

Article

Visitor-Sensing: Involving the Crowd in Cultural Heritage Organizations

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Abstract: As organizations are increasingly involving individuals across their boundaries in the generation of new knowledge, crowd involvement can also be beneficial to cultural heritage organizations. We argue that in an “Open Innovation in Science” approach, visitors can contribute to generate new scientific knowledge concerning their behavior and preferences, by which museum managers can re-design the cultural offerings of their institutions in ways that generate major economic and social impacts. Accordingly, we advance visitor-sensing as a novel framework in which museum managers leverage digital technologies to collect visitors’ ideas, preferences, and feedback in order to improve path design and the organization of artwork in exhibitions, and to shape a more satisfying museum experience for visitors. We contend that visitor-sensing has the potential to yield higher numbers of visitors, with positive impacts in terms of increased revenues and increased literacy of the general public, thus benefiting the economic and social sustainability of cultural organizations towards the achievement of the Sustainable Development Goals outlined in the Agenda 2030.

Keywords: Open Innovation; Open Innovation in Science; cultural heritage organizations; sustainability; museums; managerialization; Sustainable Development Goals; Agenda 2030

1. Introduction

“Museums need to step into the future” as recently written by Dr. Walker, President of the Ford Foundation, that supports cultural heritage institutions [1]. In particular, museums are increasingly being demanded to employ new digital technologies and to serve a wider population. An “Open Innovation in Science” (OIS) approach can help to achieve these aims by leveraging in-bound knowledge flows to generate new scientific knowledge concerning visitors’ behavior and preferences, by which museum managers can shape the cultural offerings of their institutions in ways that generate major economic and social impacts. Thus, following an OIS approach, engaging the general public into cultural heritage organizations’ activities can contribute to scientific advancements for the benefits of both cultural heritage sites, and the entire society, contributing to the attainment of the Sustainable Development Goals (SDGs) established by the United Nations and outlined in the Agenda 2030 [2,3]. While the benefits of an OIS approach may accrue to cultural heritage organizations in general, the present paper is specifically focused on museums, which represent the majority of cultural heritage sites [4].

OIS has its roots in the Open Innovation (OI) phenomenon, which has subverted, in the early 2000s, the traditional mechanism of new knowledge creation, based solely on internal human resources, by highlighting the importance of leveraging a variety of entities from outside the organization

boundaries [5,6]. The advantages of including external partners in the development of new knowledge are primarily rooted in the diversity of their knowledge, which may yield valuable new ideas and unique insights [7–9]. Accordingly, OI is increasingly attracting scholarly and managerial attention because of the benefits it can bring to organizations in terms of innovation performance and R&D outcomes [10–13], as well as of sales growth and productivity [14,15].

Among the several categories of partners that are employed as knowledge sources in OI practices, e.g., suppliers, competitors, universities [11,16–18], growing importance is attached to crowds, whose involvement in OI practices has been significantly enhanced by recent advancements in information technologies [19–21]. Individuals have actually been shown to be potentially valuable sources of information and new ideas and to be employed in the creation of new knowledge [20,22]. Thus, the involvement of crowds in inbound OI initiatives, i.e., where knowledge flows from outside to inside the organizational boundaries, is increasingly practiced by public and private organizations, through crowdsourcing or citizen science initiatives, for their research purposes and to improve their products, services, and organizational routines [22,23].

Crowdsourcing consists of campaigns aimed at collecting new ideas from dispersed individuals in exchange for a bounty to support the processes of innovation development and problem solving, with positive effects on performance [21,23–26]. In addition, crowds are increasingly being involved toward non-profit goals in socially oriented crowdsourcing campaigns aimed at sustaining innovations and solutions for social causes [27], or in citizen science activities [28–30]. In citizen science, participants devote their time and efforts voluntarily, rather than for a reward, towards scientific tasks, like collecting or analyzing data, for social, typically environmentally oriented, objectives such as aiding the clean-up of a polluted canal [31–33]. Citizen scientists are volunteer citizens helping professional researchers in conducting their research, who can be tremendously helpful in addressing Grand Challenges, i.e., “highly significant yet potentially solvable problems [. . .] with intertwined technical and social elements” [34] (p. 1). However, the ways in which, at the crossroad between crowdsourcing and citizen science, crowds can be involved by cultural organizations for enhancing the scientific understanding of the behavior and preferences of visitors, the insights they can provide, and the ensuing benefits for both cultural organizations and the overall society, have not been systematically examined so far. We believe, instead, that investigating crowd involvement in cultural organizations can be crucial for academics, museum managers, and policymakers, as well as to nurture future studies aimed at further advancements in the scientific understanding of how interacting with visitors can improve the management of cultural heritage organizations.

