Big Data for Decision Making: Are Museums Ready?

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Abstract This study investigates the extent to which big data support decision making in museums by highlighting the main opportunities, threats and novel requirements connected with the usage of big data for decision making in museums.

This study is based on an action research project carried out in three Italian state museums that were provided with an online platform that generated real time (big) data about online users. This platform offered the opportunity to investigate "what" type of big data are used, "who" are the big data users and "how" big data were used by museums decision makers.

Results show a contradictory picture about the usage of big data for decision making in museums. Big data are not used alone, but need to be combined with traditional data that support big data interpretation. A central element for big data usage is represented by human resources: even though data are already collected, analysed and integrated by predefined algorithms, the key challenge is about human resources and their required mix of analytical, IT and communication skills. Also the external environment influences the extent of big data usage.

Keywords Big data · Social media data · Museums · Decision making · Performance measurement

1 Introduction

This study focuses on big data for decision making in museums, shifting the attention from the big data cycle of collecting and analysing data to the issue of big data usage. Existent literature in accounting and cultural heritage claims an opening towards big data showing the opportunities offered by big data in terms of real time reporting and wider dataset (Arnaboldi et al. 2017; Romanelli 2018;

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Pesce et al. 2019). Beside these big data supporters, also some more critical positions can be found, which question the real value provided by big data posing the emphasis on analytics and algorithms as responsible for reducing the space for organizational decision making (e.g. Quattrone 2016; Agostino and Sidorova 2017). This available literature has two main limitations. First, the majority of the studies are theoretical; empirical evidence is still limited and mainly focused on technical and analytical issues (see Sivarajah et al. 2017 for a review) leaving in the background a key feature for accounting: information become knowledge only in the hands of users (Bhimani and Willcocks 2014). Second, current literature focuses on the big data cycle, emphasising the phases from data collection to data visualisation. Again, the usage of big data is often a neglected aspect. This is even more evident in the cultural heritage field, where empirical investigation on big data usage are rather scarce (e.g. Romanelli 2018; Pesce et al. 2019 are a few exceptions).

This paper adopts a different perspective, investigating the extent to which the adoption of big data support decision making in museums. This aspect is of primary importance for museums that are called to foster cultural participation (Stevenson et al. 2017). In this scenario, big data offer the opportunity to collect data about users offering personalised services. Empirically this study is based on an action research project in three Italian State Museums that were facing the challenge of using big data from social media, web channels and reputational channels (i.e. TripAdvisor and Google Maps) for internal decision making, through the development of a big data dashboard.

Results were interpreted following the three main dimensions that characterises accountability: "what" to measure, "who" is in charge of measuring big data and "how" to use big data measure (Agostino and Arnaboldi 2018). Key findings show that the main challenge for big data usage are human resources, notwithstanding the availability of algorithms and predefined analytical techniques. Human resources play a central role in big data usage with reference to the identification of the most appropriate role for leading the big data decision-making cycle and the required competences and skills for a big-data expert inside museums. Also the external environment of museums affected the big data usage, promoting and limiting at the same time the exploitation of big data for decision making.

These insights are unfolded throughout the paper that is structured as follows. First, available literature on big data for decision making is explored, with particular reference to the available contribution on cultural institutions. Then, the action research methodology is detailed followed by the presentation and discussion of the empirical evidence. Finally, some conclusions highlight the main contributions of this study for academics and practitioners.

2 Big Data and Decision Making in Cultural Institutions

2.1 Defining Big Data

"Personal Data is the new oil of the internet and the new currency of the digital world". This sentence was pronounced by the European Consumer Commissioner, Meglena Kuneva, during the World Economic Forum in 2011 to underline the opportunities connected to the new asset of big data. If during the industrial revolution oil was considered the key assets, nowadays the availability of big data and the computational capacity and competences (analytics) to analyse these data is considered as a driver for competitive advantage (LaValle et al. 2010).

