic vocations—such as science, history, or ethnography—may be more constrained by educational or preservationist mandates that limit symbolic experimentation. This suggests that innovation capacity is not only resource-driven but also shaped by institutional identity and cultural purpose.

The significance of these control factors, namely museum size, age, ownership, and advocation, highlights the importance of contextual elements. Larger and more diverse institutions seem better equipped to innovate in multiple areas, while ownership and mission alignment also play vital roles in determining innovation capability.

Conclusion

Our study estimated a multivariate path model to simultaneously examine several types of innovation in museums. Contrary to previous literature, this study identified common and specific factors that influence innovation in museums. We found the positive impact of financial resources on innovation in museums, although these had no impact on process, cultural, and audience innovations. Moreover, technological and knowledge resources are significant and positively associated mainly with technological innovations, while infrastructural capability positively impacts all types except product, marketing, and artistic innovation. In addition, human capital is significant and positively associated with product and cultural innovation, while artistic creativity is significant and positively associated with product, process, artistic, and aesthetic innovation. Concerning market factors, visitors' orientation is significant and positively associated with marketing, cultural, and audience innovation, whereas custodial orientation is significant and positively associated with artistic and Audience innovation. For relational factors, collaboration is significant and positively associated with process, aesthetic, and cultural innovation, while co-creation impacts only cultural innovation. Finally, museums size is significant and positively associated with technological, aesthetic, and cultural innovation; museums' age impacts only process innovation, and ownership affects only audience innovation.

The results offer theoretical and empirical contributions. Regarding theoretical contributions, first, we respond to recent calls to better understand the determinants of innovation in creative industries including museums (see Gohoungodji & Amara, 2023). Moreover, we advance research from an empirical perspective, consolidating the impacts of some determinants of innovation in these industries (e.g., size of industry, industry type, financial resources, R&D), using empirical evidence regarding innovation, which thus far, lacks empirical study in museums (Li & Ghirardi, 2019). For instance, drawing on the hypothesis that the quality of human capital enhances the likelihood of innovation in museums, this study constitutes one of the first explicit investigations on this impact. In addition, our integrative approach that enables exploring both symbolic and technological innovations is a significant contribution to the literature. In contrast to previous studies that focused on technological innovations, ours extends the literature to symbolic innovations and considers both. Finally, this research provides deeper insight into innovation in museums by combining and mobilizing the resource-based view, market Orientation approach, and vicarious learning perspective. This contributes to a more nuanced theoretical understanding of innovation in cultural institutions and emphasizes the need for tailored innovation strategies that consider specific innovation goals, institutional constraints, and stakeholder environments of museums.

Concerning empirical contributions, the study underlines key strategies that can help museum managers and cultural policymakers. By identifying determinants specific to each type of innovation and those common to all types, the study highlights the need for museum managers to adopt specific innovation strategies that fit their distinct resources and goals. The study also reveals that having resources like technology, artistic talent, and financial resources does not ensure innovative outcomes in museums. Instead, museum managers should tailor their resources strategically depending on the types of innovations they want to pursue, institutional constraints, and stakeholder environments. While our hypothesis positing that R&D increases the likelihood of symbolic innovations is rejected, the analyses suggest that museum managers should rethink how they integrate knowledge creation and experimentation into their everyday routines. Encouraging teamwork among various groups and embracing projects that allow for trial and error could fuel innovation more effectively than relying solely on official R&D.

Furthermore, the study underscores the value of being market focused. Museums that adjust to changing visitors' preferences are more likely to bring about innovative activities. Hence, faced with resources rarefaction in museums, knowledge of the determinants by type of innovation will enable managers to know which resources to deploy for which types of innovation. According to Landry et al. (2010), better understanding the determinants of each type of innovation enables highlighting common and specific factors that drive or block such portfolios. This allows museum managers to know which levers to prioritize and barriers to avoid to successfully implement innovation, which may increase the likelihood of their organization's survival. Moreover, building on the hypothesis of the existence of complementarity among the eight types of innovation, our analyses help improve understanding of the synergy effects between several types of innovation, thereby providing useful guidance for museum managers. This will help them develop appropriate museum innovation policies combining technological and symbolic innovations. Consequently, they can reduce the costs of their innovation activities by making more efficient use of resources that can be shared between different types of innovation

However, despite the quality of our results, some limitations must be reported. First, the data used for statistical analysis were collected exclusively from museum managers. According to Gainer and Padanyi (2005), studies of this nature would benefit from incorporating multiple opinions such as those of employees and artists to gain a more comprehensive understanding of innovation determinants in museums and their management. In addition, to generalize our findings to other cultural organizations, future research should extend the study to other creative industries, as our analysis focused solely on museums. While we have controlled for museum vocation, the heterogeneity of our sample may limit our ability to fully account for the peculiarities of different types of museums. Moreover, the study relies on cross-sectional data, which may restrict the ability to draw causal conclusions. Hence, we acknowledge the potential for reverse causality and omitted variable bias. Research using longitudinal or panel data would help address these endogeneity concerns and better establish the directionality of effects.

