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Exploring Innovation in a Digital World

Cultural and Organizational Challenges

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Exploring Innovation in a Digital World: An Introduction

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Abstract. Innovation takes place at fast pace in digital ecosystems, asking for increasing attention by academic scholars. In line with this call, we offer an overview of the most recent advances in the studies on innovation and technology in the digital space. We delve into the cultural elements that affect the diffusion and adoption of digital technologies, the pervasive role of social media, the organizational challenges of digital transformations and, finally, specific emerging trends such as Artificial Intelligence (AI) and blockchain. The plurality of views is particularly relevant for practitioners, scholars and policy makers, offering a fresh look on the most recent developments in Information Systems studies.

Keywords: Innovation · Information systems · Digital transformation

1 Aim and Scope of the Book

In recent years, major transformations have revolutionized models and practices for strategy, accounting, decision making, sourcing, human resources, marketing, innovation, product development, maintenance, manufacturing and operations (Sandberg, Holmström and Lyytinen 2020). These changes have driven the progress of human-computer interaction, smart objects and digital infrastructures (de Reuver, Sørensen and Basole 2017; Yoo, Henfridsson and Lyytinen 2010) which have been reflectively shaped by the changes in business and society at large (Benitez, Ray, and Henseler 2018; Cusumano, Gawer and Yoffie 2019; Majchrzak, Markus and Wareham 2016). To get an understanding of such complex phenomena a great effort is needed to conceptualize problems, develop models and conduct empirical investigations. Scholars in the fields of engineering and social sciences are constantly engaged in understanding the role of digital technologies in organizing through a trans-disciplinary approach (Jacobides, Cennamo and Gawer 2018; Rietveld, Schilling and Bellavitis 2019; Wang 2021).

The "informating versus automating" role of digital technologies conceptualized by Shoshana Zuboff "In the Age of the Smart Machine" (1988) has now left the floor to digital unknown unknowns that challenge our ways of thinking based on past experience and investigations (Zuboff 2015). It seems prophetic what the same author says in her recent book on surveillance capitalism regarding the social dilemmas of the third modernity:

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"Only "we the people" can reverse this course, first by naming the unprecedented, then by mobilizing new forms of collaborative action: the crucial friction that reasserts the primacy of a flourishing human future as the foundation of our information civilization. If the digital future is to be our home, then it is we who must make it so." (p. 27 Zuboff 2019).

Taking on in this challenge, in the present book we offer an overview of the most recent advances in the studies on innovation and technology in the digital space. The content of the book is based on the revised versions of the best papers (double blind peer reviewed contributions) presented at the annual conference of the Italian chapter of AIS which took place in Pescara, Italy, in October 2020. Multiple perspectives are adopted by authors, proving that understanding digital innovation cannot be confined within the scope of a single worldview. The Nordic school of socio-technical systems and the central-European school of design research are examples of approaches influencing how "organizing in a digitized world" can be studied by taking into account values such as diversity, equality and inclusion. The plurality of views offered makes this book particularly relevant for practitioners, scholars and policy makers, offering a fresh look on the most recent developments in Information Systems studies.

2 Themes

Figure 1 summarizes the organization of this book. The book is organized in four sections. It delves into digital trends and their applications in organizational contexts, cultural elements that affect the diffusion and adoption of digital technologies, the organizational challenges of digital transformations and, finally, the pervasive role of social media.

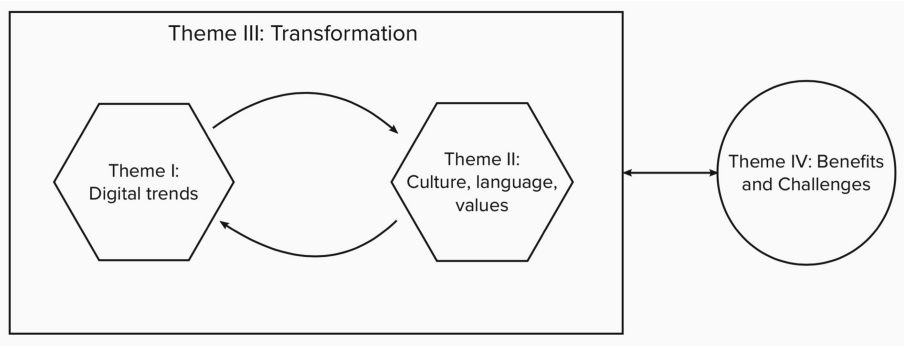

Fig. 1. An index card–sized preview of the book

The first section of the book addresses today's most relevant technological trends in the digital arena: Artificial Intelligence (AI) and Blockchain (Gregory, Henfridsson, Kaganer and Kyriakou 2020; Iansiti Marco and Lakhani R. Karim 2017). Both technologies produce relevant IS issues that require different research orientations such as design science, quantitative and qualitative studies. The first three chapters focus on AI applications in the context of e-commerce, Human Resources (HR) and healthcare.

These papers contribute to conceptualize the nature, antecedents and outcomes of AI-based decision making. The following two chapters focus on blockchain solutions that support value creation and data sharing in interorganizational scenarios. These studies demonstrate that more research is needed to understand the conditions and consequences of blockchain applications in digital environments.

The challenges of digitalization span in a variety of areas, that goes beyond technology and its application. Although often overlooked, culture, languages and personal values play a role as enablers or obstacles in the development of innovative activities and therefore in the digitalization processes (Faraj, Jarvenpaa and Majchrzak 2011; Nambisan, Wright and Feldman 2019). The five chapters included in the second section of the book explore the "soft" elements of digitalization from a variety of viewpoints and with diverse methodological approaches, such as proposition developments, bibliometric analysis, and data collected from primary sources. Authors explored the impact of the following dependent variables on digitalization processes: cultural proximity, knowledge spillovers, linguistic styles, socioemotional wealth and self-attribution bias, with the aim of shedding lights on aspects of the human behavior difficult to quantify but nevertheless crucial.

The third section of the book explores innovation as a transformation process (Vial 2019). Rather than focusing on a specific class of artifacts, the four chapters identify categories to classify goals, enablers, barriers and outcomes of digital transformation. A sociotechnical perspective is adopted to investigate the "what", "whom", "how" and "why" of technology driven innovation in different domains such as manufacturing, SMEs and non-profit organizations. These studies offer a set of analytical models to further investigate drivers and conditions to achieve sustainable growth through digital innovation.

The fourth section explores benefits and challenges of digitalization. Technologies and their application have different position in the innovation life cycle. In fact, while some of them are still in the introduction phase and we do not know their full potential (explored in Sect. 1, "digital trends"), others have been already applied for more than 20 years, having already reached the so called "maturity phase". Among such technologies, social media platforms and mobile applications are the paramount example of digital tools that already developed their potential in terms of benefits and detrimental effects (Alaimo, Kallinikos and Valderrama 2019; Baptista, Wilson, Galliers and Bynghall 2016). Their effect on society attracted the attention of a large share of scholars and a portion of the debate will be addressed also in this section. More specifically, the four chapters included in the last section of the book explore the implications on political communication, news circulation, relationship with patients in a medical setting and organizational identity.

3 Content Overview

3.1 Digital Trends

The first section of the book addresses today's most relevant technological trends in the digital arena: Artificial Intelligence (AI) and Blockchain. Marco De Marco, Paolo

Fantozzi, Luigi Laura and Antonio Miloso, in their study "AI-powered curricula selection: a neural network approach suited for small and medium companies" investigate the application of AI in HR management. The authors design and validate a method based on Neural Network to support HR experts in the screening process of curricula. Their results show that with off-the-shelf components it is possible to train and run an artificial neural network that automatically associates candidate CV to job positions. Ransome Bawack, Samuel Fosso Wamba and Kevin Daniel André Carillo, in their study "Adoption of Smart Speakers for Voice Shopping" investigate the effect of perceived risk, privacy concerns and perceived learnability of smart speakers on the intention to use smart speakers for shopping purposes. Through semi-structured interviews on smart speakers users contacted on Amazon Mechanical Turk and a survey involving more than 200 participants, the authors validate a conceptual model based on the theory of reasoned action. The study contributes to the literature on AI adoption in e-commerce by adding learning capabilities to the beliefs that influence the adoption and use of smart speakers. Federico Cabitza, Andrea Campagner and Edoardo Datteri, in their study "To err is (only) human. Reflections on how to move from accuracy to trust for medical AI" argue that the quality of AI-based predictions emerges from the context in which decisions are made rather than depending on the accuracy of a Decision Support System (DSS). Drawing on the case of an AI-based Covid-19 diagnostic online tool, the authors conceptualize accuracy as a relational attribute emerging from the situated interaction between the system and its users. The paper contributes to extend the application of a semiotic engineering approach to the design of AI-based DSS.

Roberta Cuel, Francesco Virili, Cristiano Ghiringhelli and Francesco Bolici, in their study "An Emerging Digital Ecosystem: Blockchain Competence Certification Networks" explore value generation in blockchain-based ecosystems. The authors conduct a case study on the development of a digital academic credential system on which they have build a dataset of project documents, direct observations, focus groups and structured interviews. The authors define blockchain as an enabler of trustless transactions and focus on complementarities among the involved actors to illustrate the emergence of a digital ecosystem around the blockchain-based platform. Ronald van den Heuvel, Rogier van de Wetering, Olaf Kruidhof, Rik Bos and Jos Trienekens, in their study "How Distributed Ledger Technology Can Influence Trust Improving Data Sharing in Collaborative Networks" investigate how blockchain influence trust and data sharing in collaborative networked organizations. The authors design and evaluate a decision model for selecting a suitable set of DLT-characteristics in the context of a collaborative network of European law enforcement agencies. Through the AHP method and the analysis of 15 semi-structured interviews, the authors offer guidance for the selection of blockchain-based solutions to improve trust and data sharing in collaborative environments.

3.2 Individual Culture, Language and Values

Section 2 is comprised of five chapters, exploring the "soft" elements of digitalization from a variety of viewpoints. A theoretical analysis is provided by Federica Ceci,

Simona Leonelli and Francesca Masciarelli that emphasized the role of cultural proximity, intended as cultural compatibility, identity, and shared creativity norms of organization members or between different firms. They explored the relationship between cultural proximity and innovation, investigating the moderator role of digital technologies on the relationship between cultural proximity and firm innovation. The relationships between people belonging to different cultures (i.e., with low cultural proximity) are facilitated by employing digital tools. However, the impact of culture on such process is still partially unknown. The chapter proposes some testable propositions and contributes to the debate about the importance of cultural proximity and the development of digital-based interactions on innovative activities.

The chapters by Filippo Marchesani and Francesca Masciarelli and Eleonora Monaco, Gianni Onesti, Diogo Cruz and Pierangelo Rosati focused on the latest trends of innovation in finance. More specifically, Filippo Marchesani and Francesca Masciarelli studied the role of local knowledge spillover and human capital as a driver of crowdfunding investment. The role of territory has already been studied in terms of campaign success, but the impact of territory on the use of financial sources like equity crowdfunding is not yet known. Using a sample of 435 equity crowdfunding campaigns in 20 Italian regions during a 4-year period (from 2016 to 2019), the authors evaluate the impact of human capital flow on the adoption of crowdfunding campaigns. Results show that inbound knowledge in the region, measured in terms of ability to attract national and international students, has a significant effect on the adoption of crowdfunding campaigns in the region itself. On the other hand, Eleonora Monaco, Gianni Onesti, Diogo Cruz and Pierangelo Rosati, in their work, investigated the phenomenon of Initial Coin Offerings (ICOs), an alternative source of entrepreneurial finance enabled by digital technologies. ICOs have attracted significant attention from the start-up community and from investors. Despite all the hype around ICOs and the growing number of new token offerings being launched on a daily basis, little is known about the characteristics of successful ICOs. Their study aims to fill this gap in the literature by exploring whether and how the linguistic styles adopted in the white paper affects the success of an ICO as measured by the actual amount raised by the offering. Results are based on a primary dataset of 131 ICOs completed between June 2017 and October 2018. Results suggest that the use of precise language is positively associated with the amount funded while the use of a concrete language and more numerical terms is negatively associated with the amount funded. This study contributes to the growing literature on ICOs by providing novel insights into the role of the communication strategy adopted by token issuers.

Stefania Migliori and Stefano Za explored the scholarly structure and trends in the scientific debate on socioemotional wealth (SEW) in family business studies. They analyse publications focused on SEW published to date in any sources of the Scopus database. Using a bibliometric analysis, they identify the scientific community debating SEW in terms of publication activity for authors, journals and countries and the publication's impact measured in terms of citation for authors and per year. Moreover, to picture the main themes researched, they develop a co-word analysis on the most used keywords by authors using social network analysis tools. This chapter provides a preliminary description of the state-of-art in SEW literature, identifying and potential future research directions for the consolidation of the literature on SEW.

Finally, Raja Nabeel-Ud-Din Jalal and Simona Leonelli explored the self-attribution bias impact on investor perception about cryptocurrency market efficiency, with mediating role overconfidence in the relation of self-attribution with perceived market efficiency. Structural Equation Modelling outcomes indicate no significant impact of self-attribution bias on perceived market efficiency. It was found that overconfidence bias has a significant effect on perceived efficiency. Further, the decomposition analysis indicated the presence of the mediating effect of overconfidence in the relationship of self-attribution with perceived market efficiency.

3.3 Transformation, Organizational Process and Procedures

The third section of the book explores innovation as a transformation process. Emanuele Gabriel Margherita and Alessio Maria Braccini in their study "Exploring Sustainable Value Creation of Industry 4.0 Technologies within the Socio-Technical Perspective" analyze the discourse on Sustainable Value Creation of Industry 4.0 technologies to assess how sociotechnical perspectives have been adopted to explain the outcomes of digital transformation. Starting from the analysis of three systematic literature reviews they select 23 cases that are then associated to different categories of socio-technical views. The studies complement previous literature in IT value by adding the environmental and social dimensions.

Angela Locoro and Aurelio Ravarini in their work on "Digital metamorphosis competencies as a human-centric approach to digital transformation: an instrumental collective case research" investigate the managerial competences that are necessary in different phases of digital transformation projects. They adopt the notion of digital metamorphosis to make a distinction between what and whom is being transformed. Digital metamorphosis refers to a set of implicit processes acting at different levels of a socio-technical system that determine a qualitative change only observable at the systemic level. Through the analysis of six projects, they identify different competencies configurations that are relevant in different project phases.

Alberto Bertello, Paola De Bernardi and Francesca Ricciardi in their work on "Open innovation for digital transformation in traditional SMEs: analysis of pre-competitive collaborative projects" explore open innovation processes in low- and medium-tech SMEs. Through a multiple embedded case-study on seven collaborative R&D projects in the field of Industry 4.0, the authors identify ten barriers to open innovation and group them in four dimensions. The empirical findings are then discussed to shed light on the obstacles to digital transformation in the context of SMEs.

Finally, Michele Cipriano and Stefano Za develop a taxonomy of digital transformation in the domain of non-profit organizations. Through a systematic analysis of a dataset of 137 papers, the authors identify five dimensions and twenty-nine values as a first step in the development of a taxonomy-based framework for mapping digital transformation scenarios in the context of non-profit organizations.

3.4 Benefits and Challenges

The four chapters included in Sect. 4 of the book explore the implications on political communication, news circulation, relationship with patients in a medical setting and

organizational identity. In the first contribution included in this section, Maximilian Haug, Heiko Gewald and Philipp Brune focus on one of the most used social media platforms, Twitter, and on its functionality to spread news. In fact, celebrities, institutions and news outlets increasingly tweet information which they deem as worthy. However, independent users are also able to share various information, which makes it increasingly hard to distinguish which information is credible. In this research, they attempt to gather an overview about Twitter users' attitude towards news sharing on Twitter and how credible they find information provided on Twitter. Drawing on the elaboration likelihood model, they operationalized the elaboration likelihood with the default cognitive style of the users. Surprisingly, the results show that people with a more rational cognitive style prefer Twitter as a news source.

Benedetta Gesuele, Concetta Metallo, Maria Dolores Guillamon Lopez and Ana Maria Rios Martinez studied the role of social media in political communication and their possible influence on electoral results. For this purpose, they analyze the parties' Facebook Fan pages in the last general election in Italy (March 2018) over two periods: from 1st February to 4th March 2018 (Election Day); and, from 5th March to 31st March 2018. Results show that there is a positive and significant relationship between the effort of the parties to inform citizens thorough the use of Facebook before the elections and their electoral outcomes in the congress. Specifically, they find that the higher the parties' engagement, the better their electoral results. Nevertheless, they do not find any evidence that a higher engagement of citizens on a party's Facebook Fan page before the election leads to this party having better electoral results. Finally, they explore if the parties change their political discourse before and after the election on their Facebook Fan pages, and find that there are, indeed, differences.

Rocco Reina, Marzia Ventura, Concetta L. Cristofaro and Walter Vesperi tackled an actual yet relevant issue: the reduction in face-to-face relationships in the Covid-19 era. For this reason, the Information and Communication Technologies (ICT) are becoming the main tool able to substitute the direct relationship among people. So, one tool able to support health authorities in monitoring and mitigating the ongoing COVID-19 was Mobile Applications (mApps), by facilitating follow-up among patients and practitioners and providing direct guidance to citizens in order to play their part in the control of the disease. The main purpose of the chapter is to know and analyze features and functionalities of the mApps for COVID-19. The results obtained at this stage of the research have provided a preliminary taxonomy of the mApps specifically oriented to COVID health management in Italy.

The organizational identity (OI) concept has been explored by Stefano Di Lauro, Aizhan Tursunbayeva, Raluca Bunduchi, Gilda Antonelli and Marcello Martinez. Although this concept is used only sporadically in information systems (IS) research, it is of paramount importance given to the fact that technology in general and social media (SM) in particular are transforming the way individuals, groups and organizations think about and define themselves. This study examines the relationship between the extent of employees' SM use for professional purposes and the nature of OI that employees hold about their employer. This relationship is examined in a medium-sized Italian HR Consulting Company. Data were collected by interviewing 22 employees

and from examining their LinkedIn accounts. Analysis unearths both strategic and cultural aspects of employees OI, with the former prevailing, and finds that that neither of these sides of OI vary depending on the extent of employees' SM use. Considering that LinkedIn is the world's largest professional SM, this study also has important practical implications highlighting the need to better explain SM use to employees.

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Digital Trends

AI-Powered Curricula Selection: A Neural Network Approach Suited for Small and Medium Companies

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Abstract. AI and Big Data, in the last years, are changing the business in any aspect. In this paper we deal with the process of curricula selection for small and medium companies, i.e. the so-called last mile of the digitalization. This study proposes a new algorithm that could be integrated into the preliminary CVs screening process carried out by an interviewer in order to assess the right collocation to the skill set of the interviewee for the specific job position. The algorithm analyzes the text of a CV to correctly predict the right job position for the candidate. In particular, we show that with off-the-shelf components it is possible to train and run an artificial neural network suited to support HR in the process of curricula selection.

Keywords: Artificial intelligence · Human resources · Natural language processing

1 Introduction

In the last two decades marketing has adapted and transformed in according to trends and forces that have characterized the market. This transformation occurred in developing new approaches regarding value creation process. Thus, Holistic Marketing was developed [21].

This approach considers the business system as a whole, indivisible and interconnected. Therefore, a strategic plan has to consider that all company's functions take part in the value creation process. In a market reality where a company tries to deliver value for the customer through its products, services or experiences to satisfy the needs of its customers, the marketing strategic plan needs to bring together all the processes of the company [20].

The holistic marketing approach considers different aspects of the company such as: how the company handles relations between internal and external agents (Relationship Marketing); how the company contributes on themes involving ethics, environment and

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legal issues (Socially Responsible Marketing); how the company manages all the correlate aspect of its processes such as communication, distribution channels, products and services; at last, how the internal part of the organization, such as managers, employees and the staff, interacts with the rest of the company [17].

Recently, companies have realized that the overall strategy includes the cooperation between the internal agents of the company at all the levels vertically and horizontally in the organization [35]. Only with the cooperation between employees of different functions, it is possible to deliver to the customers the right product or service followed by a positive synergy. This positive synergy enhances the productivity of employees who result to be more engaged with the company, connected with its beliefs and values and much more capable to spread the company culture outside the organization.

To accomplish that state-of-the-art, Human Resources (HR) division must manage the hiring and the formation processes of new employees accordingly to the company's standards. Human Resources represent one of the main critical factors for business success since their involvement allows the company to highlight their qualities and to leverage on their potential in order to create a competitive advantage that lasts over time. The HR department must adapt to a continuous and accelerated market transformation. However, strategy creation requires data and HR experts need more support from IT tools to deliver better results more effectively. Technology is a key resource to improve HR activities implementing a new framework that improves the internal value of the company [7].

With the advent of Industry 4.0 that brings together innovations from smart business and smart factory [34], the digital transformation supported HR in its functions such as recruitment, onboarding, learning and development, social sharing, and crowd-sourced feedback [35].