Big data have been defined as: "a large volume of complex data (structured and unstructured) from a variety of sources (internal and external) that can support value delivery, performance measurement and establishing competitive advantage" (De Santis and Presti 2018). Big data distinctive features comprise: volume, velocity, variety, veracity, value and variability (Gandomi and Haider 2015). Unlike traditional data, big data are generated from internal and proprietary organizational databases, but also by external sources, such as social media, sensors or open administrative databases. This heterogeneity of sources give rise to data variety, since data come in the format of number, text, videos, hyperlinks or photos; data velocity since they are continuously generated; data volume since the quantity of these data is incomparable with the past. In their original raw dataset, big data are noisy and unstructured, and with limited added value (Al-Htaybat and von Alberti-Alhtaybat 2017). This requires the development of a big data cycle, which facilitates the transformation of large and unstructured data set into a limited amount of valuable information. For this big data cycle to occur, analytics and algorithms are necessary to collect data, reduce the size of the dataset and extract knowledge from a huge amount of data (Arnaboldi et al. 2017). As Chen et al. (2012) underlined, analytics refer to "analytical techniques in applications that are so large (from terabytes to exabytes) and complex (from sensor to social media data) that they require advanced and unique data storage, management, analysis, and visualization technologies" (p. 1166). Nowadays, analytics play a crucial role to value big data with software vendors such as Google, Amazon, IBM or Microsoft that are investing money to provide always more powerful software to retrieve, store and analyse big data. Big data have limited value if they are not associated with the computational capacity of transforming a dataset into usable information for decision-making (LaValle et al. 2010), stimulating a lively debate on the importance of data science as a new model of knowledge production (Priestley and McGrath 2019).

2.2 Big Data and Decision Making in the Heritage Field

The importance of big data for decision making finds contrasting views in current literature. On the one hand, proponents of big data underline their value in offering novel data visualisations (Lindquist 2018), their potentiality to be integrated with official statistical data (Kuempel 2016) and their greater timeliness and completeness. One of the former contributions in this area is that of Bhimani and Willcocks (2014), who underlined how big data favoured the development of different types of knowledge inside organizations and emphasise the big data potentialities for providers of accounting information. Following this wave, the opportunities offered by big data analytics to develop a better, faster and more complete knowledge of the environment have been theoretically discussed (Cao et al. 2015; Warren et al. 2015). The paper by Al-Htaybat and von Alberti-Alhtaybat (2017) is one of the few empirical studies addressing big data reporting. The authors found timing (i.e. real time reporting), accuracy and the prospective nature of reporting (i.e. predictive analytics) as the main benefits of corporate reporting based on big data analytics. With a specific focus on financial accounting, some other scholars acknowledged the benefits for financial accounting for more transparent information (Teoh 2018) or for a deeper understanding of the strategies and practices of high-frequency trading in financial markets (Seddon and Currie 2017).

At the same time, also the drawbacks of big data for decision making are highlighted. Some authors acknowledge the dark side of big data in terms of diminishing the realm of action for decision makers with algorithms that are not neutral (Quattrone 2016; Martin 2018). In this respect, Quattrone (2016) questioned the capacity of big data to inform better decision making. His study underlined the risk connected with a data driven society with accountants being fascinated by the dream of perfect information rather than posing questions and being critical. Through an empirical investigation, Agostino and Sidorova (2017) emphasised instead the risks of big data adoption with organisations adapting their online behaviour depending on online actions by users. In other words, rather than users being influenced by the organisation, the opposite behaviour was found: organisation significantly adapted their actions on users' online activities. Other risks connected with big data usage have been highlighted with reference to the risks for the data protection of individuals and the lack of transparency in collecting data often without transparency of making users aware of this data collection (Federal Trade Commission 2014; Bolognini and Bistolfi 2017; Uluwiyah 2017).

While in accounting field, studies offer some reflections about the potentialities and risks of big data usage for decision making (e.g. Agostino and Sidorova 2017), cultural and heritage studies are investigating the big data realm at a slow pace. The available studies provide a technical discussion on how to retrieve or analyse big data in museums (e.g. Hausmann 2012; Chianese and Piccialli 2016; Zhang et al. 2016; Romanelli 2018; Pesce et al. 2019). This literature on big data for decision making in museums provides us with a preliminary picture on the potentialities of big data, with particular reference to the possibility to report information real time

and in a more transparent and complete way. Yet, the majority of these studies are conceptual and theoretically discuss potentialities or risks of big data for decision making in museums. We have to date limited evidence on empirical implementations, adoption and uses of big data inside museums and cultural institutions. This has favoured the emergence of a gap between the premise of big data and reality. This paper contributes to fill this gap by empirically investigating three museums in charge of exploiting big data for decision making.