Based on the above, in the present paper, we address the following research question: can crowds, specifically visitors, be involved in OIS practices by cultural heritage organizations, and what benefits such an involvement may offer at both the organizational and societal levels? Accordingly, the purpose of this paper was to advance visitor-sensing as a novel framework that, while drawing on OI, OIS, and specifically, crowdsourcing and citizen science, is focused on (and devoted to) cultural heritage organizations, and museums in particular, and to shed light on the advantages of its implementation. We believe that identifying the boundaries of visitor-sensing and its benefits can stimulate scholars to conduct scientific studies about it and cultural organizations to put in practice our proposed framework.

In the remainder of the paper, we first introduce the OI, citizen science, and crowdsourcing phenomena (Section 2). We then discuss how crowd involvement can be implemented in the context of cultural organizations (Section 3) and outline our proposed framework and the ensuing propositions (Section 4). Finally, we report the discussion and conclusions of our work (Sections 5 and 6 respectively).

2. Open Innovation, Citizen Science and Crowdsourcing

As defined by Chesbrough, OI is “a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market” [35] (p. 1). Depending on the direction that the flows of information can take [17,36,37], different types of OI have been identified: (i) in-bound OI, where companies benefit by the outcomes coming from outside their

boundaries; (ii) out-bound OI, where knowledge goes from inside to outside firms' boundaries; and (iii) coupled, where knowledge flows in both directions. Recently, the fundamental principles of OI have been applied to a variety of contexts. In particular, the involvement of crowds is increasingly adopted to accelerate search and knowledge creation at the societal level towards OIS. The United Nations and the World Bank, among others, recognize the importance of OIS in addressing societal challenges. The difference between this open approach to science and the traditional one has been described with an effective analogy in a recent study [38]. The generation of new knowledge occurring decades ago was similar to a cathedral project where everything is built and managed by a known group of skilled artisans chosen from inside the organizational boundaries and among whom there are strict hierarchical relationships. Conversely, the open approach called into action by Chesbrough closely resembles a bazaar where everyone can enter the group and contribute to the overall need of goods exchange, and the inclusion of numerous independent and self-motivated individuals is critical for value creation. This may happen in a number of different organizational contexts, even in the presence of tight hierarchical internal structures [24,27,39,40], which, we argue, also include cultural organizations, where visitors may enter the cultural "bazaar" and contribute to its operations and even success, if invited to do so.

This open approach to the production of new knowledge is increasingly being adopted by private and public organizations and has been shown by previous research to bring benefits in terms of innovation, R&D outcomes, and overall performance [10–12,14,15,41]. In particular, the involvement of dispersed individuals from outside an organization's boundaries allows to leverage the "crowd wisdom" that arises from heterogeneous mind-sets and from knowledge diversity [20,42,43]. Crowd-based initiatives have also been facilitated by recent advancements in information technologies which facilitate the involvement of dispersed individuals from all over the world, overcoming geographical, social, and cultural distances among participants [31,44,45]. Therefore, it is increasingly possible for companies to tap into crowds and leverage the wide variety of expertise and resources people are endowed with [46].