To embrace new opportunities in HR a possible solution involves the adoption of Industry 4.0 approaches [9]. Those concepts help to implement the automatization and digitalization of processes mainly used for production but also capable of being applied as well as to other fields [4]. HR was able to develop new activities and to improve the previous ones [14], thanks to technologies such as Internet-of-Things, Big Data Analytics, and artificial intelligence (AI) and fast data networks. Sivathanu and Pillai described some applications of these new technologies in HR [35]:

- Big Data can help to automate the selection process of the candidates that are more suitable for the job position. This will reduce the time spent by companies to actively advertise a newly opened position and waiting for the candidates. Therefore, HR can search online or in an internal database possible matches according to the skill set required.
- Augmented reality/virtual reality (AR/VR) can guide new employees in their first period with the firm through a formation program designed specifically for that employee rather than the traditional one-size-fits-all program. This technique reduces the time that employees spend in their formation period before starting working at full speed for the company and improves the engagement between employees and the company.
- Faster data network connections (4G/5G) enable remote job interview, which reduces recruitment process duration considerably.

– AI chatbots can participate in the selection process in reviewing the candidate without any sort of bias and can help a potential candidate in finding the right job position to apply for.
– HR Analytics can include automated and customized testing that will predict the fit of the interviewee to the job position.

The use of algorithms and models through the candidate selection process is a practice widely used by recruiting companies. Thanks to Human Resources Predictive Analytics, HR reduces the costs of the hiring process and optimizes business performance [9].

In this paper we show that, nowadays, it is possible to build an effective artificial neural network using off-the-shelf components, thus obtaining a tool that can be helpful for HR departments of also small and medium companies, allowing them to quickly cluster, filter and scan a huge dataset of curricula, searching for the set of skills needed for the job. The results obtained by our approach are shown in Table 1, where we partition by category the curricula in the dataset.

The next section discusses related work and the impact of AI and Big Data on HR. Section 3 details our approach, whilst the experimental results are described in Sect. 4. Finally, Sect. 5 addresses conclusive remarks.

2 Related Work

In the academic literature, numerous studies about the hiring process to develop new methodologies for the candidate evaluation or new tools to improve the accuracy of the overall process have been conducted [8, 12, 13, 25]. The hiring process has been broken down and analyzed from many angles [1] through all the steps of the process which are:

1. Circulation process
2. CVs selection
3. Exam by the Job Recruiters
4. Results of the Selected Candidates.

In according to this list, the first step deals with the communication of the open positions that is made through all the communication channels that the company believes suitable for the purpose: personal website, job portals, recruiting companies, newspaper, magazines or else. The usual job offers' format includes designation, skills required, salary scale, last day for submitting the job application and other possible details. After that the company has published the job offer, the potential candidate has to find out the offer with the concrete risk of missing it. Once the applications have been sent, a CV screening is made before the candidate examination. This process is composed of two screenings done to the CV. Firstly, a quick scan to ensure that the candidate possesses all requirements. Secondly, a more accurate screening than the first one, assess if the candidate could be a valuable asset for the company. Sometimes, companies are looking for explicit characteristics to ensure adequate heterogeneity among their employees according to gender, attitudes or psychological profile. After the first selection, recruiters organize some examination sessions that are different between companies, job position

or recruiters. Among the possible examination alternatives, the followings are worth to be mentioned:

– The individual interview where a candidate is interviewed by the recruiter to assess his competencies;
– The group interview where more candidates are interviewed simultaneously to understand how they relate to each other;
– The workshops where more candidates are brought together to work at a case study to come out with a possible solution.

There are other possible solutions to evaluate the compatibility of a candidate with the job position and generally, a session includes more solutions consequentially [1]. At the end of the examination process, the selected candidate is notified. New technologies were applied to the job interview process, mainly at the job recruiter examination step: in this phase, recruiters are always looking for fair and accurate methodology or tools to evaluate a candidate. The first successful approach to this need was psychological. Indeed, psychology theorized accurate models to understand the behavior of a potential candidate. Afterwards, the psychological approach was integrated with the application of psychometry that through psychological measurement was able to create reliable frameworks that allowed recruiters to evaluate candidates correctly. Since psychometry evaluates measures taken by all sort of instruments in a short time, it was clear that the AI was going to help in acquiring the data needed and in processing them with more complex models to shape a flexible and reliable framework [15, 23, 29]. Among the applications of new technologies in a potential candidate evaluation process, the study conducted by Naim [27] is worth to be mentioned. In this aforementioned study, the Nonverbal Behavior Recognition analysis was applied to identify, during a job interview, features such as:

– Speaking style to understand the intonation and the rhythm of the speech to model the social intent;
– Lexical feature to provide information about the interview content and the interviewee's personality;
– Facial features to detect smiles or other facial expressions.

The technologies involved in this process are: facial recognition algorithms needed to capture and recognize the facial expressions, pattern recognition software to interpret the prosodic features (speaking style) and the Natural Language Processing (NLP) algorithms together with the speech-to-text algorithms to extract information from the recorded interview. Another step of the hiring process which benefits from the new technology adoption is the CVs selection.

In this phase, the two screenings that recruiters usually do can be easily automated by AI. The first screening, considering that is a summary verification of the candidate mandatory skills for the job position, it can be easily done by a machine. Unfortunately, one of the biggest challenges, that not only recruiters find hard to handle, is the variability of the CVs structure. It is a hard task to teach AI to recognize patterns where there are no structured patterns to learn from. Indeed, candidates often personalized their CV as

it is interpreted as a sign of creativity and as a proof of document creation skill. This uncertainty concerns, not only the CV's format, but its contents as well. Personalized CV's format and contents may cause misleading in the training process of the model because the test phase would cause errors. The algorithm will be expecting to find a certain type of information in a precise place that is not common to all the CV formats leading to the error. With this exception in mind, it is possible to recognize that the ideal algorithm has to analyze the CV contents as a whole, without considering its structure.

3 A Neural Network Approach for Resume Classification

Since the classification of a document is a classical NLP task, we have chosen state-of-the-art NLP models to try to achieve the resume classification. Currently, the best models to solve these tasks are the ones based on Transformer architecture. Unfortunately, most of the state-of-the-art transformer-based architecture are too large to fit in common hardware and need huge resources to be trained.

Anyway, there are some models that guarantee near state-of-the-art results with smaller architectures. The architecture we used to try to solve this task, is a DistilBert [32] architecture composed by 6 layers, 768 dimension and 12 heads, totalizing 65M parameters. We have chosen this architecture because it's small enough to be run on hardware available in a company of any size.

To test the method we have designed, we have taken a public available dataset (https://www.kaggle.com/dhainjeamita/resumedataset) containing anonymized resume with a category assigned to each of them. The dataset contains 169 resumes of different lengths. Even if 169 resumes are very few to train a machine learning model, we have chosen to use this dataset because it is an actual repository from a company HR department. So, it has the right size and the right differentiation of elements to represent an HR database of most of the middle-size companies.

We merged some categories to make them more homogeneous, and the result is a partition of 17 categories. This change does not imply a loss of generality because they are anyway manual annotated, so they are the choice of a single HR expert that could be totally different from another HR expert. We also transformed all the resume in lower case because the case in the resume is often wrong, especially for the technical terms.

4 Experimental Results

As we described in the previous section, we built a DistilBert architecture composed by 6 layers, 768 dimension and 12 heads, totalizing 65M parameters. We performed fine-tuning of the pre-trained model "distilbert-base-uncased" with batch 2, learning rate $10-6$ and 2000 epochs. We used a Nvidia Titan-Xp GPU with 12 GB of ram for training. We divided the dataset in the train/validation/test sets using a split 0.7/0.2/0.1.

So, we fine-tuned the model using the 90% of the curricula to create an implicit connection between the \words" in the curricula and their category. Then we tried to classify each of the 10% of the curricula remained using the model. The chosen learning rate seems more than ok, as we can see from the learning rate/loss curve, shown in Fig. 1. Thus, the resulting model loss and model accuracy are shown, respectively, in Fig. 2 and Fig. 3.

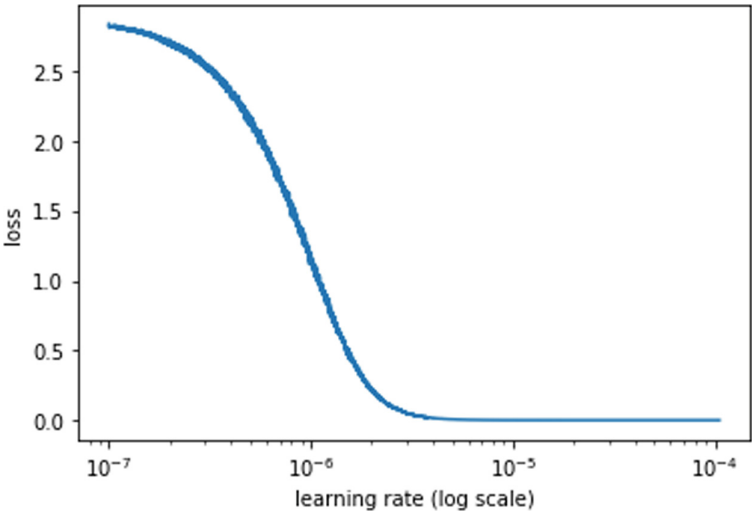

Fig. 1. Learning rate/loss.

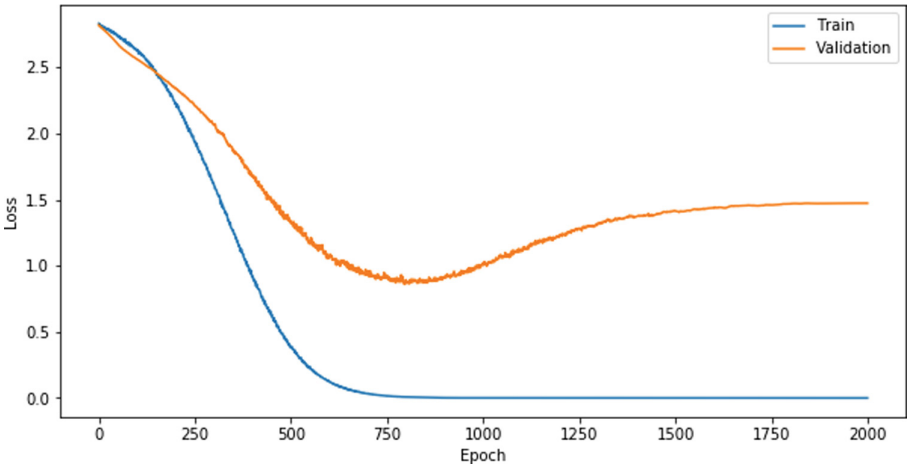

Fig. 2. Model loss.

As already mentioned, the results obtained by the model are shown in Table 1: here, for each category, we show the values of precision, recall and f1-score.

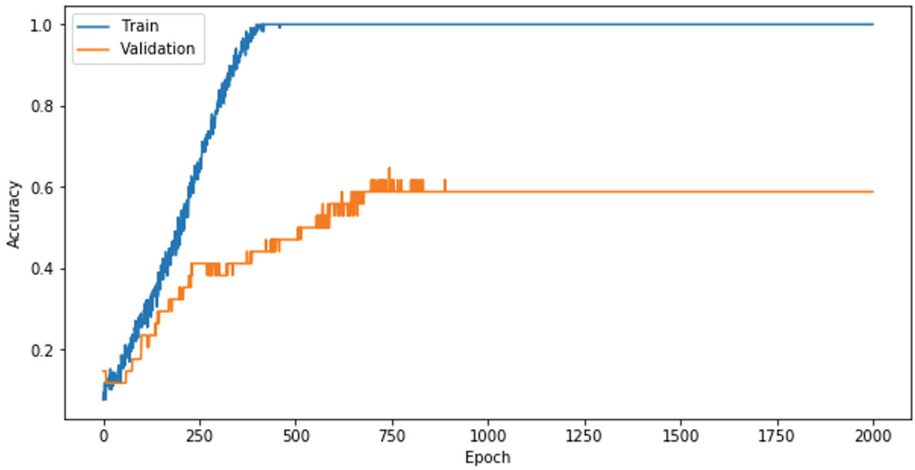

Fig. 3. Model accuracy.

From the table mentioned before it is clear that for well partitioned skills the model correctly identifies the category, while for skills that can overlap between categories it fails. For instance, for each curriculum of HR, Health and fitness and SAP Developer, it always assigns the correct category, because the skills owned by each one of these professional figures are not owned by other ones. At the same time, most of the curricula of Data Science candidates are categorized as Python Developer, likely because a Data Science professional figure needs to know at least a subset of skills from a Python Developer.

Note that we have chosen to use the model trained in 2000 epochs, even if clearly overfitted, because we achieve better results with this model than the early stopped model. It is easy to note that some categories are not recognized at all. This means that, in an actual application, we should increase the number of samples for those categories.

From these experiments it seems clear that, in a real application, it should be either increased the number of curricula used to fine-tune the model or reduced the number of categories associated. Also, it could help to have a tree of categories. For instance, Python Developer and Data Science inside the category Computer Scientist. In this case we could have also a tree of models \dedicated" to sub-trees. Anyway, the most important part of the process is still the annotation of the curricula used by the training phase. This means that, this kind of methods couldn't be used by any company any time, but its adoption should be planned to prepare and pre-process the data used later in the training phase.

5 Conclusion

In this paper we presented a new algorithm that could be integrated into the preliminary CVs screening process carried out by an interviewer in order to assess the right collocation to the skill set of the interviewee for the specific job position. The algorithm analyzes the text of a CV to correctly predict the right job position for the candidate. In

Table 1. The results obtained by the neural network, partitioned by category. We report, for each category, the values of Precision, Recall and f1-score

	Precision	Recall	f1-score
Advocate	1	1	1
Arts	0	0	0
Business analyst	0	0	0
Data science	0	0	0
Database	1	1	1
DevOps engineer	0	0	0
DotNet developer	0.5	1	0.67
Engineering	0.5	1	0.67
HR	1	1	1
Hadoop	1	1	1
Health and fitness	1	1	1
Java Developer	1	1	1
Network security engineer	1	1	1
Python developer	0.5	1	0.67
SAP developer	1	1	1
Testing	0	0	0
Web designing	0	0	0
Accuracy			0.65
Macro avg	0.56	0.65	0.59
Weighted avg	0.56	0.65	0.59

particular, we show that with off-the-shelf components it is possible to train and run an artificial neural network suited to support HR in the process of curricula selection: we used a Nvidia TitanXp GPU with 12 GB of ram for training, and a DistilBert architecture for the artificial neural network.

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Adoption of Smart Speakers for Voice Shopping

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Abstract. This study aims at determining the effect of perceived risk, privacy concerns, and smart speaker learning capabilities on the adoption of smart speakers for voice shopping. To this end, we used the theory of reasoned action (TRA) and the interpersonal theory of personality to propose a conceptual model that we tested using a mixed methods research design. Our results show that indeed, perceived risks, privacy concerns, and perceived learnability of smart speakers influence consumer intention to use smart speakers for voice shopping, which then influences actual use. Theoretically, this paper contributes to new theoretical perspectives regarding the learning capabilities of AI systems and their importance in AI adoption. Specifically, we use an insightful interpersonal theory and develop a scale that can be used to measure the learnability of AI systems as perceived by users. Practically, we show information systems (IS) and marketing managers key factors that need to be considered when providing voice shopping services through smart speakers.

Keywords: Smart speaker · Voice shopping · Artificial intelligence voice assistants · Learnability · Perceived risk · Privacy concerns

1 Introduction

Smart speakers are among the latest technological innovations that are transforming business environments. Given their high household penetration rates in recent years, researchers and practitioners in marketing and information systems (IS) are interested in understanding its adoption in e-commerce contexts. This includes understanding advertising (Lee and Cho 2020) and marketing (Smith 2018) through smart speakers, as well as barriers to its adoption (Hong et al. 2020). Several organizations like Amazon, Walmart, and Target are already leveraging smart speakers to gain a competitive advantage by providing customers with voice shopping services through these devices (Kinsella and Mutchler 2018). Investing in such technological innovations implies several organizational changes like revising organizational processes and developing new business models that bring their services closer to the consumer (Behrenbeck et al. 2015). Also, the fact that smart speakers use artificial intelligence (AI) technologies like machine learning (ML) and natural language processing (NLP) gives service providers the possibility

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to capture insights from (big) data that can be used to improve customer experiences and influence their behavior.

Although customers appreciate the convenience, speedy responses, and "natural" interactions they have with smart speakers, this technological innovation seems to generate major privacy concerns and is perceived as risky by many consumers (Kinsella and Mutchler 2018; Rzepka et al. 2020). Also, smart speakers have been sold as an AI-based technology. This implies it is capable of learning and improving itself to adapt to its user with continuous use (Bawack et al. 2019). This is an exciting feature that makes consumer-oriented AI technologies very interesting in terms of human-computer interaction and usability. However, there is very little empirical evidence to determine if these beliefs influence consumer adoption of smart speakers for shopping purposes.

This study aims at understanding the effect of these beliefs on smart speaker adoption. Specifically, we seek to determine the effect of privacy, risk, and smart speaker learnability on the adoption of smart speakers for shopping purposes. Using the theory of reasoned action (TRA) and the interpersonal theory of personality, we show that perceived risks, privacy concerns, and perceived learnability of smart speakers influence consumer intention to use smart speakers for shopping purposes, which then influences actual use. Theoretically, this paper provides a new theoretical perspective regarding the learning capabilities of AI systems and their importance in AI adoption. Practically, we show IS and marketing managers key factors that need to be considered when providing voice shopping services through smart speakers.

In the section that follows, we present a literature review on the adoption of smart speakers in e-commerce. After that, we present the theoretical foundations of our study and our proposed conceptual model. Next, we present our methodology, followed by the results, discussion, and conclusions of our study.

2 Literature Review

A smart speaker is a type of wireless speaker capable of sensing its local environment and interacting intelligently with its user through voice assistants (O'Keeffe 2018). The most popular smart speakers in use today are Amazon Echo and Google Home. They are each equipped with AI-based voice assistants called *Alexa* and *Google Assistant* respectively. Extant studies acknowledge that research on the adoption and use of smart speakers is very scarce yet very important given the rising popularity and the increasing number of services provided through these devices. Voice shopping is one of the services currently being provided through smart speakers. Consumers already adopt it as an alternative online shopping channel. Rzepka et al. (2020) used interviews to show that while consumers perceive it to increase efficiency, convenience, and enjoyment, they deplore its privacy gaps and low technical maturity of smart speakers for voice shopping. This often leads consumers to have to trade privacy for convenience which influences the way they adopt smart speakers (Lau et al. 2018).

Using a qualitative approach, Haug et al. (2020) show that privacy concerns are among the key issues smart speaker users face. However, these concerns seem overshadowed by perceptions of risk although they do not prevent the adoption of this technology. They recommend further investigations on the effect of perceived risk on smart speaker

adoption since they found the perceived risks of users somewhat hypothetical. They identified the e-commerce use case to be particularly interesting because it seemed to increase perceptions of risk and privacy concerns, especially given how easy it is to purchase through smart speakers. Furthermore, Huang et al. (2020) show through interviews that privacy concerns regarding the use of smart speakers are not limited to information shared with manufacturers and service providers. They also extend to privacy concerns regarding housemates and anyone who has access to the device. Therefore, they recommend risk management strategies that can help smart speaker users cope with these perceived risks.

There are a few quantitative studies regarding smart speaker adoption in e-commerce. Although not specifically tied to voice commerce, Hong et al. (2020) show that perceived risks increase the resistance to adopt smart home devices like smart speakers. Given that the study was limited to Korea, the authors encouraged similar studies to be conducted in other geographical contexts and other factors that may influence resistance. Han and Yang (2018) show that privacy, security risks, and interpersonal attraction affect the adoption of voice assistants. They explain that using their AI capabilities, voice assistants should be able to learn its user's behavior and proactively take relevant actions without user input. This implies that through components like sensors embedded in smart speakers and AI technologies like ML and NLP, voice assistants should be able to collect user information that will enable them to learn and provide proactive and accurate responses to user requests. This is expected to increase social attractiveness and hence the intention to adopt voice assistants.

This literature review reveals several research gaps we seek to address. First, the literature on smart speaker adoption in e-commerce is mostly based on qualitative studies. Although they reveal the importance of privacy and risk perceptions, there is barely any quantitative empirical evidence to support these findings. Second, no recent quantitative study addresses the specific topic of smart speaker adoption for voice shopping. Current studies discuss smart home devices in general and do not address specific contexts of use. Third, no study has investigated the effect of the learning capability of smart speakers on the intention to adopt them for voice shopping. We believe filling these research gaps will improve the extant body of knowledge on the adoption of voice-based AI technologies like smart speakers in e-commerce contexts.

3 Theoretical Background and Hypotheses

3.1 Intention to Adopt and Actual Use of Smart Speakers for Voice Shopping

Based on the theory of reasoned action-TRA (Hill et al. 1977), we posit that the adoption of smart speakers for voice shopping is driven by the behavioral intention of the user which is a function of the attitude of the user towards using smart speakers for voice shopping. TRA has served as a foundation for the development of several consumer-oriented technology adoption theories and models like TRA-privacy (Bansal et al. 2016) and the consumer version of the unified theory of acceptance and use of technology (UTAUT2) (Venkatesh et al. 2012). Thus, we believe it forms a strong theoretical foundation for explaining the smart speaker adoption behaviors of voice shoppers. Thus, we hypothesize that:

Hypothesis 1 (H1): Intention to adopt smart speakers for voice shopping influences its actual use for voice shopping.

The attitudes of interest to this study are perceived risks and privacy concerns associated with using smart speakers for voice shopping. We assess the effects of these attitudes on the intention to adopt smart speakers for voice shopping.