2.3 Framing Big Data for Decision Making

The investigation of big data for decision making in museums is here framed along three main dimensions that characterises accountability: "what" type of big data are used, "who" are the big data users and "how" big data were used by museums decision makers (Agostino and Arnaboldi 2018).

The "**what**" to measure refers to the technical sphere of big data in terms of Key Performance Indicators (KPIs), the data collection process and big data reporting tools. This is the most investigated aspect in the big data literature with several contributions discussing the technical instruments to retrieve, clean, analyse and report big data (i.e. Chianese and Piccialli 2016). Also studies on big data in museums have tackled this sphere recognizing the need of ad hoc computational tools to retrieve and analyse the high volume big dataset (e.g. Zhang et al. 2016).

The "**who**" addresses the organisational dimension of big data, posing the attention on the professional roles involved in the process of collecting, analysing, reporting and interpreting big data. This is a far less investigated sphere. Although there is a wide recognition on the need for ad hoc professional competences (Priestley and McGrath 2019), often other than accountants, with statistical, analytical and information systems skills, we have to date limited evidence about who manages the big data process inside organizations, and museums especially.

The "**how**" is related to the type of usage of big data for decision-making posing the attention on the type of decisions supported by big data and receivers of big data report. In this respect, some literature underlines that algorithms and analytics are driving decision making processes inside organisations (e.g. Martin 2018), while some others suggest that algorithms are relevant and support data reduction, but not enough to drive decision making processes (e.g. Quattrone 2016). Through this dimension, this study will shed light on the approach towards the exploitation of big data in museums.

3 Research Setting

The investigated context is that of three Italian state museums, out of the thirty museums that received autonomy by a ministerial Reform in 2014. The reform is called Riforma Franceschini upon the name of the Ministry who promoted it. The main content of the reform can be summarized in two main points. First, state museums, for the first time in Italy, gained financial, scientific and organizational autonomy. This means that museums can have a director with a strategy and a plan to be implemented alongside with a budget to be managed and an annual report to be prepared. For the first time, directors of the museums are appointed with a public bid open worldwide with the aim to have the best managers in the cultural field. The second distinctive aspect of the reform is that the visitor were required to be positioned at the centre of the museum's strategy, fostering cultural participation. Museums' activities should not be carried out for the museum itself, following a custodial approach, but audience engagement and attractiveness to a wider audience should be taken into account and become a priority.

Within this reform, the digital aspects, and big data in particular, played a central role as underlined several times by the Ministry and its staff in public interviews and public documents:

> The Italian Ministry of cultural heritage and tourism (MIBACT) is putting at the centre communication and promotion offices of museums. The Ministry can, in this way, enhance the creation of an online network of Italian museums leveraging on web and social media campaigns, gaming and leisure activities on the web to engage a wider public on museums and cultural heritage sites" (Musei Italiani 2014–2017)

The importance of the digital turn was also rendered visible with two main concrete actions by the central government. The first action was a strong promotion of social media usage, with the cultural direction of the central government opening social media pages on Facebook and Twitter and promoting social communication with the hashtag #museitaliani. This was intended to create an online community between the online audience and the network of Italian museums.

Second, a concrete analytical tool was developed by the central government and rendered available to each autonomous museum. The tool consisted of a digital platform that, upon registration, provided a real time and detailed view of online engagement, sentiment and content of audience of museum. Alongside the individual access by museums, also a comparative offline report was annually rendered available to the general public ranking museums on the basis of a synthetic index derived from a combination of the big data analytics calculated (see Fig. 1).

Data showed the frequency of online interactions, the content of the interaction and the reputation of the museum by the general public. Big data, in this dashboard provided to museums, referred to web data, data from reputational channels (e.g. Tripadvisor or Google Maps) and social media data.