Citizen science and crowdsourcing are phenomena related to in-bound OI, which involve dispersed individuals from outside firms' boundaries to leverage their fragmented knowledge [25]. Citizen science and crowdsourcing can be distinguished based on the motives underlying individuals' participation and on the type of contributions they provide. In citizen science, non-scientist volunteers devote their time and efforts towards scientific tasks set by professional researchers [31]. In these types of projects, participants involved in data collection and analysis primarily respond to intrinsic motivations, i.e., those related to the pleasure and fun of contributing to a social aim [31,47,48]. The term citizen science implies, indeed, that every citizen without any particular knowledge requirements can participate in the scientific process by performing specific, well-delineated, and typically simple tasks. When, instead, crowds are involved in more complex tasks like solving problems and propose new ideas to innovate, we speak about crowdsourcing. The term was coined by Jeff Howe in 2006 [49] to identify the rising managerial tendency to tap into the latent talent of people loosely affiliated through the Internet. In this case, participants are mainly motivated by extrinsic motivations, i.e., they contribute in exchange of a reward [50], which can be money, social recognition, or even a gadget [27].

Drawing on this literature that analyzes the involvement of crowds in the production of new knowledge for scientific aims, in the present paper, in accordance with an OIS approach, we argue that crowds can also be leveraged to gain a deeper scientific understanding of the behavior and preferences of museum visitors, which, in turn, should be translated by museum managers into improved cultural offerings for the benefits of both their organizations and the overall society.

3. Crowd Involvement in Cultural Heritage Organizations

Until the recent past, cultural heritage organizations were used to adopt top-down approaches, where the decisions concerning the organization of cultural experiences were taken by top managers without careful consideration of the visitors' preferences [51]. This trend is recently shifting towards

the adoption of bottom-up approaches where visitors' insights are leveraged to improve the products and/or services provided [51,52]. In fact, as a part of their ongoing "managerialization" (i.e., the application of managerial concepts to non-business-like organizations), cultural heritage organizations are increasingly implementing state-of-the-art managerial practices in order to improve their efficiency and effectiveness [51,52]. As crowdsourcing and citizen science have been shown to be effective bottom-up means by which organizations can improve their products and/or services, their underlying logics may also be applied to cultural heritage organizations. While previous studies have adopted a relational marketing approach to customer involvement in cultural organizations, by focusing on the creation of long-lasting relationships with specific individuals (e.g., lead users) to improve value creation [53,54], the OIS approach discussed in this study is based on short carefully designed interactions with the broadest possible audience.

A peculiar aspect of cultural heritage organizations is that they are hybrid organizations, i.e., organizations driven by two different logics that should be addressed simultaneously. Hybrid organizations, as defined by Battilana and Lee [55] (p. 1), are "enterprises that combine the organizational forms of both business and charity". Cultural organizations are hybrid organizations in that, although pertaining to the public realm, their managers have to take care of both their social sustainability, i.e., of increasing the general public reached and of the overall literacy of citizens, and economic sustainability, i.e., of increasing their revenues to ensure self-sustainment and improve the quality of the products/services provided. Crowd involvement, i.e., the inclusion of all the willing visitors of cultural organizations, can be beneficial to both aims. Indeed, visitors can represent a valuable resource, external to the organization's boundaries, to be leveraged in order to improve the cultural experience offered to the general public, while also increasing the museum's audience. Doing so can exert a positive impact on both the economic and social sustainability of museums [27], thereby generating outcomes that are extremely valuable, especially in the current conditions of chronically scarce financial resources for cultural heritage organizations [56,57], and of great efforts towards Sustainable Development as outlined in the United Nations Agenda 2030 [2,3]. Indeed, the proposed framework could help reach the SDGs proposed by the UN. In greater detail, Goal 11.4, i.e., "strengthen efforts to protect and safeguard the world's cultural and natural heritage", and Goal 4, i.e., "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" are targeted by the proposed framework, whose purpose is to support and sustain cultural organizations and increase their reach on citizens. Moreover, it is important to highlight that the voluntary contribution of citizens represents a further strategic option available to cultural organizations to increase value creation, rather than a way to offset their strategic deficiencies by exploiting the crowd.

We contend that visitors' involvement in museum contexts may represent another effective way to leverage the external crowd and its possible knowledge inflows. In particular, and interestingly to our purposes, previous scholars [42] have suggested that cultural organizations should involve crowds in data and idea collection processes to enhance the overall cultural experience and visitors' satisfaction (by satisfaction, we mean the degree to which individuals positively evaluate the outcomes and experiences associated to a product or service, which evokes overall positive feelings [58]). However, the boundary conditions that characterize the involvement of dispersed individuals in cultural organizations, and the related benefits, have not been properly identified so far.