3.2 Perceived Risk

Perceived risk is the belief that obtaining the desired outcome could lead to some degree of suffering (Pavlou and Gefen 2004). There is extensive research on the effects of perceived risk on the behavioral intentions of consumers in e-commerce environments. Using websites, these studies show that perceived risks reduce intentions to purchase online, especially risks regarding the security of payment and data protection (Kamalul Ariffin et al. 2018; Zhou et al. 2018). As shown in our literature review, the same can be said about voice shopping. Voice shopping using smart speakers also exposes the user to security, privacy, and financial risks that are both external and internal.

External risk involves exposing the smart speaker owner to risks associated with the smart speaker manufacturer or voice shopping service provider. Using smart speakers for voice shopping implies giving these external entities access to personal information like financial information and personal preferences. This exposes the user to the risk of information abuse, especially given that consumers are generally not aware of how the information collected is used besides the general claim that it is used to enhance customer experience and services.

Internal risks are risks regarding the household (environment) in which the smart speaker is found. Voice shopping through smart speakers is relatively easy. Since these devices are "always listening", users can mistakenly place orders thereby exposing them to significant financial risks. Also, there are significant risks of identity theft. Someone could trick the smart speaker into thinking it is its original owner and use the speaker to make unauthorized purchases. Since the literature shows that perceived risks of smart users are hypothetical (Haug et al. 2020), we do not focus on a specific type of risk perception but rather on the effects of the overall perceptions of risk related to using smart speakers for voice shopping. Thus, we hypothesize that:

Hypothesis 2 (H2): Perceived risk reduces the intention to adopt smart speakers for voice shopping.

3.3 Privacy Concerns

Privacy is defined as the ability to control when, how, and how much information an individual can communicate with other people (Hong and Thong 2013). However, the famous definition of privacy as being the right to be left alone (Borning and Kesdogan 2001) is becoming more important now than ever given the current spread of "always listening devices". Privacy concerns have also been extensively researched in the context of e-commerce (Teubner and Flath 2019; Wunderlich et al. 2019). Furthermore, our literature review also reveals qualitative evidence that privacy concerns affect the

intention to adopt smart speakers for voice shopping. There have been several debates on the trade-offs consumers have to make when sharing sensitive information online (Gopal et al. 2018; Lau et al. 2018; Teubner and Flath 2019). In a theory developed based on TRA, Bansal et al. (2016) suggest that privacy concerns negatively affect the willingness to disclose personal information. Voice shopping through smart speakers involves disclosing personal information online. Owning a smart speaker already poses privacy concerns given that it is an "always listening device" constantly collecting the user's personal information while listening for the "wake-up" word. This implies that the moment one installs a smart speaker in their home, it will listen to everything they say thereby prying into their private lives (Bohm et al. 2017; Malkin et al. 2019). This changes research on privacy because before it was a question of how much information one was willing to share and at what cost. This could discourage users from using smart speakers since they may not be willing to share their personal information with people who have access to information collected by smart speakers. Thus, we hypothesize that:

> Hypothesis 3 (H3): Privacy concerns influence the intention to adopt smart speakers for voice shopping.

3.4 Perceived Learnability of the System

Learnability is a concept in human-computer interaction that describes how easy it is for a new user to learn how to interact with a system (Bringula 2016; Brito and Stoyanova 2018). It is often studied as one of the dimensions of usability (Cruz and Karatzas 2019; Seo et al. 2016). As such, it has been shown to influence the behavioral intentions of consumers in online shopping contexts (Rahmawati and Liswandi 2018). The easier it is to learn how to interact with new technology, the better the user feels about using the technology (Brito and Stoyanova 2018). The rationale behind this dimension is that users tend not to use new technology if learning how to use it is difficult. Thus, manufacturers have to make systems easy to learn to increase the chances of adoption (Poushneh and Vasquez-Parraga 2017; Tractinsky 2018).

In this study we approach learnability from the opposite end, that is, from the system's perspective. We define learnability as the ability of the AI system (in this case smart speaker) to learn and adapt to the behavior of its user. Unlike other technology artifacts, AI artifacts like smart speakers are expected to be capable of learning and getting better at meeting user needs without direct input from the user (Han and Yang 2018). In such a scenario, the user no longer carries the burden of learning how to do voice shopping using smart speakers. Instead, the user has to speak naturally to the smart speaker and the smart speaker is expected to understand the user's request well enough to respond accurately (e.g. purchase a product).

We argue that the concept of learnability from the system side functions like from the user side. That is, the more the user perceives the system as having learned their shopping habits, the better they feel about using the smart speaker for voice shopping. This is because it would make shopping more convenient for the users as they would not need to perform repetitive shopping tasks, for example. Since the smart speaker would have automatically learned their shopping habits, it will be able to understand their request much faster and take relevant shopping actions at the right time. This

would, therefore, increase the social and task attractiveness of smart speakers as well as their sense of security when using it for voice shopping. This argument is based on the interpersonal theory of personality developed by Harry Sullivan (Sullivan 2013) that suggests that interpersonal interactions determine people's sense of security and the dynamism that motivates their behaviors. Thus, we assume that when the smart speaker user perceives the learning capabilities of the speaker, it improves their interpersonal interactions and motivates the intention to adopt smart speakers for voice shopping. Therefore, we hypothesize that:

Hypothesis 4 (H4): The perceived learnability of smart speakers positively affects the intention to use smart speakers for voice shopping.

Figure 1 presents our proposed conceptual model that we will test using a mixed-methods approach.

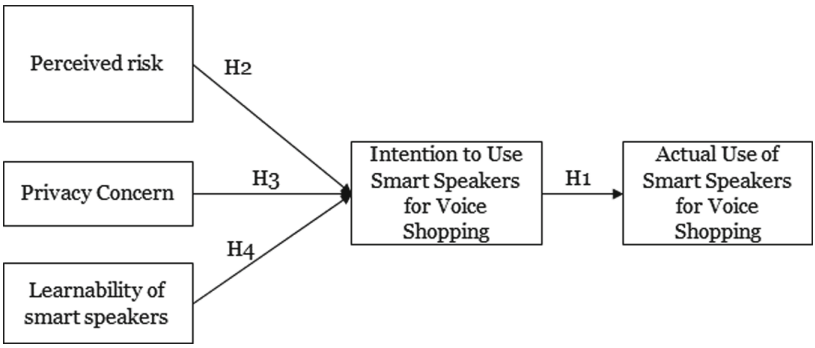

Fig. 1. Proposed conceptual model

4 Methodology

To measure the effects perceived risk, privacy concerns, and the learnability on the adoption of smart speakers of voice shopping, we chose to use a mixed-methods approach as suggested by Venkatesh et al. (2016). We chose this approach because we didn't find any scale that could be used to measure the new concept of learnability introduced in this study. Since AI adoption in voice commerce is a relatively new phenomenon, it is difficult to find and adapt scales from the existing literature. Therefore, we conducted 2 studies. In study 1, we conducted semi-structured interviews with smart speaker users to better understand and propose a scale to measure the user perceptions of the learnability of AI systems. In study 2, we used our learnability scale and existing scales on perceived risk, privacy concerns, and behavioral intention to test our conceptual model.

In study 1, our interviews were guided by theories of intelligence and its measurements (Thorndike 1921). Specifically, we asked smart speaker users about how they perceived their smart speaker's ability to learn their use habits over time and to adapt

to their new use cases or situations. We purposively recruited 38 participants using the Amazon Mechanical Turk (MTurk) platform, which is a platform that has been used to recruit quality participants for several academic studies (Deng and Joshi 2016; Hibbeln et al. 2017). The participants all lived in the United States of America (US), had some experience using smart speakers, and had used smart speakers for voice shopping at least once. After providing essay-time responses to our questions, all approved participants were rewarded with USD 6 in cash.

We analyzed our qualitative data in four main steps: Our data analysis iteratively went through four main steps: (i) data processing and preparation; (ii) data coding (iii) assertions and propositions (hypotheses) (Ridder et al. 2014). Data processing and preparation involved cleaning and organizing the data for coding. The data was initially coded by the authors. After that, a panel of six PhD students also coded the data. A discussion session between the PhD students who volunteered and the authors led to the final codes used in the study (see Table 1). These codes were then used to develop the measurement scales for learnability.

Table 1. Sample codes from the qualitative study.

Respondent	Excerpt from original field notes	Open codes
R12	I have definitely noticed that as we "work" together more, she is able to… learn more about my needs	Learning user needs
R16	I am very appreciative of its ability to understand the information I provide. It amazes me every time I use and I feel like the technology is only getting better	Getting better at understanding information
R21	My smart speaker has gotten used to things I order often. This has saved time since the first time using it to make an order	Getting used to user's habits
R21	My smart speaker has been very helpful and that helpfulness has appeared to improve over time	Improving over time
R22	I think that Alexa does an amazing job as adapting to my shopping habits. I think that as time goes on, she learns more and more about me	Learning user's habits

In study 2, we tested our new measurement scale and model constructs (Moore and Benbasat 1991). We began by pretesting our questionnaire using a sample size of 20 participants made up of Ph.D. students from diverse social science disciplines. The participants provided feedback on the clarity and relevance of our questionnaire. After that, we did a pilot test and obtained 94 valid responses that enabled us to confirm

the understandability of our questionnaire and the stability of our constructs. Finally, we validated our measurement instrument using participants recruited through an online participant recruitment platform called Prolific. This platform is known to provide access to high-quality research participants with multiple profiles (Adjerid et al. 2018; Harnish and Roster 2019). We used the platform to limit our survey to participants who live in the US, whose first language is English, who own a smart speaker, and who have used it at least once for voice shopping. This was to ensure consistency in our data. All participants who submitted approved responses were rewarded with a cash prize worth £6.42 per hour. At the end of the data collection phase, we obtained 224 valid responses which was the recommended sample size we calculated using the GPower 3.1 software (Faul et al. 2007). Summarily, 55% of the participants were male and 44% were female. 67% were between 21 and 40 years old, 49% had a household income between $50K and $100K, and 67% used an Amazon Echo smart speaker for voice shopping.

Our data analysis was conducted using structural equation modeling partial least squares (SEM-PLS) with the help of SmartPLS 3.3.2 software. Each item was measured using a seven-point Likert scale ranging from "strongly disagree" to "strongly agree" except for the "actual use" construct that just asked people to select from a range of options how often do you use your smart speaker for shopping purposes, from "never" to "always". Below, we present the scales used to measure our latent constructs and the sources from which the scales were adapted.

Actual Use (Authors)
How often do you use your smart speaker for shopping purposes?

Intention to use (Venkatesh and Bala 2008; Venkatesh et al. 2003)
I believe it is worthwhile for me to use my smart speaker for shopping purposes
I intend to use my smart speaker for shopping purposes in the near future
I intend to use my smart speaker very often for future shopping purposes
Given that I own a smart speaker, I predict that I would use it for shopping purposes

Perceived risk (Pavlou and Gefen 2004)
There is a considerable risk involved in using my smart speaker for shopping purposes
There is a high potential for loss involved in using my smart speaker for shopping purposes
My decision to using my smart speaker for shopping purposes is/would be a risky one
There is a considerable risk involved in using my smart speaker for shopping purposes

Privacy concerns (Bansal et al. 2016)
My financial/personal information will not be abused at all once submitted through my smart speaker
My financial/personal information will not be compromised at all once submitted through my smart speaker
My extent of concern regarding the misuse of my financial/personal information submitted through my smart speaker is very low

Learnability (Authors)

Modify its behavior based on the way I use it
Improve the quality of its recommendations the more I use it
Adapt to the way I use it
Improve its understanding of me the more I use it
Remember commands from one session to another

We used the guidelines proposed by Sarstedt et al. (2016) and some updates made by Hair Jr. et al. (2017). This approach involves two main stages: measurement model assessments and structural path assessments.

To assess the measurement model, we analyzed the reliability and validity of the constructs using Cronbach's alpha, DG-rho, composite reliability, and average variance extracted (AVE) criteria. For good results, Cronbach's alpha, DG-rho, and composite reliability values have to be at least 0.7 while the AVE values have to be at least 0.5. To measure discriminant validity, we used the Fornell-Larcker criterion. For discriminant validity to be verified, the square root of each construct's AVE must be greater than its highest correlation with any other construct.

To assess the structural model, we use the R-square (R^2) value as the coefficient of determination to determine the predictive poser of the model. In marketing-related studies, R^2 values of 0.75, 0.50, or 0.25 are generally respectively described as substantial, moderate, or weak although some although consumer behavior studies on issues like customer satisfaction sometimes perceive R^2 values of 0.20 as substantial (Leguina 2015). To evaluate the path coefficients, we use bootstrapping with 5000 subsamples. For significant results, the p-values are expected to be lower than 0.05, 0.01, or 0.001.

5 Results

In Table 2, we report the Cronbach's alpha, DG-rho, composite reliability, and AVE values of our measurement model. There all meet the required thresholds thereby validating the reliability and validity of our measurement constructs. In Table 3, we report the Fornell-Larcker criterion values. The square root of each construct's AVE was greater than its highest correlation with any other construct thereby validating the discriminant validity measurements. Together, these results support the reliability and validity of our measurement constructs. To check for common method variance (CMV) we used suggestions made by Pavlou and Dimoka (2006) we ran a factor analysis to identify the variable with the highest explained variance. After adding it as a new independent variable to our measurement model, no change was observed in the variance of the dependent variable thus CMV was not a threat to this study.

As concerns the predictive capability of our model, the model has an R^2 value of 0.50. This means our model explains 50% of the variance in the actual use of smart speakers for voice shopping. In Table 4, we present the significance of the paths measured. Based on the path coefficients, all our hypotheses were verified.

6 Discussion

The objective of this paper was to determine the effect of perceived risk, privacy concerns, and smart speaker learning capabilities on the adoption of smart speakers for voice

Table 2. Construct reliability and validity measurements.

	Cronbach's alpha	rho_A	Composite reliability	AVE
Actual use	1.000	1.000	1.000	1.000
Intention to adopt	0.967	0.969	0.976	0.911
Learnability	0.912	0.921	0.934	0.739
Perceived risk	0.925	0.926	0.952	0.870
Privacy concerns	0.897	0.929	0.935	0.829

Table 3. Construct reliability and validity measurements (Fornell-Larcker criterion)

	Actual use	Intention to adopt	Learnability	Perceived Risk	Privacy concerns
Actual use	1.000				
Intention to adopt	0.707	0.955			
Learnability	0.253	0.397	0.860		
Perceived risk	−0.378	−0.376	−0.099	0.932	
Privacy concerns	0.357	0.371	0.113	−0.593	0.910

Table 4. Path coefficients and their significance.

	Original sample	Sample mean	Standard deviation	T-Statistics	P values
Intention to adopt → Actual use	0.707	0.707	0.032	22.402	0.000
Learnability → Intention to adopt	0.352	0.353	0.064	5.514	0.000
Perceived Risk → Intention to adopt	−0.223	−0.224	0.070	3.185	0.001
Privacy concerns → Intention to adopt	0.199	0.202	0.064	3.112	0.002

shopping. To this end, we used the theory of reasoned action (TRA) and the interpersonal theory of personality to propose a conceptual model that we tested using a mixed methods research design. Our results show that indeed, perceived risks, privacy concerns, and perceived learnability of smart speakers influence consumer intention to use smart speakers for voice shopping and eventually their actual use for voice shopping. Our study is in line with the extant literature and complements the qualitative studies conducted on perceived risk and privacy concerns presented in the literature review. Consumers recognize that there is a considerable risk involved in using smart speakers for voice shopping and they stand much to lose by exposing themselves to such high risks. Also, consumers have serious privacy concerns regarding their financial and personal information. Consumers were shown to be more willing to adopt smart speakers for voice shopping if they could be made to feel less concerned about their personal/financial information being abused or compromised. Regarding the learning capabilities of smart speakers, consumers will feel more confident using them for voice shopping if they observe that it can adapt to the way it is been used. This includes automatically improving its understanding of user requests and the quality of its recommendations over time.

This study was motivated by the rising adoption of AI adoption in e-commerce environments and the desire of retail companies to leverage these technologies to enhance customer experiences. High levels of digitization have led consumers to raise their expectations as high as expecting smart devices to purchase items for them quickly and automatically. Thus, omnichannel online sales are expected to make all the difference between retailers in the nearest future (Behrenbeck et al. 2015). Thus, retailers are considering strategic investments in alternative sales channels (Lawrence et al. 2019). Organizations that are early adopters of AI are poised to lead the market (Singh et al. 2019). When considering AI-based highly interactive and speedy sales channels like smart speakers, it is important to consider the privacy and risk concerns that the consumer might have to trade-off. Given that the learning capability of smart speakers could positively influence the adoption of this sales channel, designing a voice shopping service should seek a balance between learnability and perceived risk/privacy concerns. Furthermore, the learning capabilities of AI devices could make interactions with smart speakers very seamless, highly personalized, and anthropomorphized, thereby enhancing the online relationship between companies and their customers (Steinhoff et al. 2019).

Theoretically, this study contributes to the scarce body of knowledge on AI adoption in e-commerce environments, especially regarding smart speakers and voice shopping. Firstly, we propose a parsimonious model capable of explaining 50% of why consumers use smart speakers for voice shopping. Parsimonious models are highly encouraged in research as they reflect the strength of the independent variables identified (Leguina 2015). Secondly, using TRA and an interpersonal relationship perspective, we show the critical role features unique to AI devices like learning play in the adoption of AI devices. In addition to learning, AI devices are also expected to understand their users and interact with them in a more human-like manner. Thus, future research could investigate other factors unique to AI that could influence the adoption of AI devices, especially in e-commerce contexts. Thirdly, we used a mixed-methods approach to propose and validate an instrument that can be used to measure the learning capabilities of AI devices. This rigorous process shows the reliability and validity of the measurement instrument.

Nevertheless, future research should test our instrument in other AI contexts to determine its generalizability. Furthermore, our findings are limited to voice shoppers based in the US, thus the need to replicate this study in other contexts.

In practice, many businesses do not adopt AI because of poor and uncertain commercial returns, inciting the need to investigate the strategic requirements and implications for AI adoption (Kumar et al. 2019). Our research provides practitioners with three key elements that must be considered when designing market and sales strategies around smart speakers. They need to develop strategies that will mitigate the privacy concerns and risk perceptions of their customers to enable them to feel safe and secure during the voice shopping process. Furthermore, when designing the voice shopping service, they need to ensure that they use the best ML algorithms that would enable the voice shopping system to understand and adapt quickly to consumer behaviors. If the consumer perceives the system as being able to learn them quickly, it would increase their chances of using this service. It could even become a point of competitive advantage in the sense that consumers may prefer to use voice shopping services of a retailer where they perceive a higher learning capability of the system rather than from one that demonstrates lower learning capabilities.

7 Conclusions

In this study, we conceptualized the learning capabilities of smart speakers and tested its effect on the adoption of smart speakers for voice shopping alongside the effects of perceived risks and privacy concerns. This study contributes to the existing body of knowledge on AI adoption in e-commerce environments and provides key elements for practitioners to consider when integrating voice shopping into their sales and marketing strategies. We hope our findings, especially regarding the learning capabilities of AI devices, provoke several debates and incite other behavioral studies on the unique capabilities of AI devices and their impacts on AI adoption and use.

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To Err is (only) Human. Reflections on How to Move from Accuracy to Trust for Medical AI

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Abstract. In this paper, we contribute to the deconstruction of the concept of accuracy with respect to machine learning systems that are used in human decision making, and specifically in medicine. We argue that, by taking a socio-technical stance, it is necessary to move from the idea that these systems are "agents that can err", to the idea that these are just tools by which humans can interpret new cases in light of the technologically-mediated interpretation of past cases, like if they were wearing a pair of tinted glasses. In this new narrative, accuracy is a meaningless construct, while it is important that beholders can "believe in their eyes" (or spectacles), and therefore trust the tool enough to make sensible decisions.

Keywords: Accuracy · Decision support systems · Medical artificial intelligence · Machine learning

1 Introduction

Machine Learning (ML) techniques (or, broadly speaking, Artificial Intelligence - AI) are becoming more and more common in Decision Support Systems (DSSs) employed in an increasing number of business processes, especially in regard to discriminative tasks, like disease detection and classification in medicine.

To address the so called "trust chasm" [9] and hence gain impact on situated practices of decision making, DSSs are usually associated with "vanity" measures that are supposed to relate to their intrinsic and context-independent quality, and hence the extent they are trustworthy in real-world practices. This sort of quality is universally denoted as *accuracy*. Both in its narrow sense, and its broadest one, *classification accuracy* is always related to the concept of *error*: in the former case, the relation is straightforward, as accuracy is but the complement of error rate; but also all the other more popular measures, like specificity, sensitivity, precision, F-score, G-mean, C-statistic, are grounded on the so called

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"confusion matrix", and therefore to the tally of the various types of errors that have occurred in (several) executions of the classification algorithm.