In this context, the ambition of museum directors was the creation of a big data dashboard to report online data generated by social media, web and reputational channels such as Tripadvisor or Google map. These data had to be reported

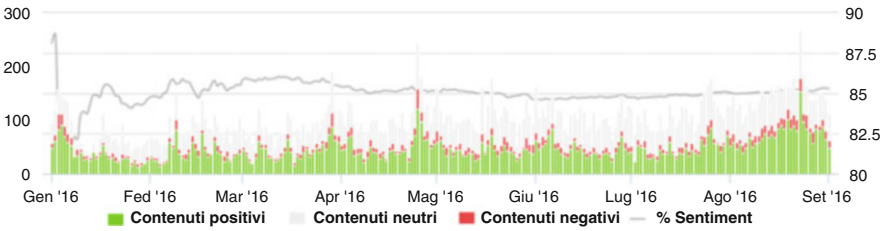

Fig. 1 Example of analytics provided by the online platform by the central government

alongside with other traditional data already collected by museums: revenues, costs, ticketing data. This need started the action research project.

4 Research Design

This study adopts an action research approach carried out between February 2016 and March 2018 in three Italian state museums.[1] The choice of the action research lies in the possibilities to investigate a practical concern on the field acting with the studied organization (Eden and Huxham 1996). This is particularly suitable to explore the contribution of big data for decision making in museums. The action research methodology provides the main benefits of acting on a practical concern while at the same time addressing a theoretical problem (Avison et al. 2001). The practical problem addressed was represented by the valorisation of big data. Operationally, this consisted into the development of a big data dashboard to report about museum online performance and reputation. The big data dashboard was expected to report both big data derived from online and web channels as well as traditional financial and non-financial data about the museum (e.g. revenues, costs, customer satisfaction data or amount of ticket sold). The theoretical problem, similarly, refers to the challenges for museums to endorse big data for decision-making.

The distinctive aspect of action research is the active involvement of researchers in the studied setting (Eden and Huxham 1996). Both the authors were actively involved in the three museums supporting them methodologically in the activities of big data collection, analysis, reporting and interpretation.

The project has been activated with one researcher who was contacted by one museum director asking for a methodological support in the process of valuing the big data available from the online platform, giving rise to a big data dashboard. Once the agreement on the project was achieved between the researcher and the director, other two directors facing the same issues decided to join the activities. This ensured a high commitment by the three museums directors and their staff during the entire

[1]For confidentiality reasons the name of the museums are keep anonimous as well as the name of the interviewees.

duration of the project. The three museums are located in different areas in Italy, with different types of collections and dimensions. However, they all share some common features. First, they are not ranked as the most visited museums in Italy, posing the issue of audience engagement and cultural participation as a central aspect. Second, they are not located in the most famous Italian touristic cities, again posing the issue of attractiveness as crucial. The three directors of the museums, according to the Reform, were newly appointed at the end of 2015. They had a similar background covering managerial positions in cultural institutions worldwide, while having a deep expertise in cultural heritage. This was a crucial aspect to move away museums from the traditional view of custodial approach.

4.1 Data Collection and Data Analysis

Various data collection methods were used: face-to-face meetings, interviews, observations, documents and archives, and external information (e.g. newspaper, websites and analytics).

Face-to-face meetings represent the primary source of data. Five plenary meetings were organized between the research group and directors of the three museums. These meetings occurred at different stages of the research project: one at the beginning of the project to plan activities, three ongoing meetings to keep track of advancements and one final meetings. Moreover, a final public presentation to journalists was held to public disclose the main results of the study. These meetings were particularly useful to share the big data dashboard, the organizational roles involved and the type of big data usage by museum directors. Interviews and additional meetings were also organized in each museum, involving also museums staff. The organization of the three museums was very similar with the presence of five organisational areas, as required by the regulation for state museums: administration and finance, communication and marketing, curatorship, facility and security management, education. Each of these areas was composed of a responsible role with his/her operative staff. Interviews were carried out with each unit of the staff of the museum, achieving 415 units of staff interviewed. Individual interviews to all the units of the museum staff were also possible because the authors collected data about workload of each employees on a set of museum activities previously identified. This activity was particularly useful (although not central in the development of the big data dashboard) to grasp the competences of the museum staff and their primary activities, compared with the need to introduce novel activities for big data management.