The following future research areas have been identified. First, future studies could improve the classification of innovation types by exploring more areas such as the social and environmental arenas. Second, while our research focused on museums' current resources, future studies could delve further into how museums develop, combine, and adapt their resources over time to keep innovating. Third, this study is limited to Canadian museums, which may constrain the generalizability of the findings. Nonetheless, Canada presents a relevant and rich context for examining museum innovation due to its linguistic duality,

cultural diversity, and strong public support for the arts. These characteristics may influence how museums engage in different forms of innovation including symbolic innovations. Future research could extend this analysis to museums in other countries to assess the influence of institutional, cultural, and policy environments on innovative trajectories. Fourth, given the context-specific nature of our study, future research could investigate whether the factors that drive innovation differ across various cultural or geographic settings, types of museums (e.g., art vs. science museums), or ownership structures. Fifth, outside innovation adoption, future studies could examine how innovation affects museum performance, including aspects like visitor satisfaction and financial resilience.

CRediT authorship contribution statement

Paulin Gohoungodji: Writing – original draft, Writing – review & editing, Methodology, Investigation, Data curation, Formal analysis. **Nabil Amara:** Funding acquisition, Project administration, Methodology, Data curation.

Declaration of competing interest

The authors report there are no competing interests to declare.

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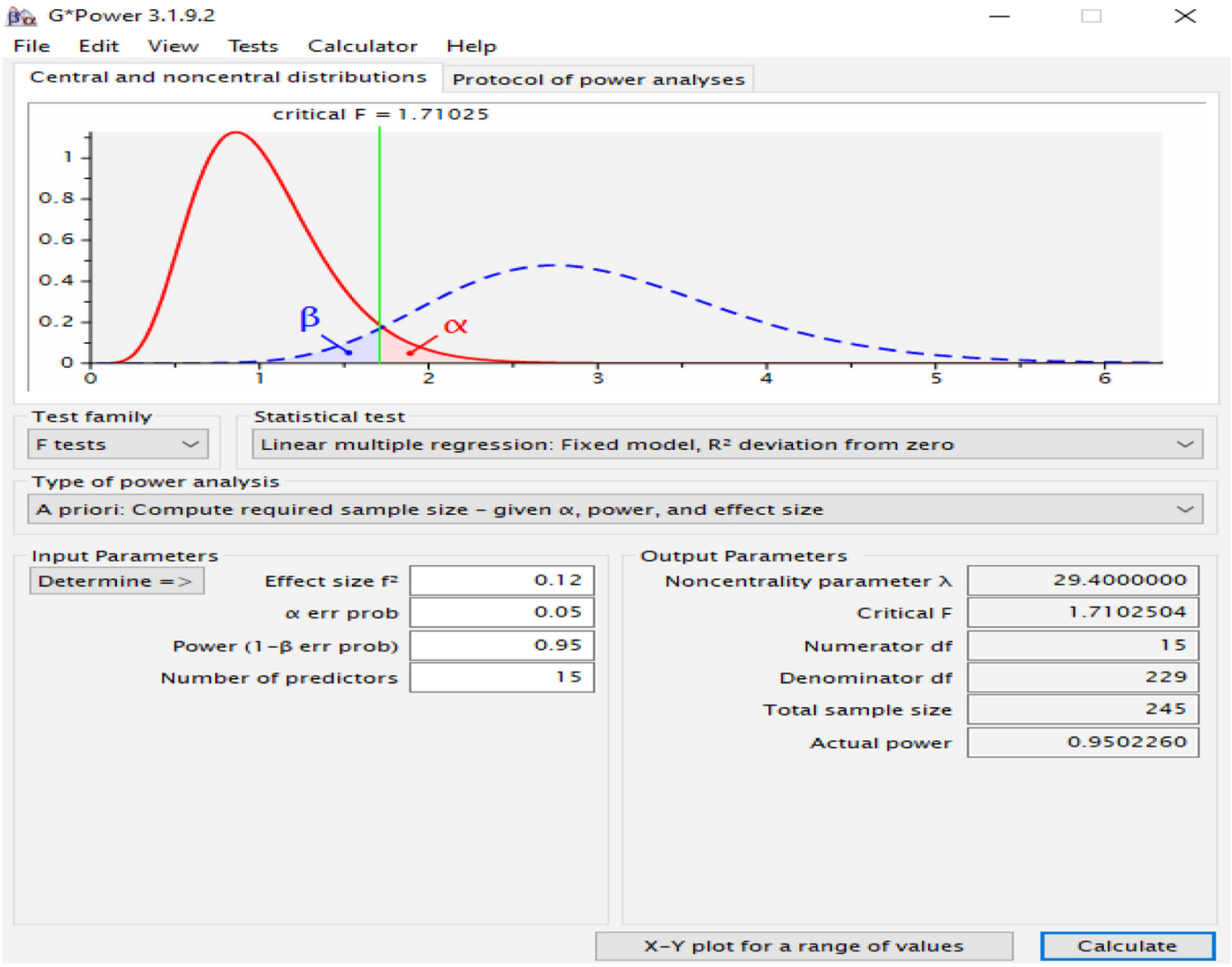
Appendix