This contribution stems from the recognition that accuracy, broadly meant, is a partial and imperfect quality measure. It is partial because it only regards discriminative performance, while the quality of a DSS used in real settings should also (or rather) encompass estimations of calibration quality, and fit-for-use metrics [13], like efficiency and utility (or net benefit), not to mention more socio-technical and human-related measures, like user satisfaction, fairness (in terms of error disparity across different population groups [37]) as well as social and human sustainability: in particular the former kind of sustainability regards "how organisational activities affect people's physical and mental health and well-being" [36], while the latter relates directly to human development and continuous learning as necessary components of work practices to achieve quality work results and excellence [4]. For this reason, an extremely accurate system that brought an "excess of efficiency" with itself in terms of throughput, or that led to unrealistically higher expectations by the consumer [39], or that induced forms of over-reliance on its services by its users, and subsequent automation bias and deskilling [10,23], would be a technology with very low social and human sustainability and potentially harming the company where it is operated, regardless of its accuracy.

Moreover, also these considerations apart, accuracy is an imperfect measure because it entails two ill-grounded ideas:

- accuracy on past data is equal to accuracy on unseen data. This is true only on a probabilistic perspective and if the unseen (new) data are similar to past data, that is, e.g., data are taken from similar populations and measured in similar ways (which is often not the case [30]) and, most notably, the so-called *concept drift* [40] has not occurred. Only if the data used to train the predictive model are not significantly different from the new instance that the model has to classify, the frequentist statement "the system was accurate for 90 cases out of 100" can become a probabilistic one like "the system has a probability of 90% to be accurate on this new instance". However, data similarity between new and old data, despite being important for generalization of a DSS [2], is almost never verified and the uncertainty about past performance is seldom represented (e.g., in terms of confidence intervals or average confidence scores).
- the accuracy of a DSS is the accuracy of decision making (and, related but different, this latter could not be lower than the DSS accuracy). Both these assertions could be plausible only if we considered human decision making as occurring in the vacuum, as a structured evaluation of alternative options, and if human decision makers did not rather rely on gut feeling, intuition [29], and contextual information that are hard (if not impossible) to codify or represent as data; or, the other way round, as if they did not develop forms of *automation complacency* and *automation bias* quite easily [23,34], especially if supported by allegedly "very accurate" decision aids.

To circumscribe our argumentation, we will focus on the second point (although we will also briefly touch on the first) and will take the medical decision making as reference application domain, not only for our extensive experience in this field (e.g., [8,9]), but also for the challenges that medical data and medical processes pose to those who want to build useful and trustworthy decision support systems, especially in terms of variability [11] and concept drift [26].

To put this point within the frame of socio-technical research, we can rephrase it in terms of the necessary shift between a *technical* way to assess classification accuracy to a more socio-technical one, that is one taking into account how decisions are made in naturalistic settings [28], and by whom.

2 A Framework for a Different Narrative

The traditional way to look at decision support systems embedding models that have been built with machine learning techniques, and their output, which is usually denoted as a *prediction* (even if they do not regard future events), grounds on two basic assumptions.

1. predictions regard objects that are out-there, in the real world.
2. predictions are statements that can be assimilated to judgements, that is assertions with a true/false value.

The first attitude characterizes what we can call an "externalist" view of machine learning, because it is related to external things with respect to the data (symbolic) representation of these objects. The second perspective, on the other hand, is what allows many commentators to assimilate the main functions of these system to *cognition* (i.e., recognition, understanding, interpretation, judgment and similar terms that are often associated with machine learning systems), and hence what inspires those researchers that like calling this kind of technological support *cognitive computing* [15].

To this perspective we want to counterpose a dual one: a perspective that we could call both *internalist* (as opposite to externalist) and *perceptual* (as opposite to cognitive, and on the same metaphorical level); from this twofold standpoint predictions are, on one hand, symbolic representations that do not refer to external objects but, rather, they complete an internal, and purposely left incomplete, representation. On the other, predictions are not the expression of agents endowed with any form of cognition (or with a behavior that is assimilable to cognition in its capability to state the truth), but rather the "tint" (metaphorically speaking) of a translucent medium through which humans can perceive an object. To this respect, DSSs do not assert any statement about the external world but rather facilitate human observers in seeing objects associated with a specific symbolic representation, in light of the assumptions taken to build a mathematical model that describes the representations of other (past) objects.

In this new narrative, we need to move from appraising the accuracy of decision aids to assessing their *trustworthiness* (and hence the reliability of their utterances or interpretations). The former concept regards *truth*, which in its

turn is beyond the scope of any computational system and entirely within the network of meanings that constitute (and is constructed by) a human collective and community; the latter concept, on the other hand, regards more context-dependent and situated aspects, like the users' perceptions, attitudes and preferences, and also an idea of the *integrity* and *benevolence* of the machine vendor, which are (along with competence) the main components of trust [16].

This entails some small but significant shifts: it means to move from seeing "intelligent" decision support systems as autonomous agents and *truth enunciators*, to tools that represent (instantiate) a symbolic model of a third actor, the designer (so that these tools act as *designer's deputies* [19]) and are endowed with a memex-like function [7], that is the capability to help humans recall cases, experiences, past interventions, and thus help them establish (and make) sense of new cases through an ever-new network of signs [21]. Another shift requires us to move our focus from accuracy-related metrics to other relevant dimensions that characterize the possible roles of decision support tools in human agencies, like utility, causability [25] and acceptability, which all regard the capability of these systems to contribute to the discourses that motivate action (beyond classification decisions) and provide post-hoc justification for those actions.

This also means to move from the world of objectivity (i.e., of the truth that is indisputable and manifest to anybody) into the world of inter-subjectivity [31], where prospective users of these systems are first involved to create a representative *ground truth* (often by taking true labels on a majority vote); and then their actual users are made aware of the intrinsic reliability of this reference truth, and finally involved to assess the extent they would recommend such a system to their peers (recommendability), or would keep relying on its advice to make their decisions, and be responsibly accountable about them towards any stakeholder.

Concretely, this means to attach to any DSS response a whole network of human experiences and perceptions, related to, e.g., (to keep the analysis quantitative):

- how many times decision makers (DMs) and the DSS agreed upon a case (concordance);
- how many times DMs believe the DSS is right (confidence);
- how many times the DSS is proved right after the fact (accuracy);
- how many times DMs changed their mind for the DSS' advice (performance impact);
- how many times DMs have perceived the DSS useful (usefulness);
- how many times DMs believed to have received interesting elements to factor in their decisions (utility);
- how many times they believe to have been faster in their decision making or, rather, hampered by the DSS (satisfaction);
- how many times the DSS output has facilitated or censured discussion with their colleagues or the patients (collaborative impact);
- how many times it has facilitated learning or relieved from the "burden" of recalling, analogical reasoning and deductive inference (cognitive impact).

– also, how many times users believe such a tool can have nurtured confirmation bias, defensive medicine, disciplinary bandwagon effects and other biases (like automation bias and complacency).

Technically speaking, this also means to discover how probability (or confidence) scores are calculated; how to make explicit and comprehensible the model assumptions; how to represent the uncertainty that affects both the input and the output of these systems; how to take into consideration the similarity between the case to be classified and the cases of the training set, and the similarity between the former case and all of the other cases that are considered belonging to the same class.

3 A Case from Current Events

To illustrate what we practically mean with the above concepts, we will outline a real-life case, taken from our current research activities. In [6], we presented a machine learning model that, on the basis of few hematochemical parameters extracted from routine blood examinations, is capable to determine whether the patients from whom the blood samples at hand were drawn are positive to the Sars-COV-2 virus, i.e., suffer from COVID-19. This model has also been embedded in an online service[1] that can provide the above "prediction" in few seconds once a short questionnaire has been filled in with the blood parameters (see Fig. 1).

The service is provided as-is and we made it available to the broader community of Internet users as a proof-of-concept of the feasibility of using routine blood exams for COVID-19 screening, as well as to assess its usefulness either as integration or substitution of the more complex RT-PCR[2] test: in short, we did not intend this machine-learning service to provide any medical advice, but rather we want to assess its utility, not only in those settings where there is a shortage of nasopharingeal swabs or molecular test reagents, but also in any setting where blood exams can be done fast and cheap and in a matter of minutes, instead than the many hours necessary for the molecular assays, to diagnose COVID-19.

In what follows, we will imagine that the accuracy and reliability of such a system has been validated and that hence the intended use of this system is twofold: to support the fast screening and management of COVID-19 suspects, while doctors wait for the result of any gold standard reference test (either the molecular or serologic assay, CT scans,...); and to complement the result of the reference test in case this latter one were found negative even in presence of serious COVID-like symptoms. This assumption makes our system akin to any software-as-a-medical-device, whose intended use is to support diagnosis with explicit advice given to physicians, when provided with a number of data attributes regarding the signs and symptoms of a given patient.

Thus, in this light such a system asserts:

[1] Available at https://covid19-blood-ml.herokuapp.com/.

[2] This is the acronym for Reverse transcriptase-polymerase chain reaction, a laboratory technique for the quantification of viral RNA in research and clinical settings.

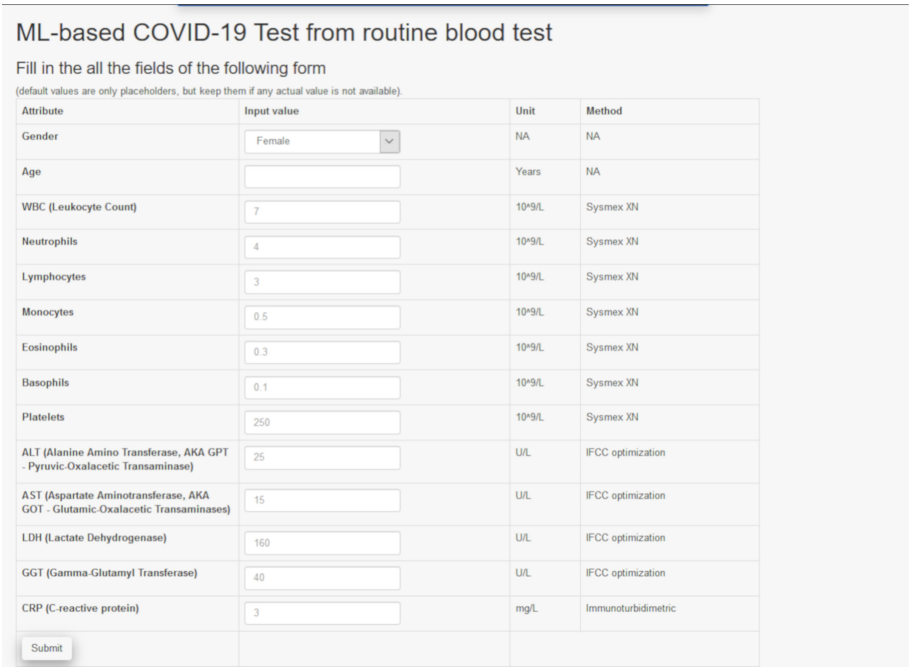

Fig. 1. A screenshot from the diagnostic online service for fast COVID-19 screening.

1. what disease the person who has those symptoms suffers from.
2. what disease an ideal person suffers from, who manifests only those symptoms and, (we assume) who has all the other physiological parameters within the normal range of values.
3. which, among the records that the system received as a training set, the record at hand resembles the most.

The output of the diagnostic software does not change across these three alternative ways to interpret it, only the expectations of the users does; and the underlining idea of the role of the software within a decision making setting: an externalist, cognitive, and potentially substitute (for the sake of efficacy and efficiency) role in the first case; a more prudent but still cognitive and externalist view in the second case; an internalist and perceptual (in the metaphorical sense above) sense the third and last one. Moreover, and more importantly for our argumentation, the first two views can be interpreted in terms of error, and hence accuracy. Conversely, the third one is more open to analogical reasoning, and to the further interpretation by the physicians involved.

In Fig. 2, we see the three ways in which the above system can (and actually does in the current version online) display the result of its computation. The first one (a in Fig. 2) only gives the predicted target label: this is a common approach in the machine learning community but also in medicine, as it is how exam results are given, to either patients or the prescribing physicians, in the

case of so-called qualitative tests. This response is the most straightforward one, as it is easy to convene, and it addresses the original inquiry that motivated the prescription and collection of the test: is this patient positive to COVID-19?

The second method (b in Fig. 2) presents the result in a tabular form: in particular, the table reports the so-called *confidence scores* (also known as probability scores); intuitively (but the next section will get into the details of this aspect), the system exposes how much confident it is (or the human decision maker can be, by taking the machine's response at face value) that the patient does not suffer from COVID-19: in particular, the model estimates that there is one possibility out of 5 that the patient should be isolated from other patients, admitted to a specific hospital ward, and put, e.g., under anti-inflammatory steroids as soon as possible.

The third method (c in Fig. 2) renders the same information above in a visual manner, and more in particular in terms of a *vague visualization* [1], that is a visualization where quantification aspects are purposely concealed from the decision makers, so that these latter ones are nudged towards a more comprehensive assessment of the case at hand. In this specific case, the horizontal position of the circle expresses the confidence (or probability, as mentioned above) so that the closer the circle to one extreme of the colored bar, the stronger the confidence; while the dimension of the circle graphically represents the confidence interval of the probability estimate so that the larger the circle, the higher the uncertainty of the estimate. Moreover, whenever the confidence is lower than a specific threshold, and the circle moves into the middle section of the bar, its color tends to blur with the color of the bar itself so that, in extreme cases, the visualization does actually hide the machine's response from view, and it acts as a *programmed inefficiency* [10] within the decision aid. The ways in which a vague visualization can be rendered are many: our system could have used transparency, instead of position and hue, so as to mimic real serological tests, where even a faint line in the test region is noted to be positive; or other metaphors could be used, like those mentioned in [1]: in any case, the reader would have had to interpret the result, instead of receiving it plain and simple in numeric or quantitative terms.

Both cases b and c in Fig. 2 deal with the concept of confidence, in either numeral or visual form. In the next section, we will see this concept in more details, and outline further alternative ways in which the same information resulting from the DSS computation can be expressed, according a more internalist and perceptual standpoint.

4 Inside the Confidence Machine

As we previously argued, the shift of emphasis from an *externalist/cognitive* perspective to an *internalist/perceptual* one may require the construction of a network of additional information, as a sort of meta information, which is aimed at clarifying and describing different (internal) aspects of the DSS: namely, how its output is to be interpreted and understood; on which grounds this output

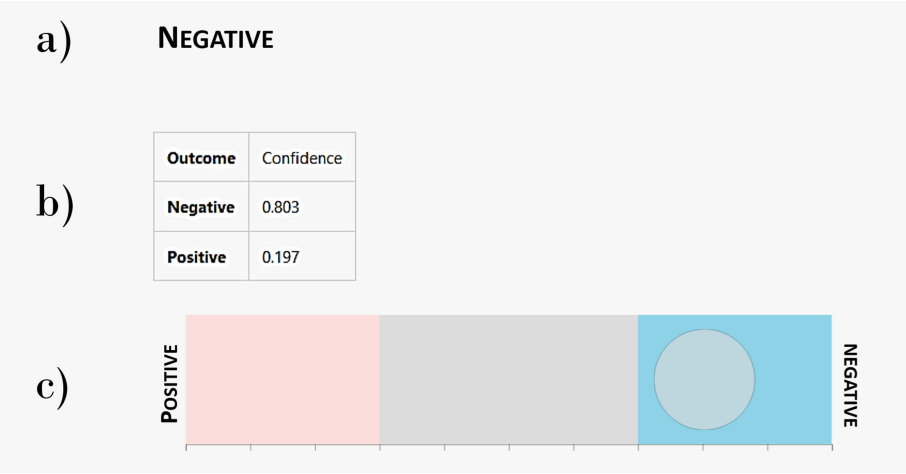

Fig. 2. Three alternative (or complementary) ways to present the output of a prediction model for COVID-19 screening: a) the target label for the case at hand; b) a pair of confidence scores; c) a visual, and purposely under-specified, rendering, or vague visualization.

is computed; how the inner workings of the DSS can be employed to provide additional informative pieces of data.

The first aspect that requires to be understood regards the concept of *confidence score*, which could intuitively be seen as a form of uncertainty representation. As we mentioned above, in the externalist perspective, the DSS is often supposed to return a single label as output (hence the emphasis on computing error): nonetheless, the actual output of DSS is usually provided as a weight vector $w \in R^{|Y|}$ that attaches to any possible label $y \in Y$ a so-called confidence score $w(y)$, whose underlying semantics is that the greater the value of $w(y)$, the more confident the model is in assigning label y to the case at hand. This weight vector is usually required to be *normalized*, that is $\sum_y w(y) = 1$: in this case, the scores $w(y)$ are called *probability scores* and are assumed to define a probability distribution over the class labels.

While, intuitively, having a quantification of the uncertainty attached to the DSS response may be seen as useful, it should be made clear that the meaning and usefulness (from a decision support perspective) that the decision maker can draw from the confidence scores may be affected by how these scores are actually computed. From a technical perspective, this heavily depends on the specific algorithmic family to which the DSS belongs to; as examples: in ensembles of Decision Trees (a class that encompasses popular algorithms such as Gradient Boosting [22] and Random Forests) the probability of a given a label, for a specific case x, is computed as the (possibly weighted) fraction $p_x(y)$ of trees associating y as response to case x; on the other hand, in regard to the Logistic Regression (and, by extension, Artificial Neural Networks) this same probability

$p_x(y)$ is computed through the application of a non-linear function (i.e. the logistic function $\sigma(t) = \frac{1}{1+e^{-t}}$) to the response of a linear model.

In order for the confidence scores to be useful as uncertainty quantification mechanisms, these should be required to satisfy some intuitively useful properties, such as *calibration* [5] (a requirement for the probability scores provided by the DSS to be well-aligned with observed likelihoods), or the ability to distinguish and properly represent *aleatoric* (uncertainty due to variability in data) vs *epistemic* (uncertainty which is only due to the nature of the adopted DSS and its training process) uncertainty [27]. Notice that not all classes of DSS satisfy these properties (or others) by default:

- As regards calibration, it is widely known that logistic regression (and, by extension, classical non-regularized neural networks) or Bayesian models (such as Gaussian Processes) are well-calibrated; the same does not holds true for most other algorithms [14] (such as tree ensembles, modern deep learning algorithm [24] or support vector machine) that typically require the application of post-processing techniques such as isotonic regression or Platt scaling [32];
- In the same way, most model classes do not provide a clear distinction between aleatoric and epistemic uncertainty sources and, more in general, this second property is seen as an open problem in the current debate within the ML community [27].

Apart from technical considerations on the confidence scores provided by a DSS, the shift towards an internalist/perceptual perspective also requires to reflect on to how the DSS could be used to provide additional information such as, as we mentioned in the previous Sections, the collection of cases which are most similar to the case at hand, in order to provide the decision maker with some form of analogical ground for the DSS predictions. To this aim, the most intuitive approach requires the definition of a *similarity function* associating each pair of cases to a number that represents their similarity with a positive real number: the above mentioned information is provided by a direct application of this function to the relevant cases. Notice, however, that this method completely ignores the structure of the DSS itself, as most common approaches to implement DSS do not directly rely on this kind of similarity functions: indeed, among the popular approaches used to implement DSSs, only k-nearest neighbors and support vector machines could be properly interpreted as similarity-based [17]. In all other cases, simply applying an external similarity function might provide results that are in contrast, and completely unrelated, both to the response provided by the DSS and to how the DSS actually uses the past experience to provide that response: in those cases, more meaningful measures of similarity (hence, means to provide the above mentioned network of information) can be obtained on the basis of a technical understanding of the model assumptions that underlie the specific DSS under consideration.

As a simple illustration, consider the cases of tree ensembles and neural network models. In the former case, the notion of similarity between two cases x, x' can be defined as the number (or proportion) $s(x, x')$ of trees assigning the same

label y to both x, x' [20]; on the other hand, in the latter case this same quantity could be meaningfully defined as the similarity between the representations of x and x' computed by the last hidden layer of the neural network [33]: in both cases the provided definition of similarity aligns well with the DSS assumptions (e.g. in a tree ensemble, if two cases are frequently classified in the same way, than we also expect the ensemble as a whole to assign them to the same label) and it provides useful summary information about the conceptual structure through which the DSS interprets its past experience.

Finally, we notice that similarity can be employed not only to describe the most similar (or dissimilar) cases for a given case at hand, but it could also be applied to evaluate the similarity of a given case with respect to the training set *as a whole*, for instance by looking at whether the average similarity of the case at hand with all the cases in the training set is compatible with the distribution of similarities *inside* the training set itself, using an approach that reminds of *nonconformity scores* [41] for hypothesis testing or multi-variate permutation tests. This information could ultimately be useful to assess whether should decision makers trust the predictions and information provided by the DSS for a specific case or, more in general, to evaluate the robustness of the DSS itself.

5 Conclusions

In the next future, DSS will be increasingly more part of the networks of agents that are mobilized to make faster, more accurate, more sensible decisions in sensitive fields like the medical one, e.g., to decide whether a patient is ill or not, will benefit from a treatment more than she will be harmed from it, or even whether she should receive a treatment or not. For this reason, we feel the urgent need to advocate a radical shift in considering the role of DSS in human decision making, especially in sensitive fields where decisions can produce "legal or similarly significant effect on individuals" (cf. art. 24 of the Regulation EU 2016/679, also known as General Data Protection Regulation, or GDPR), that is have an impact on individuals' life, health and well-being.

The shift we advocate is the one from the naive perspective that sees AI-based DSS as actors that can discern the right from the wrong, and hence be right or make mistake; to the perspective seeing these computational systems as tools by which users can "mine" (i.e., retrieve and analyze) past experience and get clues for significant correlations and associations. However, attaching significance and making sense out of these hints will be the call of humans, who are the only ones who can make mistake, according to their local, yet public, sense of right, wrong, and truth.