Documents and archives of the three museums represent a further data source. These comprise public documents such as annual reports, sustainability reports, budget plans and strategic plan. Also internal data not available to the general public were accessed. These include also the access to the online tool provided by the central government that was particularly useful to grasp the content and structure of already available big data analytics for museums. Finally, external sources in the

form of newspapers, web and social media data were collected during the entire period of analysis.

The process of data analysis was highly iterative, going back and forth between empirical material and theory, generating a plausible fit between theory, problems and data (Ahrens and Chapman 2006). One of the most well-known limit of actions research is related to its distinctive feature: the active involvement of researchers that can be a source of bias (Malina and Selto 2001). To overcome sources of bias, we constantly verify data between researchers, and discuss emergent insights with museum directors.

5 Findings

Results are here presented following the three dimensions of "what" to measure, "who" measures and "how" big data are used. Alongside the discussion of these dimensions, challenges connected with big data for accounting will be detailed.

5.1 "What"

"What" to measure is connected with the technical sphere of the big data cycle, which comprises data collection and cleaning, data analysis and data reporting. These issues were the first element of discussions for museum directors when starting the big data project. The data collection activity was not an element of discussion since there was the availability of the ministerial online platform that allowed a real time visualisation of the online reputation of each museum.

The most debated aspect related to the type of traditional data to be collected and reported alongside big data, as highlighted in this dialogue:

> We should include also data about why the audience does not come to my museum. In addition to the perception of our audience gained with analytics, we might think about collecting data on the reason why people prefer to go somewhere else rather than here. (Director, Museum A)

> I do not think this can be feasible. If I remember correctly, we do not have this data in the requested document to fill for the ministry nor in the online tool (Administrative staff, Museum B)

> But this is not our role, we have to enhance the value of our arts collections, develop further studies about them. Potential audience should not be our preoccupation (Curator, Museum B)

This dialogue underlined the first need for museum directors to combine big data with other traditional data. Big data were considered a precious source of information to support decision making when linked to other traditional data, such as those from annual report of customer satisfaction survey:

> We run a post-visit customer satisfaction survey three times a year, we have online ticketing data, data from Facebook, Instagram and TripAdvisor, from our financial statements and onsite ticketing. I would like to put all this together and create a single profile per visitor. If I know a visitor's gender, nationality, education, age, how they respond to my social media posts, when they buy tickets and where they go in the museum, then I can tailor my services and promotions to that user. In the long term, this allows us to engage more closely and lastingly with our visitors. (Director, Museum C)

As it emerges from this quote, the research project was pushed toward the collection and analysis of big data that would have to be reported and visualised alongside with financial and non-financial data already available in museums.

5.2 "Who"

"Who" is in charge of managing big data supported the exploration of the organizational roles involved in the process of big data collection, analysis, reporting and interpretation. In the three investigated museums, the organisational roles in charge of managing big data varied between the communication and digital office and museum director themselves. Notwithstanding the type of organizational role involved, the development of the big data dashboard did not find a unique leading organisational roles, but various actors were involved in specific phases, often with some conflicting perspectives.

The staff from the administrative and finance area did not want to be engaged in the big data process. Their main preoccupation was that of ensuring compliance to the central government requirements and respecting deadlines and external requests. This staff was mainly in charge of preparing and delivering documents to the central government, without questioning the content or being propositive on the further elaboration derived from the collected data. This was true also with reference to the big data process: administrative staff did not want to be engaged since it was outside of the assigned roles by the central government. This quote provide an example:

> The director asked me to ask me to periodically check the online platform and prepare a report with the key insights. I cannot do this. This is not my role; I'm in charge of budget, annual report. A cannot analyse and look at online data (Administrative Staff, Museum C).