4. Visitor-Sensing: A New Framework for Crowd Involvement in Cultural Heritage Organizations

The growing attention towards the behavior of museum visitors is evidenced by recent research [59,60] and museum initiatives, like the one of the Philadelphia Museum of Art [61], which set up a Department of Interpretation whose primary tasks are questioning visitors about their cultural heritage site space appreciation and gathering their overall feedback. This study goes further in this direction by advancing a framework, i.e., visitor-sensing, and by highlighting how it can be crucial in helping museum managers to offer better museum experiences and at the same time, increase the number of visitors. In addition to the facilitated involvement of crowds due to IT advancements [19–21],

new digital technologies allow the collection of a variety of data and ideas in new stimulating ways for participants. For example, thanks to the use of mobile applications and to wearable devices for GPS positioning and emotion tracking, visitors can effectively be engaged in providing insights and ideas in immersive experiences [62]. However, the benefits that cultural organizations can obtain by collecting data and ideas through these innovative technologies have not been systematically analyzed so far. Thus, in what follows, we advance our visitor-sensing framework by identifying its boundaries with respect to related crowd-based phenomena and we advance a number of propositions on the benefits it may offer to cultural heritage organizations.

While rooted in the previous literature, visitor-sensing has its own distinctive features. Analogously to crowdsourcing, visitor-sensing entails the collection of valuable data and ideas from external individuals, but based on voluntary participation, as it happens in citizen science initiatives. Moreover, visitor-sensing differs from the lead user phenomenon [63–65] in that interactions occur only one or a few times, without establishing long-lasting relationships with users. Finally, visitor-sensing is also different from customer co-creation [66,67] for two reasons. First, rather than resulting from long-lasting collaboration with customers, encompassing the whole innovation process from idea generation up to the product launch or service provision, in our framework the insights of visitors are collected through specific, short, and carefully-designed interactions. In addition, these insights are at the disposal of the museum managers, who decide whether and how to use them. Second, the interactions with visitors happen inside the organization's environment, which may influence the visitors' level of engagement and satisfaction, as well as the quality of their feedback and of the final outcomes [31].

Based on the above, visitor-sensing can be defined as (i) the involvement of visitors on a volunteering basis, rather than in search of a reward, as it happens in citizen science; (ii) who provide highly valuable ideas and insights, which resembles crowdsourcing initiatives; (iii) in the peculiar context of cultural heritage organizations, and museums in particular; (iv) by means of interactions occurring inside the organization's environment; (v) with the final aim to increase both the economic and social sustainability of museums. These core features of our framework are reported in Figure 1.

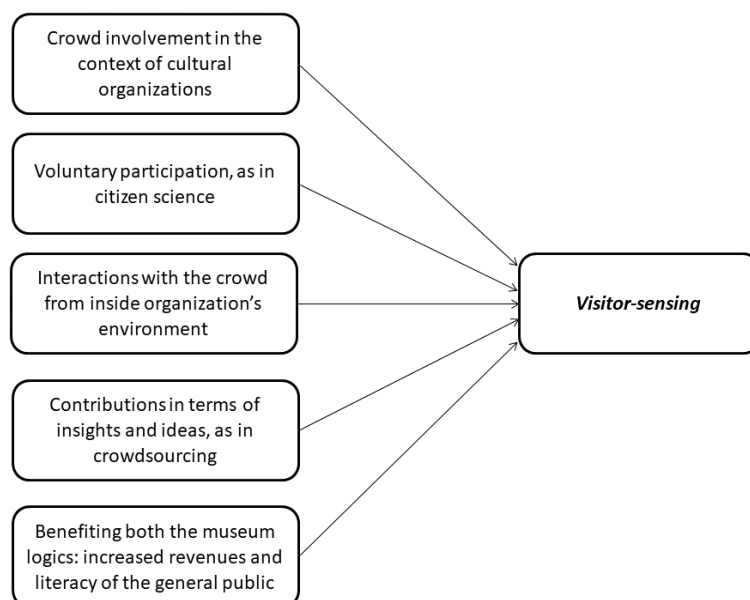


Figure 1. The core features of visitor-sensing framework.