Appendix 1, Appendix 2, Appendix 3

Appendix 1
Operational definitions and descriptive statistics of the dependent and independent variables.

	Measure	Sub-items	Tolerance*	Cronbach'sα
Dependent variables: Technological and symbolic innovation				
Product innovation [PROD]	Museum has introduced new creative products or services (e.g., new exhibitions, new artwork, new training for artists, etc.) during the last three years. 1 if there is innovation, 0 otherwise			
Process innovation [PROC]	Museum has utilized new processes (e.g., procedures in artists programming, in sponsor or financing search, in ticketing, etc.) during the last three years. 1 if there is innovation, 0 otherwise			
Organizational innovation [ORGA]	Museum has introduced changes in organizational structure (e.g., museum chart reorganization, creation or deletion of positions, personal training, etc.) during the last three years. 1 if there is innovation, 0 otherwise			
Marketing innovation [MARK]	Museum introduced novelties in marketing strategies (e.g., changes in entry prices, changes in advertising, segmentation in audience age, etc.) during the last three years preceding the survey. 1 if there is innovation, 0 otherwise			
Artistic innovation [ARTI]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of four statements regarding artistic innovation, over the last three years preceding the survey.	We strongly invite our artists to present new artworks during our exhibitions. We present artists from different disciplines (sculpture, photography, painting, etc.) during our exhibitions. Our artworks' artists add something new to their traditional or existing artworks during the exhibitions. Our artworks' artists have increasingly turned to technological creative opportunities.	0.908	
Aesthetic innovation [AESTH]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of five statements regarding aesthetic innovation, over the last three years preceding the survey.	We make new scenography for each exhibition. We exhibit artworks that present new aesthetic novelties. We bring novelties in the exhibition's scenography design. We bring novelties in the exhibition's scenography lighting. We often add novelties in the disposition of artworks in exhibition rooms.	.887	
Cultural innovation [CULT]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of four statements regarding cultural innovation, over the last three years preceding the survey.	We organize several permanent and temporary exhibitions in our museum. We organize several educational workshops (for children, families, and adults) outside traditional exhibitions (painting, live performing arts, or other workshops). We organize several cultural activities outside traditional exhibitions (painting, live performance arts, or other workshops).	.684	
Audience innovation [AUDIE]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of two statements regarding audience innovation, over the last three years preceding the survey.	Our museum generates new audiences through online access to collections. Our museum uses online knowledge resources to inform and educate our audiences.	.690	



Appendix 2. G* Power 3.1.

Appendix 3
Exploratory factor analysis results underlying museums' symbolic innovations.

	Factorsyyy			
	1	2	3	4
Aesthetic innovation [AESTH]				
We make new scenography at each exhibition.	.847			
We exhibit artworks that present new aesthetic novelties.	.637			
We bring novelties in the exhibition's scenography design.	.831			
We bring novelties in the exhibition's scenography lighting.	.786			
We often add novelties in the disposition of artworks in exhibition rooms.	.765			
Artistic innovation [ARTI]				
We strongly invite our artists to present new artworks during our exhibitions.		.912		
We present artists from different disciplines (sculpture, photography, painting, etc.) during our exhibitions.		.905		
Our artworks' artists add something new to their traditional or existing artworks during the exhibitions.		.862		
Our artworks' artists have increasingly turned to technological creative opportunities.		.808		
Cultural innovation [CULT]				
We organize several permanent and temporary exhibitions in our museum.			.849	
We organize several educational workshops (for children, families, and adults) outside traditional exhibitions (painting, live performing arts, or other workshops).			.817	
We organize several cultural activities outside traditional exhibitions (painting, live performing arts, or other workshops).			.655	
Audience innovation [AUDIE]				
Our museum generates new audiences through online access to collections.				.910
Our museum uses online knowledge resources to inform and educate our audiences.				.678
Eigenvalue	5.874	2.320	1.345	1.096

(*continued on next page*)

Appendix 3 (*continued*)

Variance Explained	24.389	19.279	16.088	9.871
Cronbach's Alpha	.887	.908	.684	.690
(a) Total variance extracted by the five factors: 69.627%; KMO = 0.890; Bartlett's Test = 2000.190 (*p-value* = 0.000)				
(b) Extraction method: Principal components				
(c) Rotation method: Varimax with Kaiser normalization.				