Also curators were sceptical on big data usage, although with a different position than the administrative staff. They are focused on the tutorship, curatorship, maintenance and restoration of arts collection and heritage assets. Their main purpose is enhancing the value of the collection, without posing the attention on visitors or external accessibility to the collection to a wider and more generic public. They know every single detail of each art piece inside the museum and their main preoccupation is the preservation and knowledge sharing by peers. Their higher but niche expertise was visible in these quotes:

> Look at this [pointing at a book of around 1000 pages]. This is the main result of our two years activities: we have scanned our collection, inserted the pictures here and provided a very detailed technical description for each of them. Now you can come here, purchase the

> book and access to each of this single details that were previously dispersed (Curator, Museum A)

The detailed and niche language used by professional is also visible in the description of the heritage asset and artworks. This is one example of sentence used to describe a painting:

> The work shows the debt to Michelangelo's mannerism in cold chromatic tones and in the complex and crowded composition, played on the overlapping of planes. The patheticism of the figures can be traced back to the climate and the new rules of the Catholic Counter-Reformation

Curators were not against big data, but they mainly ignored the big data revolution, considering it useless to support their activity as emergent from this sentence:

> I know that you are working on the development of a big data dashboard. I do not know exactly what you want to achieve, but I'm not convinced about the importance of this activity. Our mission should be the preservation of our collection, the detailed analysis of our pieces ... this is what makes the museum alive: collection, not online reviews (Curator, Museum B)

While curators and administrative staff ignored or were sceptical about the development of a big data dashboard, museum directors were the more enthusiastic. Museum directors were recently appointed in 2015 by the Reform and were among the last unit of staff of the museum. They endorsed a more business oriented approach, being preoccupied by fundraising and balancing records, attractiveness and visitors' satisfaction. The managerial style of museums' director appeared in some of their sentences:

> I've decided to rent [*Name of the museum omitted*] to obtain additional funding. I've been criticised internally by curators, but I had no choice to complement the reduced funding if I wanted to financially survive (Director, Museum B)

> I decided to introduce a duck, the royal duck in my museum, as a game on Facebook, to create awareness and engagement around my activities. It might look as an activity with limited cultural value, but this is not true. It was a more accessible way to let the museum known to the wider public. Social media are widely accessed by everyone and, Facebook especially, allowed us to enter a new target of potential visitors (Director, Museum C)

> Fundraising and audience enlargement and engagement are my priorities. I'm hardly working on these issues with the establishment of open cinema in the main square of the museum during summer nights. This is a way of attracting people for a different event, but let them know that the museum has a cultural offer as well (Director, Museum A)

Museum directors were the most committed role towards big data analytics, but did not have enough competences to lead the entire process. For this reason, the more technical activities were carried out by the researchers following the requests by museum directors:

> I would like to understand the success of the online promotion of museum activities. I'm working a lot with the communication staff to use social media for the promotion of leisure activity inside the museum. The staff is launching these initiatives, but I would like to have some more details on the online reactions, comments, perceptions and linkage with ticket sold (Director, Museum A)

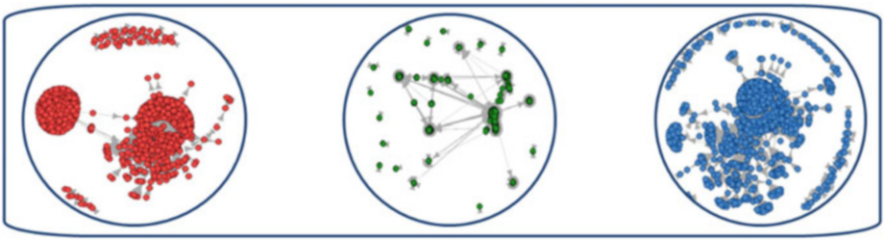

Fig. 2 Insight from the big data dashboard. Network of social media users of the three museums

> Why didn't you search for a data analysts to support your communication staff? This role could be precious in supporting big data analysis and interpretation (Researcher A)

> I cannot hire new staff. Internal museum staff is dependent on the central government. This is only a partial autonomy. I'm autonomous on my budget and strategic plan, but I cannot leverage on human resources, who still depend on the Ministry (Director, Museum A).