In addition to advancing our visitor-sensing framework, we also posit three propositions about its benefits to further attract academics', managers', and policymakers' attention, and we offer some suggestions on how these propositions could be tested and refined. By doing so, we intend to show

how visitor-sensing can be crucial in increasing the number of visitors in museums and to pave the way for future empirical research aimed at providing empirical support to our framework and propositions.

4.1. Collecting Visitors' Ideas and Preferences to Improve Exhibitions

According to the Resource Based View of the organization [68,69], the crowd composed of cultural heritage organizations' visitors may represent a valuable resource from outside the organization's boundaries to be leveraged by cultural heritage organizations to improve their offerings. In particular, ideas to improve the museum products and services can be collected from visitors both via surveys and via mobile applications. The collection of ideas from visitors during their experience inside the organization's environment, i.e., during their museum visits, may be helpful to gather extreme outcomes, or in other words, few exceptional ideas from the multitude of outcomes collected [70]. In addition, information regarding artworks and path preferences can also be collected via traditional surveys, mobile applications using GPS positioning, and wearable portable devices. Doing so would also render the visitors' experience more engaging, since standing in front of artworks becomes an active signal sent by visitors to museum managers, rather than a passive action for self-contentment. The ideas and information collected through the above means can contribute to enhance the understanding of visitors' preferences and needs, which, in turn, will help museum managers to better organize museum visits and layouts. The above reasoning substantiates our first proposition:

Proposition 1. *Collecting visitors' ideas and preferences through surveys and digital devices allows museum managers to design the layout of artworks in museum exhibitions in ways that increase visitors' satisfaction, when compared to relying on only internal decision making.*

4.2. Gathering Visitors' Feedback to Improve Their Visual and Thermal Comfort

Again, rooted in the Resource Based View, visitors can also represent a relevant resource by providing information regarding their thermal and visual comfort, which can be crucial in planning actions and renovations in museums in ways that better satisfy visitors' expectations. Thermal and visual comfort are, in fact, fundamental factors towards visitors' satisfaction, especially considering that the controlled environment to which the artworks are exposed offer a certain degree of flexibility in terms of light, temperature and humidity levels [71]. Although temperature and lighting have been analyzed in office contexts and in cognitive activities [72], their impact in recreational activities like museum visits has not been adequately considered so far. Moreover, many cultural heritage organizations, especially in Europe, are located in historical buildings, which are often lacking in terms of thermal comfort conditions, so that the explicit feedback of visitors can further stress the need to pay attention to these aspects.

As demonstrated by recent research [73], comfort sensations are shaped not only by objective environmental factors, such as measured values in line with standards and regulations, but also by subjective factors related to individuals perceptions, which in turn are also influenced by the surrounding environment. Visitors' feedback on their thermal and visual comfort can be collected through traditional surveys and through advanced digital technologies, such as portable electroencephalography helmets, that allow gauging the visitors' feelings, in order to pair them with microclimate measurements. Thus, visitors' feedback can help managers to develop a deeper understanding of the subjective comfort conditions of visitors, and hence to better plan the microclimate environmental conditions of the museums. Based on the above, we propose the following second proposition:

Proposition 2. *Systematic collection of visitors' feedback about their visual and thermal comfort through surveys and digital devices allows museum managers to improve environmental conditions inside museums and, by doing so, increase visitors' satisfaction.*

4.3. Involving Visitors to Improve Their Satisfaction and Referral Intention

Shifting the focus from the organization side to the visitors' side, in addition to providing useful ideas and insights that may lead to improve the cultural heritage experience, the inclusive approach of visitor-sensing may per se bring benefits in terms of visitors' satisfaction. When involved via new digital technologies and surveys, as described in the preceding sections, visitors perceive to be active contributors to cultural heritage organizations, rather than just passive users of their offerings. Based on Self Determination Theory [28,74,75], if visitors become active contributors to a museum's managerial decisions, they will feel more satisfied about their overall experience and willing to make positive referrals about visiting the museum. In other words, participants who decide to voluntarily contribute to the improvement of cultural heritage organizations, which are typically perceived as being detached by the influence of the public, will feel more actively involved in their management, an aspect that is also in accordance with the identification of cultural heritage as a public good. Collaborating with a cultural heritage organization in such an unconventional, new, and immersive way will lead individuals to feel more satisfied and willing to become recurrent visitors, and to recommend the museum to others, which in turn will further increase the number of visitors. Thus, we advance our third proposition:

Proposition 3. *Systematic involvement of visitors in initiatives aimed at improving the museum experience enhance, per se, visitors' satisfaction and positive referral intention, independently whether visitors' suggestions are implemented or not.*

Our three propositions argue that collecting visitors' ideas and preferences concerning paths and the overall organization of artworks, as well as their feedback about their visual and thermal comfort, through visitor-sensing, is crucial for planning a better museum experience. In addition, implementing visitor-sensing may yield a further increase in the number of visitors by directly enhancing their satisfaction levels and referral intention. By this way, museums can effectively pursue the objective of reaching the greater possible audience, which is crucial to both their economic aim of increasing their revenues and their social aim of enhancing the literacy of the general public. The benefits of our visitor-sensing framework for cultural heritage organizations, and the ensuing positive economic and social outcomes, are summarized in Figure 2.

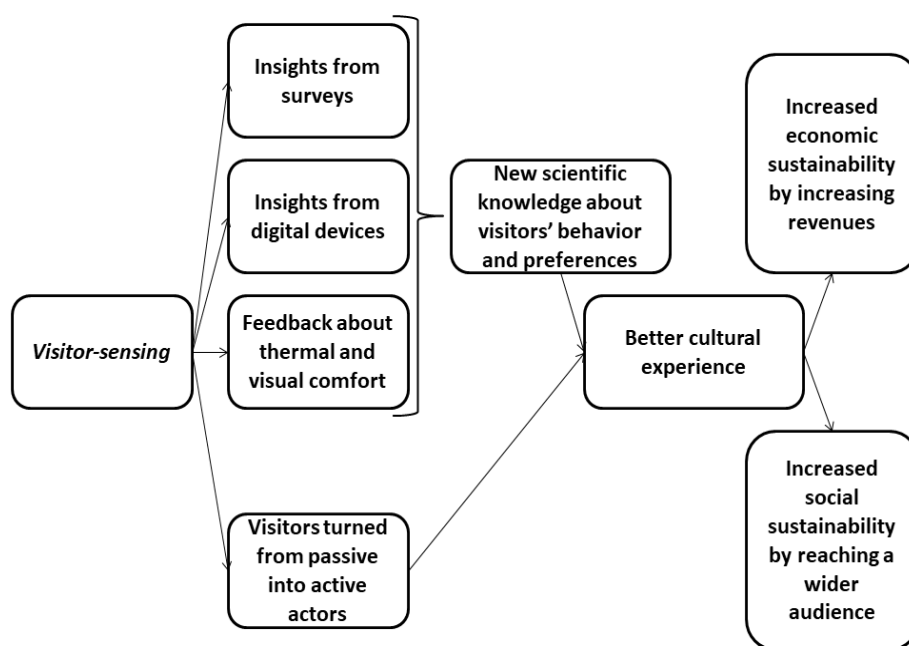


Figure 2. Benefits and economic and social outcomes of visitor-sensing framework.

4.4. Empirical Investigation

The above-mentioned propositions may be tested and refined by future studies through experiments in relevant contexts. For example, Italian cultural heritage organizations may represent a suitable field for such empirical testing. In Italy, there is the largest worldwide concentration of museums [51], but still it is a country where the audience and its experience have been neglected for decades [52]. Moreover, due to the lack of public funds, Italian museums are in special need of strategies to enhance their economic sustainability, as well as to improve the overall visitors' experience, and ultimately attract more visitors [76].

Measurable indices can be collected with surveys and digital technologies like mobile applications using GPS positioning or wearable devices, in order to assess whether there are preferences among visitors with respect to the artworks and museum paths. In addition, with respect to the exhibition environment, we have also stressed the importance of visitors' thermal and visual comfort [77]. Thermal and visual comfort feedback, as well as satisfaction and referral intention levels, can be collected from visitors via surveys and electroencephalography devices, which have been shown to represent the state of the art to assess individuals' motivation, and can be synergistically integrated [28].