Thus, due to the socio-technical nature of errors (and also to mitigate the risk of technology-related risks, like over-reliance, automation bias and deskilling [12]), we argue that DSS should be considered more as *perceptual lenses* (not devoid of aberrations), that is as tools by which decision makers can inspect new objects (cases) in the light of other past ones to which a community of experts (through some of its representative members, the raters) attached

some value of contingent truth in the past (labels), rather than oracular aids that have "the capability to state the truth" [38] on those objects. A similar point has been proposed by Pasquinelli [35] through the provocative idea to see AI as a *nooscope*, that is an "instrument of knowledge" or logical magnification that "maps and perceives complex data patterns that are beyond the reach of the human mind".

According to this perspective, we propose to abandon the discourses that mention accuracy in regard to the performance of machines that we call "decision support systems" and adopt alternative narratives, like those that relate these systems to their capability to enable a more comprehensive interpretation of the cases at hand, abstaining from the production of "machinic" interpretations. In this sense, we also support a semiotic engineering stance to DSS design [18], through which the developers of these systems tell their users about interpretations of the past, which only the users of the present have the right to let inform their current case interpretation and choice of action course.

Summing things up. In this article we have argued that the concept of accuracy is closely related to that of error, intended as an objective (that is objectively established within a normative system) difference (or deviation) from the *right* answer, choice or belief. We have briefly reflected on the oft-neglected inductivist and probabilistic nature of the concept of accuracy whenever this is related to error rate; we have also shed some light on some unintended consequences that this mindset brings in, like calling the output of a DSS, which this latter associates with a new case, a "prediction". Since a prediction is, literally, a forecast, or a statement about something that still does not exist, associating this idea with DSSs would suggest that these "predictive" systems tell us something about the future, or tell us something we still ignore. Rather, we invited to see the output of these systems as what it essentially is, i.e., a *post-diction*: that is a statement *after* (and, to some extent, *about*) the past cases used to train the DSS. As a consequence of the predictive mindset, the output of ML systems are also considered new elements to be put into the discursive and generative practices of the decision makers (e.g., medical diagnosticians). Conversely, we have argued, what ML systems produce is but metadata, which computational procedures attach to data in light of both the previous records upon which the ML model has been trained, and of the implicit assumptions (what, in the technical jargon, is referred to as inductive bias [3]) underlying the ML model itself. For such an interpretative, post-hoc (post-dictive) metadata, speaking of accuracy and their relation to truth, is inappropriate.

In this new light, DSS should rather be called "medical experience miners", more than predictive models, and be appreciated not for their "divinatory" skills but rather for their capability to present the case (or cases) from the past that resemble the new case at hand more closely; as well as for their capability to allow for counterfactual reasoning on this past-present relationship, like when one asks oneself "to what extent these two cases would be more or less similar if these data were different?"; or to prune information in order to understand what

features of the case at hand contribute in suggesting a particular categorization more than others (cf. feature selection).

However, as we also argued in [9], accuracy is still considered an ontological attribute of DSSs, i.e., something that belongs to these machines regardless of the conditions in which they operate, or of contextual conditions that usually are not to be found in the data (e.g., the difficulty, complexity or rarity of a medical case) but nevertheless characterize the socio-technical setting. Failing to see accuracy as a relational attribute, which emerges from the situated interaction between the system and the user(s), still prevents these systems from fully realizing their potential as decision aids: i.e., bridging what we called the *chasm of trust* in the last mile of AI implementation [9]; and building a *trust relationship* with their users, as a necessary condition for responsible and appropriate use in real-world settings.

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An Emerging Digital Ecosystem: Blockchain Competence Certification Networks

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Abstract. In this paper, we investigate how blockchain technologies improve the certification system and generate added value for different involved actors - learners, educational institutions, and businesses. An exploratory study is proposed to systematize the overall impacts of blockchain in the field of digital certification while focusing on university education as the main research area. We carried out a desk analysis, direct observation/focus groups and semi-structured interviews with key players of the two Italian universities which had first adopted certification and blockchain-based-certification systems. The aim is to understand the drivers and value generation conditions in the new scenario introduced by the development of DACS (Digital Academic Certification System) through insight into the relationships between actors in the ecosystem that characterize the different types of complementarities between actors and services before and after the introduction of blockchain-based platforms and the personal wallet containing titles and certifications. Three main findings arose from the study related to actors, ecosystem, and complementarities. The main theoretical contributions of this study is that it produces the first empirical evidence of the new Ecosystem Theory proposed by Jacobides et al. [1]. From the managerial perspective, this study contributes to better identify and debate the conditions and success factors unlocking value generation and benefits embedded in Digital Certification Ecosystems.

Keywords: Digital ecosystems · Blockchain · Competence certification

1 Introduction

The need for specific skills and competencies evolves in response to environmental, social and organizational conditions. However, the model for certifying competence levels has remained almost unchanged for centuries: universities (and other institutions) verify and certify that a person has reached a certain level of knowledge and through a

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stand-alone solution. The output is often a signed and stamped document that undoubtedly contains limitations in the present international, multilingual, and dynamic job market. Studies on skills and competencies have often taken for granted that universities and other educational institutions would continue to act as independent certification bodies. This traditional certification routine is now under pressure. On the one hand, there are new actors (not necessarily universities or traditional educational institutions) in the education and training market. On the other, technological progress and globalization, to name just two factors, demand a radical innovation of the whole educational sector and thus introduce new competitive challenges for traditional institutions.

Universities are now at the centre of this challenging scenario where tensions exist among legacy systems, European and national regulations, learner empowerment and an increasing number of students who complete their learning programs across different institutions with different learning techniques.

Innovative forms of competence certification, enabled by digital platforms and in particular blockchain systems, are playing an increasingly relevant role. Here universities, students, and firms show diverse interconnections, value perceptions, and drivers.

Blockchain has recently been studied across a broad range of sectors – from finance to healthcare, from tourism to public administration. A main appeal of blockchain is the possibility to conclude transactions without the need for a central authority, and thus to operate along a decentralized model without increasing the risks embedded in the transaction. As synthesized by Bolici [2], its specific design – a mix of cryptography, governance model, distributed computer network and individual economic incentives – defines blockchain as an enabler for trustless transactions: every actor does not need to trust anyone else (the other part of the transaction or a central authority) to conclude her/his arrangement. The absence of intermediaries and a strong anti-tempering system makes possible a transaction system without central authority.

In this paper, as the first step of a structured research agenda, the theory of ecosystems recently proposed by Jacobides et al. [1] is adopted to make sense of value generation drivers and conditions in the scenario depicted above. We conducted a first set of interviews, and a focus group with key players from the first Italian universities starting to adopt a blockchain certification system.

On this basis, we propose an exploratory study aimed at shedding light on the ecosystem's relationships characterising the different types of complementarities between actors and services before and after the introduction of blockchain-based platforms and personal wallet (Digital Academic Certification System) embedding titles and certifications.

2 Theoretical Framework

Interorganisational systems and networks are recognized as the dominant form in the post-Fordist era [3]. This transition has already produced several effects both at the organizational level exemplified in a large number of merger & acquisitions, outsourcing, business networks, online marketplaces, and at the social level in new communication forms, the emergence of social network, the virtualization of relationships and work, and the emerging communities of practice [4].

Among these effects is the emergence of digital business ecosystems in which both social and technical factors are simultaneously taken into consideration. The term Digital Business Ecosystem (hereafter DBE) initially referred to a *"…collaborative environment made up of different entities that co-create value through information and communication technologies* [5]*"* (see also [6]).

The early notion of DBE has been gaining attention in the practitioners world for several years [7] while still requiring further theoretical development and commonly accepted definitions in the academy of sciences. The last few years have clearly registered increasing attention to ecosystems. For example, the bibliometric analysis in Suominen et al. [8] shows a citation network of over 300 selected papers on this topic and significant steps towards a systematic analysis of this concept have been accomplished. Useful reference points are studies from different perspectives of value co-creation in ecosystems [9–14].

Using a grounded theory based literature review, Senyo et al. [6] evidenced relevant gaps for future research and a specific need for theorization. Early partial answers to the need for a systematic understanding are given by de Reuver et al. [15] with a convincing comparative analysis of digital platforms and digital ecosystems, and by Gupta et al. [16] who classified different types of ecosystems (business, innovation, and digital). A recent study [1] gave an important contribution towards a theory of ecosystems by drawing a crystal clear distinction between ecosystems and entities like hierarchies, markets, alliances, networks or other forms of business aggregation: an ecosystem is typically formed by a set of actors experiencing (different degrees of) complementarities in production and consumption. The analysis of production/consumption complementarities, in this view, is the elective tool of investigation to understand and characterize an ecosystem, with particular attention paid to the enabling role of modularity.

We are embracing this perspective in the analysis of the digital competence certification ecosystem by observing how the different actors and their complementarities are orchestrating the emergence of the ecosystem itself.

3 Methodology

In this study we carried out a systematic exploration of the ongoing development process of the Digital Academic Credentials System in the field of university education. We collected data through a three-step process of desk analysis, direct observation/focus groups, and semi-structured interviews.

The desk analysis represents the initial collection of secondary data needed to frame our research work. We extensively collected and analysed the literature regarding:

1. the most common stream of studies in organization and ICT (Information and Communication Technology) and identified three main perspectives (see Sect. 2);
2. past experiences aimed at developing an innovative framework of competence certification systems, regulations, and ICT solutions with a specific focus on blockchain.

Two of the authors were involved in some of the discussions, roundtables and focus groups on the development of a distributed digital system for competence certification

in their own institutions. Thus, we were able to collect a set of direct observations on the motivations, gateways, triggers, obstacles and potentialities at different stages of the process. We recognize the potential bias of collecting data through participatory research [17, 18], but smooth them by integrating such data with semi-structured interviews with key actors.

Thus, we developed an interview protocol to facilitate and guide semi-structured open-ended interviews. We conducted a first set of interviews with the key players promoting a blockchain-certification system. The interviews focused on value creation factors and conditions for the different entities of the blockchain certification ecosystem. We recorded the interviews, all researcher listened to them for later research discussion. All the collected data were analyzed individually by each researcher, and then discussed and structured together. Significant episodes retold by the interviewer emerged and were then matched to organizational elements. In the following section, we highlight key episodes and draw attention to their organizational relevance.

4 Main and Expected Findings

The main findings evidenced by our analysis are the following.

The first finding is a reconstruction of the actions taken by the first mover in the field; a brief history in which actors playing an important role in the Italian ecosystem are described.

The second finding concerns the identification of a digital ecosystem and its changes. It describes whether and to what extent the relationships between actors may change with the introduction and the adoption of Digital Academic Credential Systems (DACSs) based on blockchain. Consistent with this model, some dynamic isomorphic tensions are described and underly how national and international institutions are introducing new norms to boost the adoption of DACS in Europe and USA.

The third finding considers the digital ecosystem complementarities and provides a more specific analysis of the relationships between actors in the ecosystem.

4.1 A Brief History

In 2016, the University of Milan-Bicocca (hereafter UniMiB) started a pilot project to develop a Digital Academic Credential system. The aim was to build an innovative model enabling universities to digitally certify learner competences, skills and participation activities. This service is based on an innovative concept which is becoming more widesparead in Europe and western countries, namely the digital academic credential system, in some cases called learner wallet or badge wallet.

Three key requirements lead the system development:

1. Self-verification: each certificate can be verified without the involvement of the issuer.
2. Incorruptibility: to ensure that the certificate is not counterfeit.
3. Autonomy: the digital certificate, once verified, remains valid even if the issuer ceases to exist.

The interoperability among all the interested universities is a key outcome of this Digital Academic Credential System (DACS) to facilitate student exchange, and ECTS recognition and authentication, especially at European level. During the interviews, one of the experts mentioned estimations of around 60 million students moving from emerging countries to advanced economies university systems in the near future. If confirmed, this trend will dramatically challenge the existing structure and organization of the university system. As a consequence, the role of digital learning is becoming more and more important, both in providing a partial solution to the high number of students as well as sustaining "stackable" degree programs between academic institutions and learning platforms. In this case, the ownership of the credentials are the learners that can combine all the certificates into one unique and verified system or wallet.

According to the process depicted in Fig. 1, the increasing effort on soft skill development recommended by several European institutions, including the European University Association, strongly triggered the project aimed at developing a Digital Academic Credential system at UniMiB. Ideally the DACS enables learners to collect certificates from various educational issuers, organizes all the certification in one unique system and enables third-party sharing of the certification and the related competences acquired.

In the following section, we will explain in more detail how the ecosystem will change with the advent and the massive adoption of the DACSs.

As depicted in Fig. 1, a few years ago UniMiB introduced a focus on soft skills development as a key issue in its 3-year strategic plan. At the same time, the CINECA consortium, a major technology partner for Italian Universities, developed a digital certification management system called Open Digital Badge Platform. As a result, collaboration with CINECA occurred and the first main outcome was the Open Digital Badge project. This represents the first stage of the process aimed at developing a Digital Academic Credential system. Since it was possible to integrate it with the existing technical platform (e.g. esse3 – the information system adopted by almost all the Italian universities that manages data on students services: courses, exams, grades, etc.), the Open Digital Badge project provided the inclusion of the "Diploma Supplement" in the formal certification process.

Other universities then started similar or parallel processes e.g. the University of Padua started to collaborate with UniMiB and was involved in the network of Italian universities: now other universities are interested in the project.

Blockcerts and BESTR are currently in use at UniMiB. The University of Trento is currently evaluating the adoption of Blockcerts and BESTR for certifying their degree titles. It should be noted that BESTR is one of the most common DACS solutions available in Italian Univeristies.

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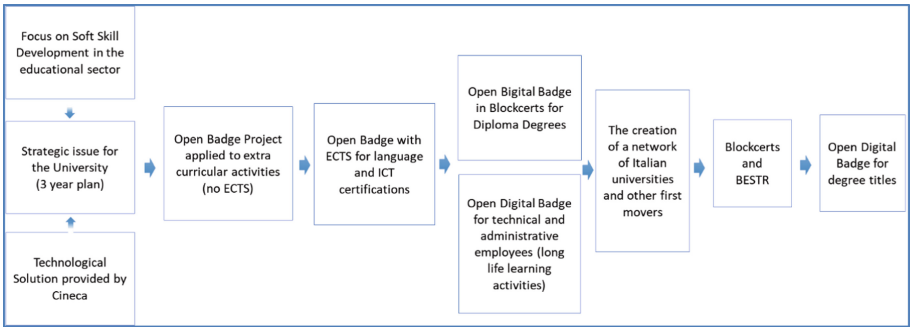


Fig. 1. The development of a Digital Academic Credential system

4.2 Various Types of Value Systems with the Diffusion of DACS

An ecosystem has been defined as "a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled" [1: 2264]. Actors are fundamental components, and our analysis is, therefore, primarily focused on the role that various actors have in the environment.

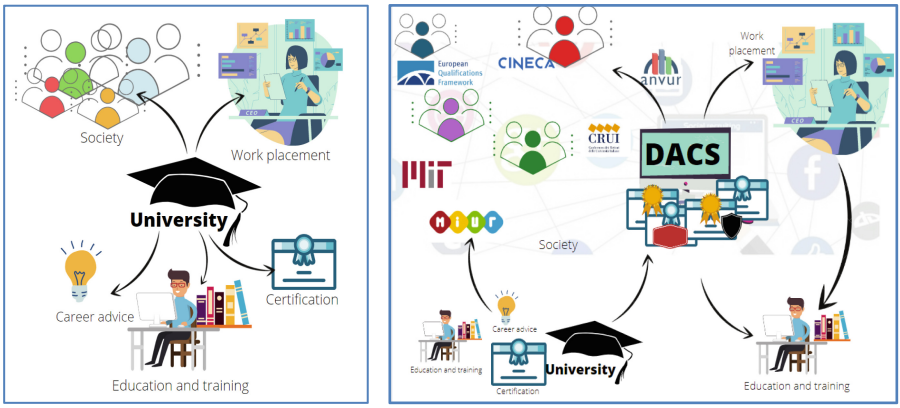
Figure 2 below compares two regimes, namely "as-is", before the emergence of the Digital Certification Ecosystem and "to-be", after the emergence of the Digital Certification Ecosystem.

In the "as-is" situation, universities have a key role in supporting career advice and selecting students, proposing education services such as bachelor, master and doctorate programs, developing training and internship services, providing diplomas and other certificates, guaranteeing the validity of these documents and the correctness in which they are obtained, etc. The quality is guaranteed by certification authorities, at both national and international levels, which evaluate universities and other equated educational bodies, and certify their educational and training programs. During a selection process, companies usually interact directly with the candidate who declares information about diplomas and other certificates she/he has obtained. In some cases, companies interact with the universities, for example when an internship is offered and/or further information is required. In northern countries in particular, companies directly contact universities to verify the certification documents provided by the candidates. With the advent and the diffusion of the Digital Academic Credential System, each candidate/student/individual can create and manage a personal wallet with her/his digital badges, certificates, and diplomas.

This new scenario, the "to-be" situation depicted in Fig. 2, gives rise to a complex ecosystem in which various actors interact as follows:

1. Universities certify degree and other competences through open digital badges. They may take advantage of blockchain and blockcert to guarantee the immutability and correctness of data.
2. Other institutions may use badges or other similar mechanisms to certify courses and other competences acquired during continuance training in the professional life of employees.

3. Individuals can manage their badges, diploma and other certificates in one unique system (their digital wallet).
4. Individuals can also share this information with third parties without contacting each issuer by just showing the badges (or few of them) in their wallet.
5. Digital wallets can be consulted directly by companies without contacting the issuers.



as-is **to-be**

Fig. 2. The educational ecosystem. Comparison of "as-is" and "to-be"

In this case, universities tend to lose their previous central role in competence certification and as a result, some resistance might occur; indeed, in the focus group, some actors expressed some lack of enthusiasm for the innovative solution and its legal consequences. Two main reasons for this resistance can be identified. First, these actors do not foresee the potential cost reduction in administrative procedures (physical system). Second, they want to retain complete control in accordance with the traditional role of the university as the sole recognized authority of certification (structure). Contrarily, an interviewee promoting Digital Academic Credentials considers the system as very valuable, and explained that a decentralized system of certification would radically change the role played by universities and other organizations in the educational market (structure).

Divergent opinions among informants emerged with regard to the lack of regulations. The interviewees have different expertise and attitudes toward technology and the foreseen certification systems. Overall, the interviews confirmed that this new scenario will generate a radical change and various actors and that consortiums are attempting to understand and influence it.

Diverse forces, dynamics and pressures will influence actors and institutions to adopt or to resist the development of the Digital Academic Certification System (DACS). In the light of the normative isomorphism view [19, 20], a constellation of various actors are investing extensive resources with the aim of introducing a new model of competence certification based on blockchain technologies. In an interview, it clearly emerged that Europass aims to assist citizens, employers, and education and training authorities

to define, certify and effectively communicate the content of curricula (according to national and international standards). MIT coordinates a group of leading universities and founded the Digital Academic Credential consortium aimed at designing an infrastructure for digital academic credentials and a set of international standards in an attempt to avoid a "lock-in" effect which could be imposed by private leading companies. In Italy, the network of the first-movers is leading the development of specific standards which the main national regulatory institutions (i.e. CRUI, ANVUR and MIUR) can be recommended as *good practice* for the Italian university system. Moreover, a further normative effect could emerge from other European universities (especially in Scandinavia) that would act as a valuable benchmark. Yet other centres engaged in the field of information and consulting services related to the procedures for the recognition of academic qualifications (such as the Italian CIMEA – Italian Information Center on Mobility and Academic Equivalences) are proposing blockchain based solutions open to:

1. the holder of the qualification creating a personal wallet;
2. the higher education institutions which can take advantage of the ecosystem in all the phases of a study path; and
3. companies that can verify the validity of titles and qualifications.

In the light of coercive isomorphism, the European Commission has put forward recommendations which underline the alignment of national certification with:

- The European Qualifications Framework, which acts as a translation device to make national qualifications more readable across Europe, promoting worker and learner mobility between countries and facilitating their lifelong learning.
- European Skills, Competences, Qualifications and Occupations (ESCO), a multilingual classification of skills, competences, qualifications and occupations.
- The electronic IDentification, Authentication and trust Services (eIDAS), the unique identifier that enables a verified, legally recognised digital signature.
- Other institutions, such as EFMD Programme Accreditation System, CIMEA, and other leading international institutions, are pushing for the introduction of an improvement in the teaching programmes. The University of Trento, for example, is involved in both programs and those employees involved in the sector consider blockchain a valid solution to support the holder of the qualification, higher education institutions, and certifying organizations.

In terms of mimetic isomorphism, universities may mimic other organizations adopting the Digital Academic Certification system. Although resistance to change can be a crucial obstacle, the successful examples of other universities, perhaps those using the same information system (esse3), makes emulating others easier.

Regarding mimetic isomorphism, it is important to state the opinion of the supervisor of one of the International Mobility offices in the University of Trento. She expressed the need for online certification, especially abroad and especially for those who have multiple nationalities, and most probably work in Europe or outside of Italy. This type of online verification of the correctness of diplomas becomes essential in an international context. In one interview, it emerged that there is a resistance to the adoption of blockchain

solutions because the flow of information is not clear, and the preservation of data, security, and privacy are not guaranteed nor tested according to traditional standards.