This dialogue underlines the desire by directors to grasp behind the usage of online tool, but also the difficulties to find internal staff with adequate competences, not lastly because of the constraints by the central government.

5.3 "How"

The "how" entails the type of big data usage with reference to the big data support to decision making. Notwithstanding the researchers' involvement in the technical phases of big data collection, big data integration with traditional data, computation of performance indicators and data visualisation, difficulties were still visible in terms of big data interpretation to support decision making. These difficulties were related to a deep understanding of the collected data, but also to the trade-off between using big data and solving every day, and urgent, contingencies.

With reference to big data interpretation, difficulties in understanding the meaning of the collected data were visible in meetings where the big data dashboard was discussed. These difficulties, although with some nuances were common to all the professional roles inside the museums. For example, when discussing the online network of the three museum derived from social media analytics (see Fig. 2), different reactions were visible.

> Curator: These analytics are nice, but we are posing the attention on analytics and the network of online audience when internally we are still struggling with the creation of online databases for our heritage assets.

> Administrative staff: This is true. We received this opportunities by the Ministry. We are in the limelight to become digital and modern, but every month I prepare data for central government on paper because this is the governmental format for official data communication

These quotes underlined mixed feelings between the desire to discover more insights and the worries of not being able to manage this new type of data. This was true for both the already available online platform and for the newly developed big data dashboard. In both of the cases, the researchers support was needed to provide insights on the approach adopted to the visualised measures and the meaning of the visualisation provided.

After the initial enthusiasm about the newly developed big data dashboard, a further difficult in using data was related to the trade-off between using big data and devoting time to solving every day, and urgent, contingencies:

> The big data analytic side of the report is fascinating and insightful, but real time data to be used need to be showed real time to take immediate action. Inside our museum, we are not ready to work real time. We are slow, administrative times are slow. The regulation is asking us to become digital, but they send us requests on paper and they ask three times in a year the same data on revenues in different format. (Director MRG)

> You are right. I've autonomy, but just on some issues. I receive almost everyday a new data request by the central government. Data are open, data are already available, but still they increase the amount of data they're asking us. The movement towards a real time reporting is too much for us in this moment. We are not ready not because we do not want, but because the central government does not give us the instruments to became fast and flexible (Director MRT)

The problem of selecting whether to dedicate effort to big data or everyday contingencies was particularly connected to the lack of a professional role with big data competences and the limited diffusion of analytical skills inside the three museums:

> I'm not convinced about the inclusion of social media data and online data. They are useful and provide nice insights, like the identification of influencers or the most engaging online posts. However, they are not of immediate comprehension as a financial data or a likert scale about customer satisfaction. If I ask for a financial data, almost everyone inside the organization can retrieve and interpret correctly my request and the data retrieved. It is not the same for big data analytics. They are subject to multiple interpretation and I have not a big data expert that can mediate between the different internal roles to collect and explain these data (Director, PD).

> My main worry is even more basical. How can I introduce this system in my organization if my internal staff in front of a pdf file, cannot use the 'round view' bottom to turn the picture in the right position? I need to be honest: this report is really nice, but I do not have internal people to run the system autonomously (Director MRG)

> This is not my situation. I have a devoted staff to communication. They know social media, big data and analytics very well, but they are not in charge of report. Reports and data analysis are in charge of the administrative staff, but the national regulation assign them the functions of financial data reporting and communication to central government. This is not in their realm of competences. I need to think about who should be responsible for this; it is something in between communication and administrative office, but we do not have transversal roles (Director, MRT)

These results highlights the complexities behind big data adoption inside museums, which went far beyond the technical problems connected with big data collection and analysis. Big data became an organizational concern, affecting human

resources and their competences. The next section further discusses and interprets these results posing the emphasis on the academic and practitioner contributions.

6 Discussion and Conclusion

Recent years have flourished with discussions and commentaries on the potentialities of big data for decision making, highlighting the benefits of timeliness, completeness and transparency of the information alongside faster and better-informed decision-making processes (Agostino and Arnaboldi 2017; Rogge et al. 2017; Romanelli 2018; Pesce et al. 2019). However, within this fast moving world of big data, there is to date limited empirical evidence about how big data are adopted in practice in cultural institutions and their role in supporting decision making. This study addresses this gap by investigating the development and usage of a big data dashboard in three Italian state museums that are facing the challenge of exploiting big data in their decision-making processes.