5. Discussion

Dr. Nina Simon, the curator of Santa Cruz Museum of Art and History, effectively argued about the importance of opening up museums to participatory activities in her brilliant 2012 TedTalkX [78]: "We decided we are going to open up to participatory culture. [. . .] Museums are seen as elite institutions that serve a limited part of a population. Instead we do not just invite you in to come visit, we expect every person who walk in into our museum to contribute something to make our museum better [. . .] and this is beautiful, it is powerful, and it is meaningful. We are not just making museum more exciting, but we are making it sustainable for the future. Our attendance to the museum (after the introduction of participatory activities) has more than doubled. And it has also increased cash from \$30,000 to \$300,000." These words clearly suggest that involving crowds in museum activities can benefit visitors' overall experience, enlarge the population served, and increase the revenues of cultural heritage organizations. However, previous research has not properly focused on how visitors can be involved in museum activities, and on how they can contribute to shaping museums' cultural offerings by leveraging new digital technologies. Our visitor-sensing framework attempts to fill this void.

By focusing on crowd involvement in a context where it has not been properly included so far, i.e., cultural heritage organizations, on participants' contributions and motivations, i.e., valuable insights and ideas provided on a voluntary basis from inside the organization's environment, and the ensuing benefits for both the economic and social imperatives which characterize hybrid organizations, the present study advances the novel framework of visitor-sensing. In addition, we shed light on the benefits of engaging visitors by posing three propositions to be tested and refined by future empirical research. By doing so, we also add to the literature on the managerialization of cultural organizations [51,52] by showing the positive outcomes of crowd involvement in cultural heritage organizations. All this has the potential to allow significant advancements for cultural heritage organizations, which have typically based their mission on the conservation, preservation, and exhibition of objects, without putting enough effort into engaging and satisfying the audience [62].

With this research, we have stressed that, also thanks to recent advancements in IT and digital technologies, museum visitors can be involved in new immersive ways that allow museum managers to collect their ideas and feedback with the aim of improving their overall cultural experience. Through surveys and mobile applications, they can suggest major improvements in the services provided; thanks to surveys, mobile applications, and wearable devices, visitors can let museum managers know their preferred artworks and paths inside the museums; and through surveys and mobile EEG measurements they can also provide valuable data about the indoor visual and thermal comfort, to be employed to make the visit more pleasant and enjoyable in order to increase their satisfaction and referral intention. Thus, while art curators have so far traditionally decided by

themselves what to show in museums (e.g., consider the big change in 2017 in the exhibition path of *Galleria Nazionale d'Arte Moderna* museum in Rome, which was not much appreciated by the general public), the active participation of visitors to the improvement of museum offerings can exert a tremendous positive impact on the appreciation of the museum experience by visitors and on their number. Accordingly, visitor-sensing may represent a strategic leverage through which cultural organizations can gain and sustain competitive advantages by offering unique experiences to better attract and satisfy their visitors. The discussion whether museum curators should have a background in arts and history or in management studies is still open. This research does not enter this debate but suggests that the managerial practice of crowd inclusion can be a useful tool for museum decision makers to increase the number of visitors in cultural heritage organizations.

6. Conclusions

The concept of OIS implies the adoption of OI practices for the generation of new scientific knowledge, whose employment may have major societal impacts. While the contributions of the crowd have been considered so far mainly in for-profit contexts (e.g., crowdsourcing) and in not-for-profit environmentally concerned projects (e.g., citizen science), we argue that they can also be extremely helpful for the purposes of hybrid organizations such as cultural heritage organizations. Involving the crowd to advance our scientific understanding of visitors' behavior and preferences may indeed allow museum managers to shape the cultural offerings of their institutions in ways that generate considerable economic and societal impacts. Following this thread, in the present study we have drawn on crowdsourcing and citizen science to introduce the visitor-sensing framework and apply it to cultural organizations. Specifically, we have shed light on the boundaries of our framework, with respect to related crowd-based phenomena, and provided three propositions about its potential benefits for cultural heritage organizations, together with suggestions for testing and refining them, with the final objectives to stimulate the adoption of visiting-sensing and nurture further scientific studies on it.