4.3 Production and Consumption Complementarities: Value Generation and Benefits of the Digital Certification Ecosystems

As explained in Jacobides et al. [1], ecosystems are based on the involvement of actors that:

- have significant interdependencies,
- provide complementary innovations, products, or services,
- belong to different industries and
- need not be bound by contractual arrangements.

These interconnections are enabled by modularity, which takes advantage of standardisation and networked externalities for digital platforms. Since the ecosystem is not hierarchically organized, the outcomes can be affected by the action of a coalition of power and first movers. In this case study, MIUR, CINECA, ESCO, and other technological providers are introducing processes and rules in an attempt to coordinate actors and services provided in the ecosystem.

In this case study the presence of Digital Badges and the development of a Blockchain based platform (DACS) may provide the technological modularity required to allow interdependent components of a system (universities, companies, individuals) to share the same information with limited coordination costs.

The DACS platform coordinates a two-sided market with demand (consumption) and supply (production). On the production side, issuers (e.g. the universities) provide digital badges; on the consumption side, owners, companies or third parties may take advantage of the information certified and available online. On the consumption side, various actors including EFMD, CIMEA, MIT and other partners may take advantage of these ecosystems providing new services on the DACS platform. Leading organizations can promote a broader adoption, eventually also sustained by coercive and top-down rules introduced by regulators. The interviews confirmed that a key issue related to the development of such ecosystems is the value perceived by the involved actors. Universities represent an extremely good setting to observe, calculate and unlock the value that a DACS can generate. DACS is not only crucial in terms of a competitive advantage in a task environment that places each university in an international and "stackable" market. It also provides key opportunities in terms of brand reputation by transforming into institutional value the direct and indirect endorsements. Moreover, important economic savings are introduced by the adoption of a DACS since it facilitates the digitalization and simplification of administrative processes. For an employer, a Digital Academic Credential System can dramatically reduce the amount of risk taken during recruitment processes (it is possible to verify that the certificates provided by the candidate are not counterfeit), and also increase the efficacy and efficiency of the CV screening. From a student's point of view, a DACS, where all her/his academic achievements are stored and shared in a standardized and secure manner, would clearly simplify the bureaucratic

process of retriving and sending these pieces of information every time an organization requests them.

In our specific case study, DACS platforms - such as BESTR and Badgewallet - would not exist if universities were unwilling to issue digital badges. This interdependence is fundamental to guarantee the advancement of the whole ecosystem.

The availability of digital and certified credentials enables organizations to immediately access the validated certificates/diplomas and reduce CV screening costs. On the production side, the administrative cost to manage certificates will decrease because of the automation of the certification sharing process. An added value can be provided because the certification is also verified via blockchain mechanisms.

As an interviewee declared, "[DACS] and blockchain solve the problem of intermediation, fairness, integrity, etc.". He also stated that "Blockcert wallets have become a worldwide reference (MIT and 10 other universities are using them). The idea is to start with Blockerts and boost the standard by introducing the concept of a consortium aiming to build a certification system fully controllable by the users, which can be verified digitally and securely in a distributed register".

Finally, modularity and scalability can be boosted by the fact that in the BESTR platform (the Italian platform supported by CINECA) the technology adopted is open. An interviewee stated that "[…] we consider blockcert because it is an open specification to represent certificates, it can be used on blockchain (ethereum) open and private for writing or reading … very flexible".

In Italy, the critical mass can be achieved quicker than in other countries because various services are centralised at national level. For instance, the National Register of Students (ANS) registers and monitors 1.5 million student careers; thus each student is uniquely identified and the related information can be easily created and updated in esse3.

The preliminary evidence produced so far shows that significant complementarities are arising both on the production and the consumption side. The detailed analysis of their different degrees and interconnection, according to the approach proposed in [1], is a viable and promising way to fully reveal the value generation mechanisms and drivers in the digital certification ecosystems under observation:ongoing research is committed to such developments.

5 Conclusions

This paper has analysed the introduction of the Digital Academic Credential System in the university sector.

The adopted perspective has enabled the authors to identify the most critical threads in the progress of the Digital Academic Credential system in all its phases of development (Fig. 1). In particular, three main findings related to actors, ecosystem and complementarities have arisen from the study. First (actors), we reconstructed the actions carried out by some firstmovers who are playing an important role in the Italian Digital Certification Ecosystem. Second (ecosystem), we provided insight into whether and to what extent relationships among actors may change with the introduction and the adoption

of Digital Academic Credential Systems (DACSs) based on blockchain. Third (complementarities), we identified and investigated the digital ecosystem complementarities and their link to the value generation and potential benefits embedded in the DACS.

This exploratory study provides two main contributions. From the theoretical point of view, it produces some first empirical evidence of the new Ecosystem Theory proposed by Jacobides et al. [1]. It suggests that it would be valuable to carry out a deeper analysis, in particular of the complementarities and modularities associated with the DACSs. From the managerial perspective, this study contributes to better identifying and debating the conditions and success factors to unlocking the value generation and benefits embedded in Digital Certification Ecosystems as well as aspects that should be further developed e.g. privacy, and the legal aspects connected to the ownership of the data.

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How Distributed Ledger Technology Can Influence Trust Improving Data Sharing in Collaborative Networks

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Abstract. Collaborative networked organizations (CNOs) strive to achieve a common goal. Collaboration within CNOs relies on information technology (IT) and trust. Trust appears in different forms, such as relational, contractual, and competence trust that strengthens the relationships. In addition to trust, data sharing is fundamental to CNOs, as it can improve business-to-business transactions. In this paper, we show how distributed ledger technology (DLT) can increase trust and improve data sharing. We created a decision model, using a design science research (DSR) approach, that provides a mapping between DLT-characteristics and trust antecedents in order to select appropriate DLT. We use an analytic hierarchy process (AHP) approach to establish the trust antecedent ranking within the CNO for European law enforcement (ELE), Europol and its operational partners. Our research provides an evaluated model to determine the DLT-characteristics that can increase trust and data sharing in a CNO.

Keywords: Collaborative networks · Distributed ledger · Blockchain · Trust · Law enforcement

1 Introduction

Collaborative networked organizations (CNOs) are composed of organizations that want to achieve a common goal. IT is an essential component of organizational collaborations to establish the interaction [1, 2]. A recent study shows that IT facilitated face-to-face communication is the preferred way to cope with dynamic, unexpected events in a CNO (so-called CNO-dynamism) [3]. Van den Heuvel et al. [3] also found that trust plays a vital role in coping with CNO-dynamism.

Trust can be divided into various categories, such as competence, relational and contractual trust [4]. These forms of trust all have their own definitions and influencing antecedents. It would be beneficial to see how we could use IT to increase trust within

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collaborations, and not only use IT to facilitate face-to-face communication, but also to facilitate information exchange.

Blockchain is an emergent technology and can act as a distributed ledger that can establish the role of a trusted third party (TTP) in transactions between organizations [5–7]. Some researchers state that DLT has the potential to be used as a cross-organizational communication platform, or operating system, for inter-organizational communication (or collaboration) [7, 8]. As described by Pedersen et al. [5] this technology still has its limitations, for instance, with regards to scalability, capacity, latency, and privacy. Despite this, there are situations where this technology aids the transaction by providing immutability, transparency, and a single-source-of-truth [5, 9, 10].

There is abundant practitioner literature on the implementations of DLT and scientific literature on the information technology (IT) side of DLT. Research on the business implementation of DLT that is supported by empirical evidence is limited [11, 12].

We anticipate that DLT could provide CNOs with the capability not only to communicate, but also to increase data sharing and trust, and be more resilient to CNO-dynamism. Our research question is:

> ***RQ**: How does distributed ledger technology influence trust, resulting in improved data sharing within a CNO?*

We evaluated the model in an international law enforcement CNO, Europol and its operational partners, via 15 semi-structured interviews. Our results can help practitioners determine which characteristics a DLT should provide to influence specific forms of trust and set up an environment that supports trust creation. Researchers can use our results to construct new business/IT alignment models and identify requirements to research the influence of DLT on trust or even what characteristics a new DLT should have in specific conditions.

Section 2 describes the theoretical background. Section 3 describes the methodology of the research project, Sect. 4 describes the decision model. Section 5 outlines the refinement of our model as typically used in a design science approach. We conclude this paper with a discussion (Sect. 6) and a conclusion (Sect. 7).

2 Theoretical Background

2.1 Networked Organizational Context

Collaboration between organizations is a common way to set up new products or services and is becoming increasingly important in our interconnected world. CNOs comprise of multiple organizations and aim to achieve a common goal, which they could not achieve individually [13]. Two main forms are distinguished: long term strategic alliances, such as business ecosystems and virtual organization breeding environments (VBE), and goal-oriented networks, such as virtual organizations (VO) and extended enterprises [14].

Current literature shows that trust is essential for collaboration in these CNOs [3, 15, 16]. Creating trust between participating organizations in a CNO takes time. Therefore,

VBEs are commonly referred to as being able to facilitate ecosystems due to their long-term partnerships and improving the preparedness to reconfigure for new collaborations. IT is an important component within CNOs for collaboration. IT components used within a CNO are, for example, collaboration platforms, conference facilities, and forums [3].

2.2 Trust and Data Sharing

Castaldo, Premazzi, and Zerbini [17], Yang [18] show that trust is a complex, multi-faceted concept. Many dimensions of trust can be considered, for example, cognitive trust versus affective trust [19], trust between people compared to trust between organizations [20], trust between people at different levels in an organization [21], or the evolution of trust over time [22]. Castaldo et al. [17] have developed an 'architectural structure' that consists of five building pieces to structure the antecedents of trust: The different ways in which the 'conceptual nature' of trust can be perceived by; 'Subjects' (trustor and trustee), via fundamental trust antecedents, that can be influenced, expressed, and experienced by; 'Future actions' that Trustors and the trustees' experience and conduct, aligned with their trust and trustworthiness, respectively, leading to; 'Positive results' or consequences experienced by the trustor, influenced by and dependent of; The trustor's willingness to be vulnerable in a 'Risky situation,' because, "Trust is only bestowed where there is an uncertain or risky situation" [17].

The 'architectural structure' shows that trust antecedents, as part of the building pieces 'Subjects', should be influenced in order to observe 'positive results' from 'future actions' in a 'risky situation.' In our research, the CNO is considered to be the 'risky situation' where improvement should be achieved as the 'positive results' from the 'future actions' communication and data sharing.

Communication and data sharing for mutual benefit is important in business-to-business transactions [23] and is fundamental in CNOs [14]. The willingness of parties to share their data is determined by several factors, the level of trust they have in each other being a foundational one [20]. These factors are especially true in a law enforcement community [24]. An essential factor for the law enforcement community to be effective is the sharing of data, within the constraints of applicable (inter)national legal frameworks. Data sharing is defined as the transfer of data and/or information owned and held by one party to another party in order to be used by the second party, in compliance with pre-agreed rules.

2.3 Distributed Ledger Technology

The cryptocurrency Bitcoin [25] and the term blockchain seem to be inseparable but are in fact two separate things. Blockchain is a method of storing data in blocks that are linked via hash pointers [26], and bitcoin is an application of the technology for use as a digital currency. The term blockchain is often overused to depict multiple related technologies or components, such as distribution mechanisms, smart contracts, ledgers, and oracles. In the current literature, researchers are moving away from using the term 'blockchain' and are referring to distributed ledger technology (DLT).

An essential aspect of DLT is distribution, where not only the data but also the transactions are distributed, and the outcome of the transactions are compared within

the network of participants. When the participants achieve consensus on the outcome, the value is collectively committed [10, 12, 27]. Trust is a central topic in DLT research where it relates to the possibility of removing a human TTP in a transaction [10] or removing the need for a TTP by increasing transparency [5, 8, 9].

DLT is facilitating new decentralized organizational structures [28, 29] and it is not hard to envision a relationship between the CNO literature and these concepts. A move away from the use of IT only facilitating communication [3] to an 'operating system' that can be used for inter-organizational operations could be a valuable endeavor.

3 Research Methodology

We used the DSR cycle [30–32] for our methodology. Based on Van den Heuvel et al. [3], we identified a need to design an artifact to select technology suitable for improving trust and data sharing in CNOs (relevance cycle). Within the design cycle, we identified DLT a promising technology. We executed a SLR (rigor cycle) to gather a more in-depth understanding of DLT-characteristics. The output of the SLR was used to create a decision model that maps trust antecedents to DLT-characteristics. The model was evaluated by executing an AHP (formative evaluation [33]) to rank trust antecedents, thereby refining and evaluating the model by interviews (summative evaluation [33]). Our DSR approach aligns with Rossi et al. [11] to analyze the interactions between the DLT protocol and application level.

3.1 Systematic Literature Review (SLR)

The components for our SLR (based on [34]) were acquired from our research question and were: DLT, data sharing, collaborative network organizations, and trust. We used forward and backward searching on found literature. The literature had to be peer-reviewed and in the English language. Searches were executed on Academic Search Elite, Business Source Premier, E-Journals, LISTA, PsyncINFO, Psychology and Behavioral Sciences Collection, PsycARTICLES and AISeL. By reviewing the abstract, the literature was classified as relevant or not. In total 30 articles were selected from the SLR.

3.2 Decision Model Creation

We grouped the found DLT-characteristics into categories based on their functionality and construction. The trust categories and antecedents are based on the paper of Cheikhrouhou et al. [4], which is a solid basis for our research. Trust antecedents were then used to create the requirements to rationalize if the DLT-characteristics could fulfil the requirement. We logged the rationale (in terms of the initial hypothesis) behind the mappings in the decision model. The model was evaluated by two experts who were closely involved and have expertise in the areas of DLT, trust, and CNOs.

3.3 Artifact Evaluation

We evaluated the artifact by applying it to a European law enforcement (ELE) CNO, consisting of Member States, Third Parties and Europol Units. The mission and vision of Europol [35] describe a clear intention of collaboration between multiple parties, thereby fitting the CNO definition, acting as an information hub in the network. The CNO described in [4] is a vertical CNO (a CNO that includes parties with different functions in a value chain) and suggests that the exercise should be executed in a horizontal CNO (a CNO that includes parties with highly similar functions) to validate the results. ELE fits the definition of a horizontal CNO.

There were 15 participants from the ELE context. 7 member states (Croatia, Finland, Germany, Ireland, Malta, the Netherlands, Romania), 3 Third Parties (Iceland, Norway, Serbia) and 5 EUROPOL units (European Cybercrime Unit, Financial Crime Unit, Information Hub, Internet Referral Unit, Serious and Organized Crime Unit).

We selected participants according to their knowledge and involvement in data sharing and their ability to reliably represent their stakeholders' position from Member States, Third Parties, and Europol Units perspective. We provided the participants with an information package explaining our research and an interview guide to equalize their initial knowledge of DLT.

Participants work in two modes, being day-to-day operations and a taskforce. Day-to-day operation (VBE) is the sharing of data continuously between partners and where a taskforce (VO) is a dedicated group focusing on a specific investigation.

The involvement of the participants was two-fold: (1) obtain the priorities of trust antecedents for the two modes of collaboration; (2) validate the need for improvement of data sharing, the role of trust in decision-making on sharing and the usefulness of technology in this context. The first objective is achieved by an AHP exercise, the second by semi-structured interviews.

The rating exercise is based on the AHP method presented by Saaty [36]. An AHP is a multi-criteria decision method that rates factors "through pairwise comparisons and relies on the judgments of experts to derive priority scales" [36], thereby creating an ordered list of all trust antecedents for our CNO context. The list can then be used to focus on the essential characteristics within the model. The rating exercise was executed for two modes of collaboration: day-to-day operations (strategic partnership, VBE) and taskforce (goal-oriented, VO) and the three types of participants (Member States, Third Parties and Europol Units). The values were combined to provide an overview of the whole CNO and per collaboration mode. We used the consistency ratio and group consensus to validate the rating and determine the consistency. Participants used a tool provided by the researchers to execute the rating exercise.

The model was evaluated by semi-structured interviews. We presented three perspectives for evaluating the artifact: (1) validating the need and potential of data sharing improvement; (2) the role of trust in decision-making on data sharing; and (3) the possible usefulness of new technology to affect trust in the context of data sharing. Interviews were conducted during six weeks at the ELE offices. Two test interviews were executed to validate the questions. The interview length was planned to last approx. 60 min. All interviews were recorded, transcribed, and anonymized. All transcripts were validated by the resp. participant. The interviews were conducted in 2019.

4 Decision Model

4.1 Trust Categories and Antecedents

In order to affect the behavior of a trustor and/or a trustee, one or more of the determining antecedents of trust must be influenced. The work by Cheikhrouhou et al. [4] builds on Msanjila and Afsarmanesh [37] and offers a rich set of 22 trust antecedents organized into five categories that focus on a CNO. The trust categories and antecedents can be found in the horizontal dimension of Table 2.

Cheikhrouhou et al. [4] identified 'information sharing' as a trust antecedent in contractual trust, but not in the other trust categories. We wanted to see if DLT characteristics could result in improved information sharing in general. Therefore, we did not add 'information sharing' as an antecedent, which would have resulted in cyclical reasoning (improving sharing by sharing). Still, we do agree with Cheikhrouhou et al. [4] that "information sharing" is a valid trust antecedent in the category of contractual trust.

4.2 DLT-Characteristics

The SLR led to the identification of functional and constructional DLT-characteristics arranged in three categories (Table 1). The architecture category addresses the embedding of DLT into an IT landscape. The membership configuration category addresses the way in which members can participate in a distributed ledger, and data management category contains characteristics related to data processing. The names of the characteristics are implementation independent.

Table 1. DLT-characteristics.

Characteristics	Construction characteristics
Architecture	
A1: Embedding in existing ICT landscape	A1.1: Extendable, configurable solutions [38]
A2: Connectivity to non-DLT environment	A2.1: Oracle [6, 29]
A3: Processing reliability	A3.1: Distributed nodes communicating peer-to-peer [6, 25, 29, 39]
A4: Autonomous behavior	A4.1: Smart Contract/Decentralized Applications [6, 29, 39], A4.2: Integrable runtime environment types [39], A4.3: Language type [29, 39], A4.4: Code verifiability [39]
Membership configuration	
M1: Participation incentive	M1.1: Tokens (coins) [29]
M2: Identity transparency	M2.1: Authentication (2-key) [29, 39]

(*continued*)

Table 1. (*continued*)

Characteristics	Construction characteristics
M3: Identity management	M3.1: Key management [39]
Data management	
D1: Transaction integrity	D1.1: Advanced signatures [39]
D2: Data access privileges	D2.1: Various levels of restrictions to access & processing [6, 29, 39, 40]
D3: Ledger Integrity	D3.1: Cryptographic hashing of data, Chaining mechanism (blocks in chain), Hash pointers [6, 29, 39, 40]
D4: Data configuration	D4.1: Number of distributed ledgers [39]
D5: Ledger ownership	D5.1: Owner type [6, 29, 39]
D6: Data persistence	D6.1: Storage mechanism [39], D6.2: Multiple transactions per block [6, 29, 39]
D7: Data reliability	D7.1: Distributed data [6, 29, 39, 40]
D8: Data validity	D8.1: Consen-sus pro-tocol type - Byzan-tine valida-tion / D8.2:Consesus protocol type - Non-Byz-an-tine [6, 29, 39]

4.3 Interrelations Between Trust and DLT: Towards a Decision Model

The decision model is stated in Table 2 and the code explanations are below the table.

Table 2. DLT-trust decision model

DLT	Trust categories																	
	C1	C2	C3	R1	R2	R3	R4	R5	T1	T2	T3	T4	T5	N1	N3	I1	I2	I4
	Competence			Relational					Contractual					Neg		Indirect		
A1.1										X							X	
A2.1	X		X				X			X	X	X	X		–		X	
A3.1	X	X	X		X		X		X					–	–			
A4.1		X	X	X	X		X		X	X	X	X	X	–		X	X	
A4.2			X															
A4.3			X				X			X							X	
A4.4			X	X	X		X				X	X	X	–		X	X	
M1.1					X													

(*continued*)

Table 2. (*continued*)

DLT	Trust categories																	
	C1	C2	C3	R1	R2	R3	R4	R5	T1	T2	T3	T4	T5	N1	N3	I1	I2	I4
	Competence			Relational					Contractual					Neg		Indirect		
A1.1										X							X	
M2.1							X		X		X	X						
M3.1			X								X	X						
D1.1			X	X			X		X			X		–				
D2.1			X	X			X				X	X					X	X
D3.1	X		X			X					X		X			X		
D4.1	X					X				X	X	X					X	X
D5.1					X	X			X		X			–	–			
D6.1		X	X				X			X	X	X	X	–	–		X	
D6.2		X	X														X	
D7.1	X	X	X		X									–	–		X	
D8.1	X		X												–			
D8.2	X		X	X	X	X			X		X		X	–	–	X	X	

We formulated requirements based on trust antecedents that should be satisfied by a DLT-characteristic. A DLT-characteristic is expected to have a positive effect on a trust antecedent if it proves/demonstrates to be a way to realize that antecedent, improves the way the antecedent can be experienced, or enables the realization or improvement of an antecedent. Each DLT-characteristic is assessed against these requirements. An example of these assessed interrelations: The architectural characteristic of a DLT variant that offers the functionality to connect to a non-DLT environment using the construct of an oracle, enables systems/components according to agreed conditions because it allows for automated and controlled connections to provide data for the service.