Results showed the key challenges associated with big data usage in museums.

The first challenge is related to the *centrality of human resources* in the process of big data usage. Although analytics are the building block of big data usage, they are not enough for enhancing a big data driven decision-making process. Human resources are the real key asset that drives the entire process in terms of: selecting the type of data to be collected and analysed, identify the most appropriate Key Performance Indicators, identify the adequate reporting tool and, above all, interpret data. This aspect was particularly visible in the investigated museums, where the existence of a predefined online tool for big data was not enough for enhancing the decision-making process. Human resources and, in particular, museums directors, were engaged in making sense and interpreting data, but also in selecting the most appropriate data visualisation.

The second challenge, connected to the previous one, refers to the *required competences and skills* that the big data decision maker should have. This is concerned to the "who" dimension previously analysed. For the big data process to take place, a set of competences were found as central: statistical and analytical competences to understand the methodologies behind data selection and data analysis; information technology competences to understand the logic behind the approaches in data collection and data filtering; communication competences to understand the social media dynamics of post, interactions, engagement and connected terminology (e.g. share, virality, retweet, impression ...). In the action research project, the research team supported the entire big data cycle from the early phase of data collection until data visualisation and interpretation. Yet interviews and plenary meetings highlight the absence of a unique organisational role that supervises all the phases. While social media terminology was overseen by the communication staff (although without social media professional background), the information technology and statistical competences were mainly absent. This result should stimulate some reflections on the professional roles currently present inside

museums: although there are some roles in charge of managing the communication, they are not enough to lead the entire big data cycle. A hybrid role between accountant, communication and data analyst should be enhanced and an ad hoc training could have been developed.

The third challenge focuses on the *external environment*, which should provide a fertile ground for a big data decision-making process to take place. In the empirical setting of the Italian museums, a lot of pressure by the central government has been provided on the importance to rely on big data. This was particularly visible with the online platform rendered available for museums. However, museums' actions are paced by deadlines defined by external impositions and the majority of the internal actions cannot be implemented without an authorization from the central government. This is particularly true for internal staff that depends hierarchically from the central ministry and not from the museum management, limiting the leverages on hiring, education and training activities of museums. This incoherence between the central pressure to innovate, but without offering enough leverages reckons the old style bureaucracy that renders very difficult a real exploitation of the potentialities of real time decision-making offered by novel technologies.

These results offer a specific example from Italian state museum, but can serve museum managers in charge of exploiting big data in their decision making processes offering them some advices and elements of attention for the big data decision making process to take place.

From an academic perspective, this study contributes to the emergent literature on big data for museum management and accountability (Romanelli 2018; Pesce et al. 2019). While the majority of the studies on big data conceptually discusses benefits and pitfalls of big data, this study offers an empirical application of big data in museums, by showing the technical and organizational difficulties connected with the big data usage for decision making. These insights moves forward the debate on big data for museums questioning whether museums are ready for big data and for exploiting their benefits in their decision making activities.

This study also underlined the complexity of accounting in museums and arts institutions, by proposing some reflections on the heterogeneous professional roles that coexist and also conflicts, inside museums when dealing with big-data. Some recent studies have showed a different usefulness of measures in museums depending on the influential group they serve and the risks of adopting private style performance measures in a context where not all the activities can be measured (Abdullah et al. 2018). This study enhance the debate about accounting and accountability in museums posing the emphasis on the usefulness, opportunities and problems connected with the exploitation of big data analytics in this field. It is important to underline the main limitation of this study, which is related to the investigation in three museums; hence, this study cannot be generalise elsewhere. Further research is needed to provide a wider spectrum about big data usage in cultural institutions, focusing on the type of analytical tools available, the professional roles involved or the type of reports and visualisation offered. Yet we think that our contribution has provided a novel practical case that can push further academic debate, but also serve museums practitioners in charge of big data usage.

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