In our visitor-sensing framework, visitors are motivated to provide data to museums' managers not only for a future better personal experience, but also to allow museums to improve their offerings and so to reach a greater audience, benefiting the whole society. Thus, the outcome of visitor-sensing is not only the achievement of a better museum experience thanks to the participation and involvement of visitors; analogously to what has been found in citizen science initiatives, where individuals actively involved in research projects feel more satisfied about scientific investigations [28], involving the crowd in the management of public goods like museums can itself be a way to enhance the satisfaction and referral intention of people. Visitors who actively participate to the management of cultural heritage organizations will also be, per se, more satisfied in that they contribute to a public good, and this increased satisfaction may encourage them to further visit the museum and to engage in positive word of mouth referrals. All this will translate into greater numbers of visitors, with positive impacts on both the economic sustainability of museums, in terms of increased revenues, and their social sustainability, in terms of a wider audience reached and increased literacy of citizens, which are two crucial aspect of the sustainability tripod to which organizations are increasingly paying attention [27,79–87]. The above-mentioned issues are relevant issues for both cultural heritage organizations and policymakers [28,56], thereby benefiting simultaneously the two logics which characterize hybrid organizations [55,88]. Considering the SDGs contained in the United Nations Agenda 2030, the framework proposed in this study also contributes to the achievement of a more sustainable global development [2,89,90], towards the advancements of Goals 11.4 and 4 (i.e., safeguarding world cultural heritage and promoting lifelong learning opportunities to all, respectively).

It is also worth mentioning that implementing our visitor-sensing framework in cultural heritage organizations may result in Big Data, i.e., databases characterized by high volume, velocity, variety, veracity, and value [91]. Big Data are increasingly valuable for managerial purposes and the benefits of its usage can be successfully extended to cultural heritage organizations, which can employ Big Data to

elicit trends and insights, such as extrapolating the target audience for which visitor-sensing can be more impactful. While it has been argued that combining existing knowledge with new data and resources resulting from the collection of Big Data is coherent with OI logics [92], and have been analyzed in the contexts of big companies and SMEs [93,94]. We contend that Big Data may also considerably benefit OIS practices in the context of hybrid organizations and cultural heritage organizations in particular. In fact, Big Data may allow advancing our scientific knowledge of the behavior and preferences of museum visitors, so offering museum managers useful insights for improving cultural offerings, with further benefits at the societal level. Such arguments may constitute a promising avenue for future research. Moreover, we caution future researchers to also carefully consider the peculiar challenges and costs associated to Big Data collection and management in cultural heritage organizations, such as those related to the infrastructure and human resources needed to collect, store, analyze, and effectively use them.

This research is not without limitations that also pave the way for future advancements. First, while our study is eminently conceptual, and aimed at proposing a theoretical framework to attract academic, policymaking, and managerial attention, future empirical studies are needed to carefully assess and measure the benefits that its implementation may offer. Second, while we have focused on to the positive outcomes of involving visitors in cultural organizations, the costs of such an involvement should also be carefully assessed. Dealing with numerous individuals and collecting large amount of data may imply substantial costs for managing the interactions, storing the information collected, and analyzing them in order to extract valuable insights and take advantage of them effectively. In addition, whether the involvement of visitors may eventually have negative effects on their attention to the exposed artworks is worth attentive investigation. Overall, future studies will have to consider the potential dark side of visitor-sensing to evaluate whether, and in which conditions, its costs may outweigh its benefits. Another promising avenue for future research concerns the typology of the interaction between the general public and the cultural heritage organizations' employees, which may exert a significant impact on how individuals participate in visitor-sensing practices, thereby affecting their degree of (dis)satisfaction in a non-trivial way. Finally, implementing visitor-sensing logics in large or small cultural organizations is likely to pose different challenges. Larger organizations are typically endowed with substantial financial and managerial resources to bear the costs of visitor-sensing and manage its processes but may lack the ability to rapidly process information and translate it into managerial action, while the opposite is true for smaller organizations. Future studies could focus on how the benefits and costs of visitor-sensing are influenced by the distinctive features of large and small cultural organizations, thereby offering unique insights to their managers.

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