When a positive effect is expected the relation is indicated by an 'X' and a negative effect is indicated by a '-.' The vertical axis shows the characteristics as mentioned in Table 1. The trust categories are identified as competence: C1 Quality; C2 Timeliness/Punctuality; C3: Reliability; relational: R1: Shared value; R2: Commitment to the relationship/relational investment; R3: Benevolent/supportive/relational flexibility; R4: Predictable behavior; R5: Friendliness/politeness; contractual: T1: Spirit of cooperation; T2: Customization/adaptation; T3: Transparency; T4: Confidentiality/Permeability; T5: Honesty; negative: N1: Dependence/asymmetric relation; N2: Opportunistic behavior; N3: Own specific asset; indirect: I1: Reputation; I2: Work standards; I3: Financial stability; I4: Qualification of employees; I5: Duration of partnership, where N2, I3, I5 were omitted because there was no mapping to the DLT characteristics.

5 Model Refinement and Evaluation

5.1 Refinement: Results of the AHP in a Horizontal CNO

The participants belong to different organizations in the CNO and therefore have different perspectives, namely: Member State, Third Party, and Europol Units. Table 3 shows the results of the AHP exercise.

Table 3. Sets of prioritized trust categories.

	Overall	Daily	Taskforce	Overall	Daily	Taskforce
Category	**Combined**			**Member States**		
Competence trust	**(1) 34.3%**	**(1) 34.9%**	**(1) 33.6%**	**(1) 28.5%**	**(1) 28.8%**	(2) 28.1%
Relational trust	(2) 23.7%	(2) 23.0%	(2) 24.4%	(2) 27.2%	(2) 26.2%	**(1) 28.2%**
Contractual trust	(3) 19.6%	(3) 18.7%	(3) 20.6%	(3) 23.0%	(3) 23.2%	(3) 22.9%
Negative trust	(4) 12.7%	(4) 12.9%	(4) 12.3%	(5) 9.6%	(5) 9.3%	(4) 10.9%
Indirect trust	(5) 9.7%	(5) 10.5%	(5) 9.0%	(4) 11.7%	(4) 12.5%	(5) 9.8%
Category	**Third Parties**			**Europol Units**		
Competence trust	(2) 26.4%	(2) 27.5%	(2a) 25.0%	**(1) 45.3%**	**(1) 45.6%**	**(1) 44.9%**
Relational trust	(4) 16.8%	(4) 16.9%	(3) 16.6%	(2) 22.2%	(2) 21.0%	(2) 23.4%
Contractual trust	(3) 20.8%	(3) 17.3%	(2b) 25.0%	(3) 13.9%	(3) 13.2%	(3) 14.6%
Negative trust	**(1) 28.3%**	**(1) 30.3%**	**(1) 26.0%**	(4) 10.3%	(4) 11.0%	(4) 9.7%
Indirect trust	(5) 7.7%	(5) 8.1%	(4) 7.3%	(5) 8.3%	(5) 9.1%	(5) 7.5%

The AHP exercise is used to refine the model to the specific horizontal CNO, operating modes, and participation styles.

The AHP shows different results in day-to-day mode, where parties share various pieces of data that require non-urgent action, and taskforce mode where a selected group of experts collaborate dedicatedly and full time (24/7) on a specific high priority case, often in the same location. Both the participants' perspectives and operation modes were grouped to provide a general overview. A tool was used to provide the trust antecedents to the participants, and in the tool the antecedents could be ranked against each other. The separate results were then combined and analyzed.

From the combined results, we can conclude that competence trust is the most crucial trust factor (34.4%), followed by relational (23.7%) and contractual trust (19.6%). These results concur with the results of Cheikhrouhou et al. [4]. Some differences are visible when looking at the different modes and groups. For day-to-day operations, the same trust categories are the most important for Member States and Europol Units. Third Parties show a deviation and rate negative trust higher (30.3%). Comparing day-to-day and taskforce modes, we see differences in Member States and Third Parties. Where Member States rate relational trust higher (28.2%) in a taskforce context, Third Parties

rate contractual trust higher (25.0%). Even so, the overall score does correspond with previous results by Cheikhrouhou et al. [4].

Another viewpoint in our AHP is the insight in the rating of trust antecedents. We can see that overall quality and reliability are ranked highest with 13.3% and 16.1% respectively, while for Third Parties the highest antecedent was dependence/asymmetric relation with 19.6%. In taskforce mode, Member States ranked quality, shared values, and reliability highest with 13%, 11.9%, and 10.3% respectively.

Table 4. Consistency and consensus ratios on trust factors.

	Combined		Member States		Third Parties		Europol Units	
Overall								
Consistency	1.7%	Strong	2.2%	Strong	7.6%	Strong	2.5%	Strong
Group consensus	64.4%	Low	85.3%	Very High	60.6%	Low	62.7%	Low
Day-to-day								
Consistency	1.6%	Strong	2.9%	Strong	6.4%	Strong	2.9%	OK
Group consensus	65.2%	Moderate	86.3%	Very High	59.0%	Low	65.0%	Moderate
Taskforce								
Consistency	2.0%	Strong	2.0%	Strong	9.9%	Strong	3.0%	Strong
Group consensus	64.1%	Low	84.7%	High	63.2%	Moderate	61.1%	Low

A consistency ratio lower than 10% indicates a strong consistency [41] of the answers per set of pairwise comparisons. Our overall consistency for combined (1.7%), Member States (2.2%), Third Parties (7,6%), and Europol Units (2.5%) is substantial. Looking more closely, the three groups shows that the Member States and Europol Units have been more consistent in their ranking within the group than third parties (Table 4).

In general, and for both modes of collaboration, the consensus between all the various participants and the consensus per group is low, except for the Member States, whose consensus is high.

5.2 Evaluation: Interviews in an ELE CNO

A total of fifty participants were invited to participate. Fifteen participants were able to take an active role in the interview; seven Member States; three Third Parties; five Europol Units. All were able to answer from their current experiences and professional positions.

Participants jointly confirmed that trust is an important component of collaboration in a CNO and also provided multiple opportunities and needs for improvement in their current way of working and IT systems (for secure messaging and large-volume data

sharing). Multiple participants used the quote "no trust, no sharing." Nevertheless, it also became clear that trust in itself is not the only issue that affects data sharing. Many practical issues were mentioned and, specifically, the need for easy-to-use tools: "Technology is too cumbersome." There are also formal obstacles in the differences between national legislation, formal data sharing agreements and their collective interpretation, and operational decision-making and procedures. Furthermore, the always present time pressure to close more cases leads to data sharing only when a clear reciprocal value is expected for the immediate case at hand: "with the workload … they just don't have the time to do it."

The most crucial recurring issue for the owner is the uncertainty whether the data will be handled in such a way that their interests will not be jeopardized, i.e., progress of an ongoing investigation or the safety of an informant. The only viable way by which this obstacle could be overcome is to have a face-to-face meeting to reach the appropriate level of trust, "I know this guy on the other side of the telephone, because we had a few meetings prior to our data exchange and I really have the impression that he is trustworthy guy, and therefore I share the data". Another sharing topic is that one of the parties should start sharing first, thus providing small portions of data to see if one gets valuable data back from the other party. A DLT could facilitate the creation of this interaction by using a smart contract and by interacting with an oracle such that data is only released when the other party also provides data. Implementing identity management and data management would not only provide transparency of the data itself but also guides proper usage, prevents abuse, and in essence, improves the sharing of that data. These DLT-characteristics could reinforce trust when it has been established.

The participants jointly confirmed that competence and relational trust are the most essential trust categories, "Because you would like to trust your recipient that he handles the data with care. …The point is to take into consideration and to make sure that you don't spoil somebody else's work." For Third Parties, negative trust is an important category, mainly due to their asymmetric relationship compared with other CNO members; as it was stated, "Different levels of membership create limitations." The participants jointly confirmed that modern technology could be useful to overcome many if not all barriers, but "it needs to be well explained how it works" to all stakeholders "in layman's terms to those who are not digi-natives." In essence, trust needs to be bestowed upon the technology. All participants stressed the importance of creating trust, initially, between persons rather than between organizations. Importance of personal trust underlines that antecedents for contractual trust are ranked as less critical.

The interview results clearly showed that there is a sound opportunity to address the trust necessary for data sharing by developing an easy-to-use, yet trusted and legally compliant, infrastructure for the law enforcement CNO, using modern technology.

6 Discussion, Limitations, and Future Research

DLT looks like a promising development to facilitate inter-organization communication as needed within a CNO [5, 7, 8]. The DLT-characteristics can be partially mapped on the CNO characteristics of Van den Heuvel et al. [16] for example, the CNO-capabilities "high amount of trust", "IT as an essential capability" and "non-hierarchical determined

control function", and thus DLT could be used to create a system for inter-organizational collaboration (an 'operating system' for collaboration) where trust is an important aspect. Our research confirms the need for trust to start data sharing in CNOs.

Due to this being a relatively new research field, dominated by technology research, implementing this technology within an IT landscape from a governance or management perspective is not yet part of the current body-of-knowledge. The interest in DLT research from a technology perspective results in a variety in DLT implementations. These DLT implementations have their own characteristics and goals and it is, therefore, necessary to choose the specific implementation based on a match between features in the DLT and requirements for the implementation itself. We think that determining the most suitable set of DLT-characteristics, matching the business needs, could help inter-organizational communication and could facilitate the complex problem of inter-organizational alignment and collaboration.

As shown in the AHP results, we concur with Cheikhrouhou et al. [4] that competence, relational, and contractual trust are the main trust factors in a horizontal CNO. Our results provided more profound insights into divisions and different styles of collaboration. The day-to-day operation could be seen as a VBE environment, whereas the taskforce mode is a VO. It seems that this difference in participation style influences the ranking of the trust factors and thus trust antecedents resulting in different needs. The DLT choice can therefore differ, or must be able to adapt to these differences. When looking at trust antecedents, we see that overall quality and reliability (competence trust) are the highest rated components. DLT can facilitate quality and reliability and facilitate data sharing between participants. While we initially foresaw the risk of cyclic reasoning as mentioned in Sect. 4.1, we discovered that well-controlled and initially limited data sharing was sometimes used as a mechanism to test if further sharing would be possible, thereby demonstrating the validity of Cheikhrouhou et al. [4] inclusion of this factor, albeit that the factor is too generic within our research.

Our model could act as a starting point for improving trust, resulting in data sharing and mutual benefits. Trust keeps being an important topic when discussing collaboration [3, 4, 16], and trust forms can be stimulated by implementing IT systems. DLT could well be a suitable solution, and our model provides a first step in influencing trust by using this technology in collaborative environments. From a practitioner perspective, our research helps to select the DLT where a specific goal needs to be achieved. If the goal of the implementation is to improve trust between parties, our model could help select a DLT that interacts with specific trust components.

Within our research, we combined DLT and CNO because we think the characteristics of these two concepts are complementary. It could be argued that any technology could be researched within a CNO context to facilitate collaboration and to cope with CNO-dynamism, however, we decided to use DLT as it seems promising for the complex collaborative context and inter-organizational communication due to its reliability emerging from its distributed nature, immutability, and transparency. We do not claim that DLT is the only solution, but it appears to be interesting to research.

We see multiple possibilities for future research. First, the mapping in our decision model between trust categories, antecedents, and DLT-characteristics is made based on requirements and evaluated by two experts. A more in-depth validation could be

executed based on empirical evidence. We do think that this method is sufficient for this paper, but additional experiments need to take place. Second, our research took place in only one CNO out of the vast number of possible configurations of CNOs, and other configurations need to be researched to strengthen the model. Even so, the resulting trust antecedents and linked DLT-characteristics provide new insights into options for trust-building in CNOs using novel technology to address CNO-dynamism. Finally, DLT research is focusing on the IT aspects, like storage, integrity, and ownership, but the usage of DLT within the IS research field is not yet part of current research. We, therefore, recommend that IS scholars should embrace this maturing technology stack as an opportunity to create operating systems for inter-organizational communication.

7 Conclusion

We researched how we could improve collaboration, specifically data sharing, between organizations by influencing trust via DLT. Our research confirmed that trust is essential for data sharing between collaborating organizations. Competence, relational, and contractual trust are the most essential trust factors within CNOs, and DLT can influence trust if the right characteristics are selected based on the type of relationship between participants and how they work together (VBE/VO). Therefore, our model provides guidance on selecting the right DLT (characteristics) to improve trust and data sharing.

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Individual Culture, Language and Values

Cultural Proximity and Firm Innovation: The Moderator Role of Digital Technologies

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Abstract. The paper explores the concept of cultural proximity and its effects on firm innovation, paying specific attention to the moderator role played by digital technologies. In order to improve the innovative performance, firms should construct and maintain relationships with the members of other organizations and should develop and take care of the relationship between the members inside the firm. Previous studies show that innovation is easily reached through the joint efforts of different actors, such as competitors and suppliers, and customers. Cultural proximity refers to cultural compatibility, identity, and shared creativity norms of organization members or between different firms. Similar firms can communicate, transfer, and acquire knowledge more effectively and efficiently. In this paper, we explore the relationship between cultural proximity and innovation. Moreover, we investigate the moderator role of digital technologies on the relationship between cultural proximity and firm innovation. The development of digital technologies allowed firms to implement a remote production control and to promote innovative forms of work organization such as smart working. After the digital revolution, people started to adopt different tools to communicate, cooperate, and be connected with. The virtual face-to-face interactions facilitates economic activities; digital technologies enable the development of shared values stimulating collaborations and interactions between people located in different places. The relationships between people belonging to different cultures (i.e., with low cultural proximity) are facilitated by employing digital tools. Developing testable propositions, we contribute to the debate about the importance of cultural proximity and the development of digital-based interactions on innovative activities.

Keywords: Cultural proximity · Digital technologies · Innovation

1 Introduction

Firm innovation is crucial for firms' growth and survival because it enhances the ability to face competition, reduces production costs, and creates dynamic capabilities [1, 2]. Resources, competencies, and knowledge are factors at the base of innovation [3, 4]. However, knowledge resources, knowledge workers, and the relationship among them are the most important firms' factors and directly impact their innovative potential. Those

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factors are followed by equipment, capital, materials, and labor [5]. Hence, firms should carefully consider and protect knowledge resources and workers and their relationship, also managing their development and improvement. In the last years, scholars have increasingly paid great attention to the firms' ability to identify, capture, create, share or accumulate knowledge [6–8]. However, effectiveness in knowledge transfer and creation is highly dependent on how well knowledge is shared between individuals, teams, and units [9, 10]. In fact, because of the extensive distribution of knowledge and research revolutions, it is almost impossible for a single firm to own all the capabilities, resources, and knowledge required for improve innovative performance. Thus, firms should construct and maintain the relationship with inter- and intra-firms' members because they possess complementary resources, knowledge, and capabilities that the firm needs to enhance its innovation process [11–14].

However, firm members' cultural proximity can impact on the way they share knowledge and manage their relationship. Cultural proximity refers to sharing tacit background and ideology and manifests itself through the adoption of similar ways of thinking, behaving, and deciding, increasing intracultural exchanges of opinion [15, 16]. We identify three mechanisms through which cultural proximity positively impact on firm innovation: cultural compatibility, identity, and shared creativity norms. Moreover, we investigate the moderator role of digital technologies on the above relationship. Digital technologies involve the use of analytics, big data, cloud, social media, mobile platforms, and intelligent solutions that have reshaped business models creating new innovative ways to manage business operations [17–19]. Digital technologies have changed and transformed firms principally because they allow implementing a remote production control and favor the smart working solutions making sometimes the physical presence of the worker superfluous. Thus, digital technologies facilitate individual communication offering new ways to communicate, cooperate, and share knowledge and information with inter- and intra-firms' members and create new spaces where information is distributed and made available to each member.

Developing testable propositions, we contribute to the debate about the importance of cultural proximity and the development of digital-based interactions on innovative activities.

The remainder of the paper is organized as follows. Firstly, we review existing work on cultural dimensions and social axioms. Secondly, we develop some proposals linking cultural proximity, digital technologies, and firm innovation. Finally, we conclude with some implications and recommendations for future research.

2 Methodology

Being a theoretical paper, we have conducted a deep literature review before stated some propositions. Published studies were identified through research on electronic databases (i.e., Google Scholar and Scopus) accessible through the authors' university library system. All results were limited to English and Italian peer reviewed journal articles. The searches for published studies were conducted systematically, following some inclusion and exclusion criteria. Therefore, papers included in the review are studies published in a peer reviewed journal, written in English or Italian language, and using as keywords the

words "cultural proximity," "digital technologies," and "innovation." No restriction was placed on year of publication or on the type of study - i.e., we consider both empirical studies than essays, literature reviews, and editorials.

3 Theoretical Background and Propositions

3.1 Cultural Dimensions and Social Axioms

Culture refers to the individual's set of attitudes, values, and beliefs that are shaped from the socio-economic historical relationships of a group of people [20]. Parsons and Shils [21] underline the importance of norms and symbols in group's culture because they guide individual behavior. In general, culture enables distinguishing the members of one human group from another because each group possesses common characteristics that influence its way to behave in response to the environment [22].

Hofstede [22], analyzing the averages of individuals' responses within each Nation, is the first who identify five features (i.e., dimensions) that are common to each member of one Nation. The considered dimensions are *Individualism versus Collectivism, Power Distance, Uncertainty Avoidance, Masculinity versus Femininity*, and *Long Term versus Short Term Orientation*, which we will briefly review. *Individualism versus Collectivism* is related to the integration of individuals into primary groups. Individualism refers to a "social framework in which people are supposed to take care of themselves and of their immediate families only," while collectivism refers to a "social framework in which people are integrated into strong, cohesive in-groups, often extended families (with uncles, aunts and grandparents) that continue protecting them in exchange for unquestioning loyalty, and oppose others in-groups" [23]. *Power Distance* refers to how people react to the problem of human inequality, exploring the extent to which people accept the unequal power distribution in institutions and organizations [22]. *Uncertainty Avoidance* shows the stress level of people in the face of an unknown future (i.e., uncertain and ambiguous situations). Cultures with high levels of uncertainty avoidance try to minimize the possibility of unpredictable situations through strict behavioral codes, laws and rules, disapproval of deviant opinions, and a belief in absolute Truth [22]. *Masculinity versus Femininity* underlines the division of emotional roles between women and men; in particular, masculinity refers to societies characterized by assertiveness and importance of money and material things instead of taking care of others and improving the quality of life, typical of feminine cultures [22]. *Long Term versus Short Term Orientation* shows the propensity of people to focus on the future or the present and past. Long-term orientation refers to future-oriented values such as persistence and thrift, while short-term orientation refers to past- and present-oriented values such as respect for tradition and the fulfillment of social obligations [24]. Hofstede, Hofstede and Minkov [25] add a sixth dimension to the basic model called *Indulgence versus Restraint*, related to the gratification versus control of basic human desires related to enjoying life. Indulgent societies allow relatively free gratification of basic and natural human desires leading to enjoying life and having fun, while restrained societies suppress gratification and regulate it by means of strict social norms.

However, Hofstede's contributions have some limitations. First, studying culture by analyzing only national differences is simplistic because a nation may be composed

of different cultural areas and minorities [26, 27]. Furthermore, Hofstede's approach is static, while cultural experiences change thought the time [28]. Although Hofstede's dimensions encounter some limitations, they are, even today, the more used to better explain the difference in country-level studies. Sometimes, they are freely adapted for individual-level studies, even if there are other measures that better represent the phenomenon. For instance, the social axioms are dimensions considering the individual level of analysis and after they are aggregated for factors within each cultural group.

Social axioms are general beliefs and refer to generalized expectancies about individual behavior in daily living. In particular, "social axioms are generalized beliefs about oneself, the social and physical environment, or the spiritual world, and are in the form of an assertion about the relationship between two entities or concepts." [29]. Hence, the social axiom concept intends to offer a cognitive interpretation of the way individuals relate each other and with the environment as well as to examine the relevance of beliefs in different social contexts [29–31]. The dimensions of social axioms are five: social cynicism, reward for application, social complexity, fate control, and religiosity [30]. *Social cynicism* depicts a negative view of human nature, mainly because it is characterized by power corruption, has prejudiced against some groups of people and social institutions, and acts unethically to achieve a goal. *Social complexity* refers to the absence of rigid rules and the existence of multiple ways to achieve an outcome, underlining the inconsistency in human behavior. *Reward for application* represents a general belief that commitment, knowledge, and planning help in achieve the outcomes. *Religiosity* asserts the existence of supernatural forces and the beneficial functions of a religious belief. Finally, *fate control* represents a belief that life events are predetermined, and that people can in some way influence these outcomes. According to Leung and colleagues [29], these dimensions serve to enhance value-expressiveness (i.e., presenting individual values), knowledge (i.e., helping people understand the world), instrumentality (i.e., facilitating attainment of important goals), and ego-defensiveness (i.e., protecting self-worth). In sum, they are useful to predict different types of behavior within a particular culture or across cultures [32].