	Measure	Sub-items	Tolerance *	(Cronbach's α)
	Independent continuous variables			
Human capital [HUMK]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding human capital over the last three years preceding the survey.	Our employees' competence is at a suitable level. When an employee leaves the museum, we train a successor. The museum supports employees in upgrading their skills and qualifications where necessary.	.668	.815
Financial resources availability [FINRES]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding financial resources over the last three years preceding the survey.	Our museum has available financial sources. If we need more financial assistance, we could easily obtain it. We can obtain short-term financial resources.	.792	.613
Infrastructural capability [INFRACAP]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding infrastructural capability over the last three years preceding the survey.	We have the capability to produce performances with high-quality sound and visual production. We manage our exhibition room and facilities, logistics, and operations at a high level. We can accommodate and support large-scale productions/exhibitions.	.527	.715
Technological resources [TECHRES]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of four statements regarding technological resources over the last three years preceding the survey.	We have adopted new technologies and resources aimed at improving management and administration. We have incorporated numerous technical innovations at the museum in recent years (e.g., giant screen, big sound hits, air-conditioning system, etc.). We use technical resources to improve audiences' leisure. We cooperate with other institutions or firms to improve the technology and innovations implemented at our museum.	.485	.767
Visitors' orientation [VISITOR]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding visitors' orientation over the last three years preceding the survey.	Our museum strategy is based on those aspects we feel may create value for visitors. The museum's goals are geared toward visitors' satisfaction. We endeavor to keep abreast of changes to assess their impact on visitors' expectations.	.607	.719
Custodial orientation [SUPPL]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding custodial orientation over the last three years preceding the survey.	We are interested in developing projects that enable us to maintain the perennial nature of our assets. The main goal of the museum is to maintain and preserve its collections. We are concerned with projecting to society a positive image of the work we do to preserve our cultural heritage.	.738	.708
Artistic creativity [ARTCREA]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding artistic creativity over the last three years preceding the survey.	Our employees are consistently generating new ideas that result in new artistic products. Our employees find artistic ways to present standard artworks in a new context for audiences. Our employees develop artistic ability to present artwork that is novel and original.	.538	.833
Artistic capability [ARTCAP]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding artistic capability over the last three years preceding the survey.	Our artworks are produced by artists who are among the best regarding their artistic performance. Our museum exhibits artworks produced by artists whose performances are executed at a high level. Our museum exhibits artworks produced by artists who can create challenging artworks.	.326	.894

(*continued on next page*)

(*continued*)

Collaboration [COLLAB]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding collaboration preceding the survey.	We maintain collaborative relationships with other arts organizations that complement what we have to offer. We collaborate with other arts organizations to offer audiences new products and services. We initiate productive working relationships with other arts organizations.	.660	.862
Co-creation [CLIENT]	Measured as a weighted mean on a Likert scale of agreement ranging from 1= Strongly disagree to 5= Strongly agree of three statements regarding co-creation over the last three years preceding the survey.	Learning from visitors. Exchange practices with partners. Collaborative practices with visitors.		.690
Size [LN SIZE]	Continuous variable measured by the total number of employees in the museum in 2023. Because of the highly asymmetric distribution of this variable, a logarithmic transformation was applied to reduce the degree of skewness.		.699	
AGE [SQRTAGE]	Continuous variable measured by the age of the museum in 2023. Because of the highly asymmetric distribution of this variable, a square-foot transformation was applied to reduce the degree of skewness		.929	
	Independent categorical variables			
Knowledge resources [R&D]	Dichotomous variable coded 1 when the museum is engaging in R&D activities to innovate and 0 if not.		.877	
Ownership [OWNER]	Dichotomous variable coded 1 if the museum is a public museum and 0 if not.		.908	
Museum vocation [VOCAT]	Dichotomous variable coded 1 if museum exhibits artworks by artists and 0 if not.		.348	

*As shown, all tolerance statistic values are much higher than 0.2. This confirms that there are no concerns regarding multicollinearity (Menard, 1995; Field, 2009).

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