3.2 Cultural Proximity and Innovation

Cultural proximity, also known as cognitive proximity or similarity, refers to sharing tacit background and ideology. It results in the adoption of similar ways of thinking, behaving, and deciding, increasing intracultural exchanges of opinion [15, 16]. In particular, cultural proximity includes both the idea of economic actors sharing the same institutional rules of the game, as well as a set of cultural habits and values such as language, shared habits, a law system securing ownership, and intellectual property rights [33, 34].

Previous studies analyze the importance of cultural proximity in the field of knowledge and innovation [34–38]. According to Wuyts, Colombo, Dutta and Nooteboom [37], this type of proximity is associated with the similarity that unites the actors in term of perception, interpretation, understanding, and evaluation of the world. Culture, values, norms, routines, visions, and goals determine the way all the firm's members approach and know the environment [39].

In the sociology field, cultural diversity (i.e., low cultural proximity) is considered an advantage. In this conceptualization, heterogeneity is represented as a reflection of the cultural sharing available to individuals [40]. Different cultures enable organizations to improve the flow of idea and increase creativity and innovation [41, 42]. However, the other side of the coin underlines that incompatibilities and differences between inter-firms' and intra-firms' members negatively impact on tasks coordination and the ability to achieve goals [43, 44]. High level of cognitive proximity among individuals increases the likelihood of collaborations by reducing the cognitive distance between those in search of mutual benefits [45]. From this perspective, organizations require a common frame of reference to transfer and acquire knowledge effectively and efficiently in order to improve firm innovation [46].

Sharing a common view about how to act enables firms to diminish misunderstandings in communication and improve knowledge sharing between inter- and intra-firms' members. According to Krause, Handfield and Tyler [47], sharing goals and objectives allows firms to understand what innovation is and how to carry it out, leading to an improvement of the innovative performance. On the contrary, when goals and cultures are not in line, misunderstandings and conflicts between parties arise, causing restrict information exchanges and hence affecting negatively the outcome for the firms [39, 47].

To explore the role of cultural proximity in enabling firm innovation, we identified three mechanisms through which cultural proximity works: (i) cultural compatibility; (ii) identity; and (iii) shared creativity norms.

Cultural compatibility refers to the congruence in organizational cultures among inter- and intra-firms' members and influences the extent to which members can accomplish a synergistic potential [48, 49]. Cultural compatibility represents the congruence in organizational philosophies, goals, and values [50]. We claim that it facilitates knowledge sharing and the development of a common language among inter- and intra-firms' members. In fact, when firms have similar referral structures, knowledge can be communicated, transferred and acquired more effectively and efficiently [51]. Based on this reasoning, we introduce the following proposition:

Proposition 1a: High levels of cultural compatibility among inter- and intra-firms' members impact the knowledge sharing activity, influencing positively firm innovation.

Identity refers to the individual recognition of feeling part of more than one social group (e.g., family, company) [52–54]. Identity has a positive effect on performance by increasing trust towards other members and the willingness to share knowledge and information supporting learning and innovation [55]. Because of high levels of cultural proximity and the common language that is used, information is transmitted efficiently [34, 56]. Also, high levels of identity facilitate tacit knowledge acquisition, since agents involved act in a very similar way [35]. Hence, we propose:

Proposition 1b: High levels of identity among inter- and intra-firms' members impact the knowledge sharing activity, influencing positively firm innovation.

Shared creativity norms refer to expectations, interpretations, and meaning systems capturing shared language and codes among firms [57]. Resulting from the organizations behavior (i.e., beliefs and practices), these norms create cultural compatibility among

actors and govern knowledge sharing [58]. Shared creativity norms promote the establishment of cultural compatibility among inter- and intra-firms' members, inform and shape cooperation, and lay the foundations for future and continue interactions. According to Kambil, Eselius and Monteiro [59], firms who develop shared creativity norms can accelerate members' entrepreneurial abilities to stimulate higher knowledge sharing. Hence, high levels of shared creativity norms enable actors that are involved in the same network promoting a mutual agreement and facilitating the exchange of ideas and resources [60].Therefore, we expect that shared creativity norms will positively affect knowledge sharing among inter- and intra-firms' members, thus we propose:

Proposition 1c: High levels of shared creativity norms among inter- and intra-firms' members impact the knowledge sharing activity, influencing positively firm innovation.

3.3 The Role of Digital Technologies

Recent technological innovations in digital technologies have brought to new industries paradigms creating the so-called "intelligent factory" or "industry 4.0" [61, 62]. Analytics, big data, cloud, social media, mobile platforms and intelligent solutions are digital technologies that drive innovations reshaping business models and reinvesting the way organizations are running business operations [17–19]. Digital technologies have changed and transformed firms [63]; implementing big data, analytics, cloud, mobile, and social media platforms into the day to day management, a process of digital transformation takes place [64]. According to Libert, Beck and Wind [64], firms can use digital technologies for two reasons. Firstly, to implement a digital upgrade, that is, using digital technologies to increase efficiency and effectiveness in a firm's business processes. Lastly, to have a total digital transformation, that is, using digital technologies firms can implement a radical change to the over-all business operations, value creation, and in some case, new digital product offers.

Practically, the use of digital technologies influences in different ways the firms' dynamics. Previous studies show that the use of new digital technologies impact on firm innovation, transforming the nature of uncertainty and encouraging a radical rethink of how individuals, organizations, and collectives may pursue creative endeavors [65–67]. Digital technologies affect firms' operations, engaging customers easily thanks to digital innovations emerging [68]. Finally, digital technologies have caused the fall of the space-time limits of work introducing the flexibility of the smart factory and allowing the reorganization of work. These changes enable remote production control and, in some cases, make the worker physical presence superfluous, by encouraging new ways of work organization such as smart working. Nevertheless, digital technologies facilitate individual communication offering new ways to communicate - for instance, with no barriers of language - cooperate, and share knowledge and information with inter- and intra-firms' members. Finally, collaborative technologies create new spaces where information is easily available to each member and it is characterized by wide access (i.e., the possibility to access everywhere), a large scale (i.e., a large amount of information and its elaboration), and a cognition distribution (i.e., the information is distributed across actors, space and time) [69, 70].

In this paper, we propose that digital technologies recover a moderator role in the relationship between cultural proximity and firm innovation. In particular, digital technologies make the relationship between high cultural proximity and firm innovation even more positive. Moreover, they facilitate and turn into positive the relationship between low cultural proximity and firm innovation. We will state our propositions following the previous schema and considering the three implicit mechanisms of cultural proximity (i.e., cultural compatibility, identity, and shared creativity norms).

As we said, cultural compatibility refers to the congruence in organizational cultures among inter- and intra-firms' members and influences the extent to which members can accomplish a synergistic potential. Digital technologies are essential to ensure high levels of interaction, connection, and sharing between different actors. They enable network externalities to achieve greater supply chain visibility, knowledge transfer, and operational efficiency [19, 71]. Digital technologies can be used to support and increase interactions, growing the flow of new ideas generation, and facilitating communication and information dissemination, along with the creation and sharing of knowledge between inter- and intra-firms' members [69].

Based on this reasoning, we introduce the following proposition:

Proposition 2a: Digital technologies positively moderate the relationship between cultural compatibility and firm innovation. Inter- and intra-firms' members' levels of cultural proximity increase through digital technologies use, and this improves firm innovation.

Regarding the identity, that is, the individual recognition of feeling part of a group, digital technologies impact particularly into the relationship between low culture proximity and firm innovation, turning it into positive. According to Treinen and Miller-Frost [72], low cultural proximity does not allow to form a sense of camaraderie between the members, and this problem is exacerbated by language and diversity [73] impacting on firm innovation. Digital technologies can affect the communication between low cultural proximity groups simplifying it. In particular, digital technologies avoid the common issues that those groups can encounter in face-to-face communication, including the use of difficult words and length in speeches, and the difficulties caused by language differences. On the other side, the loss of face-to-face communications can bring to a loss of trust between inter- and intra-firms' members [72, 74]. However, the inclusion of face-to-face kickoff meetings, frequent face-to-face meetings between team leaders, and training for cultural awareness can minimize the trust trap and underline only the benefits of the digital technologies use.

Thus, we propose:

Proposition 2b: Digital technologies positively moderate the relationship between identity and firm innovation. Inter- and intra-firms' members' levels of cultural proximity increase through digital technologies use, and this improves firm innovation.

Finally, regarding shared creativity norms (i.e., the expectations, interpretations, and meaning systems capturing by shared language), digital technologies can favor the adaptation of different tools to communicate, cooperate, and be connected with various actors, suppliers, and customers. These technologies include the internet of things and services, ubiquitous information, visual computing, intelligent robotics, product lifecycle management, cyber-physical systems, cloud computing, and others [62, 75]. However, in the

relationship between inter- and intra-firms' members, e-mail, video conferencing, and virtual communities are the commonly used tools. For example, in the design process, the use of virtual technologies is both easier and cheaper, because it potentially reduces transaction and coordination costs [76, 77]. Moreover, digital technologies improve communication reducing inefficiencies, accelerating the communication process, and spurring an interactive, iterative, network-based process that pushes the creation of innovation and knowledge [78]. Hence, we propose:

Proposition 2c: Digital technologies positively moderate the relationship between shared creativity norms and firm innovation. Inter- and intra-firms' members' levels of cultural proximity increase through digital technologies use, and this improves firm innovation.

In Fig. 1 we report a graphical representation of our analytical model, reporting the proposition here developed.

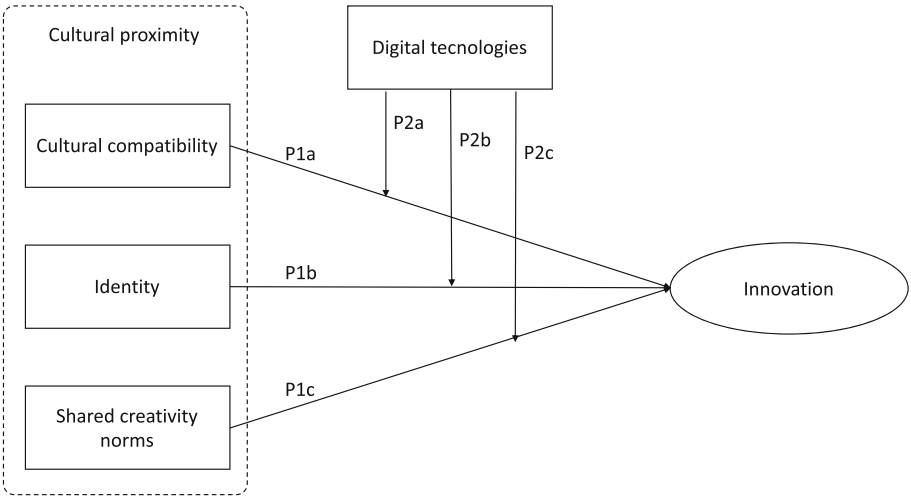

Fig. 1. Analytical model with proposition

4 Discussion and Conclusions

The aim of the paper is to shed light on the relation between cultural proximity and firm innovation, paying specific attention to the moderator role of digital technologies. We propose that high cultural proximity, through the effect of the three mechanisms we have underlined (i.e., cultural compatibility, identity, and shared creativity norms) has a positive impact of firm innovation. Moreover, we discuss the role of digital technologies as a moderator in the above relationship, making them more positive.

Theoretically, we contribute to the debate about the importance of cultural proximity on innovative activities proposing that firms should rethink the real effects that heterogeneous behaviors - those that people with low cultural proximity have - have

on performance among inter- and intra-firms' members [79]. In the investigation of the notion of cultural proximity and cultural diversity a variety of theoretical approaches such as social capital, social identity theory, cultural values, and social axioms have been employed. In this vein, cognitive proximity at the firm level can contribute to explaining the uneven access to valuable knowledge and innovation.

Furthermore, we contribute to the debate about the role of digital technologies on innovation. We explored the role of digital technologies, virtual and face-to-face contacts, and their impact on innovation. Our reasoning suggest that digital tools cannot replace face-to-face interaction when developing innovative projects. In fact, while digital tools can help to overcome distance barriers and enhance productivity, cultural diversity has been found to be a critical factor that deserves special attention and needs to be addressed sensitively, otherwise relationship breakdown would jeopardize the success of the project. Therefore, knowledge and understanding of other cultures, motivation to interact with other cultures, and communication behavior that adapts to different cultures proved to be key abilities to improve performance in teams distributed throughout the world [80–82]. However, under specific circumstances, digitalization and interconnection between distant countries and places has allowed the flourishing of communities that meet, interact, exchange ideas, build products, and start political movements, thus creating a shared culture that exists only in the virtual space. Although ephemeral, these communities play an increasing role in boosting innovation, generating knowledge, and contributing to the design and management of online activities [83–86].

Therefore, cognitions or knowledge about different cultures, motivation to interact with other cultures, and a communicative behavior that adapts to different cultures has proven to be a key ability for the improvement of performance in globally distributed teams [80–82].

This research is subject to some limitations that can represent further avenues for future studies. Despite this, we believe our work could be a starting point that highlights the importance of digital technologies in everyday life and dynamics. However, further work is needed to test these propositions. Future research will involve the testing of our propositions through case studies or quantitative methods.

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Crowdfunding as Entrepreneurial Investment: The Role of Local Knowledge Spillover

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Abstract. This paper explores the role of local knowledge spillover and human capital as a driver of crowdfunding investment. The role of territory has already been studied in terms of campaign success, but the impact of territory on the use of financial sources like equity crowdfunding is not yet known. Using a sample of 435 equity crowdfunding campaigns in 20 Italian regions during a 4-year period (from 2016 to 2019), this paper evaluates the impact of human capital flow on the adoption of crowdfunding campaigns. Our results show that inbound knowledge in the region, measured in terms of ability to attract national and international students, has a significant effect on the adoption of crowdfunding campaigns in the region itself.

Keywords: Crowdfunding · Entrepreneurship · Knowledge spillover · Entrepreneurial finance

1 Introduction

Crowdfunding as a method of entrepreneurial financing is growing very quickly following the high development of internet tools in the financial market [1]. Entrepreneurs are using Internet platforms to appeal to the "crowd" by listing and describing their investment or cause. This way, they can reach a large audience where each individual provides a portion of the requested amount to fund their start-up using crowdfunding as an alternative to a traditional form of new ventures' financing, i.e., venture capital financing [2].

Crowdfunding platforms have become diverse and specialized, increasingly targeting differentiated segments which cover several different forms such as donation-based crowdfunding, rewards-based crowdfunding, debt-based crowdfunding, and equity-based crowdfunding. Our focus is on equity-based crowdfunding which represents the main form of crowdfunding campaigns in terms of capital and financing. Based on the definition of Ahlers [3, p. 955]: "Equity crowdfunding is a form of financing in which entrepreneurs make an open call to sell a specified amount of equity or bond-like shares in a company on the Internet, hoping to attract a large group of investors", we evaluate the influence of local knowledge on entrepreneurial investment that has completely modified the original relationship between territory and new ventures.

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Until a few years ago, the relationship between local banks and start-ups was very steady because a large part of entrepreneurs preferred to borrow money from their local banks [4]. A stream of the literature shows that geographical distance matters to small business lending, although technology weakens the dependence of small businesses on local lenders [5, 6].

Therefore, when entrepreneurs have to incur higher transaction costs to borrow from local lenders, they may search for alternative sources of financing such as crowdfunding [7]. We already know that crowdfunding serves as a viable alternative to traditional sources and, in terms of local development, that a large part of crowdfunding activities are present in regions that have more concentrated credit markets [8]. Furthermore, it is important to evaluate the relationship between crowdfunding campaigns and the region to explain which characteristics in terms of knowledge and human capital promote the use of innovative financial instruments such as crowdfunding.

The relationship between crowdfunding campaigns and start-up location has been studied in recent years [9, 10]. We know that the territoriality of a campaign influences its success because local investors invest relatively early, and they appear less responsive to the decisions of other investors [10], but we are not well aware of what encourages the development of a crowdfunding campaign in certain regions and what leads an entrepreneur to use creative finance tools in these regions rather than turning to the financial market.

There are only a few studies that have tried to explain this relationship. For example, Sorenson et al. 2016 [11] states that crowdfunding appears to be relatively stronger in regions with less venture capital funding, compared to traditional hubs such as Silicon Valley and Boston. Our paper helps fill this gap by evaluating knowledge spillover in Italian regions to answer these overarching research questions: "*Do the characteristics of the geographical area in terms of knowledge attraction affect the adoption of crowdfunding*?" and "*Are regions with high foreign student flows more likely to adopt alternative financing sources such as crowdfunding campaigns*?".

To test our conjectures, we considered the most widely used Italian equity crowdfunding platforms, namely Mamacrowd and CrowdfundMe. This study was conducted using the ordinary least squares method (OLS) to verify the research framework and hypotheses. We have analyzed 20 Italian regions for 4 years (from 2016 to 2019). Hypothesis testing was conducted using a panel data regression analysis model that aims to predict the extent of the strength of knowledge spillover effects on the use of uncommon financial sources such as equity crowdfunding.

Our results show that inbound knowledge measured in terms of student mobility from other regions has a significant effect on the use of crowdfunding campaigns in the region itself. Moreover, we evaluated the impact of transnational students in the region. Our results show that both variables, inbound students from other regions and other countries, have an impact on the regional development in terms of access to the crowdfunding market. Regions with a higher number of students from other regions and foreign students are more likely to use creative finance tools, such as crowdfunding, than regions with fewer incoming student flows.

By exploring this relationship, we believe that our study is capable of offering new interesting theoretical insights to the nascent literature on entrepreneurial finance. In

addition, our findings have several implications for regional development and innovation policies. Regions with a large part of inbound knowledge flow are more likely to support the innovation process and the use of alternative financial sources, such as crowdfunding [12], which elements contribute to the development of the crowdfunding campaign in a certain area.

2 Theory and Hypothesis

The global crisis began in 2008 and drastically reduced bank borrowing [13] and venture capital investments [14], thus prompting entrepreneurs to seek alternative sources of finance for their start-ups. This has fueled the rise of equity crowdfunding, a crowdfunding model in which entrepreneurs make an open call to sell equity shares of their start-ups to the crowd of Internet users [3].

Following the definition of Belleflamme [7], crowdfunding "involves an open call, mostly through the Internet, for the provision of financial resources either in the form of donation or in exchange for the future product or some form of reward to support initiatives for specific purposes" (2014, p. 588). From this definition we understand that the "structural" factor is represented by the technological innovation of Web 2.0, which has allowed internet users to generate online content and share it with other users, de facto making crowdfunding viable [15, 16].

Research examining entrepreneurial fundraising efforts, including crowdfunding, has frequently drawn on different theoretical lens to understand investment transactions between investors and entrepreneurs [17–19].

In the last decade, equity crowdfunding has become an established source of funding for entrepreneurial firms [20], giving individual investors the opportunity to buy shares of unlisted companies online. As a result, the crowdfunding market has grown fast in recent years. To date, there are approximately 2000 crowdfunding websites, and the World Bank expects that crowdfunding could account for over $300bn in cumulative transactions by 2025 [21].

The entrepreneurial finance literature has highlighted different characteristics related to the crowdfunding campaign that can be resumed in 3 main categories: campaign characteristics, networks, and understandability of the company's concept and offering [22]. In the related literature, several studies try to understand the role of team composition [23, 24], entrepreneurial skills [25] and trait [26], but very few studies focus on the development of this phenomenon in terms of region and the role of knowledge acquisition in the region itself.

2.1 Knowledge Spillover, Human Capital, and Regional Development

The concept of human capital was fully developed in the 1960s with the emergence of human capital theory formalized by Schultz [27] and Becker [28, 29]. Human capital represents the combined intelligence, skills, experience, education, and expertise of organizational employees [30]. It constitutes a high-value corporate asset and is accepted as a prime factor in the intellectual capital framework. Following Goldin at. al 2016 [31] defining human capital as "the stock of habits, knowledge, social and personality

attributes (including creativity) embodied in the ability to perform labor so as to produce economic value", we posit that human capital represents an important economic driver on regional development, and we understand that the role of knowledge and intellectual capital plays a key role in this relationship. Following the previous literature, we assume that a "higher" human capital is associated with higher capabilities and skills concerning various aspects of the entrepreneurial opportunity, such as defining and implementing a venture's strategy [22], identifying and exploiting business opportunities [32, 33], acquiring additional financial resources [34, 35].

The literature on urban systems [36] considers these knowledge processes to be primarily an interregional macro-phenomenon, in which the geographical mobility of physical capital in terms of firms [37] and human capital in terms of labor [38, 39], determines the revealed patterns of economic geography. The literature on agglomeration and clustering puts the accent on a large number of interactions between agents within a spatially constrained environment [40]. These interactions affect local development in terms of knowledge exchange [41], industrial clusters [42], R&D investments [43], and innovation [44].

To understand the role played by human capital in economic development, it is important to build on the new growth theories. One of the most important theories was proposed by Romer [45–47] who first formally examined the role of knowledge in growth from the perception of the public good aspect of knowledge spillovers, and this type of approach has been a starting point in the agglomeration literature. Moreover, the role played by knowledge externalities connected with human capital has also been supported by Lucas [48] who emphasizes the role of human capital accumulation related to technological change, schooling, and through learning-by-doing.

To connect human capital and regional development, an important role has been played by the university. There is an extensive literature examining the role of universities in relation to economic growth [49, 50]. As already noted, universities play a key role as producers of creative and high human capital that is embodied in their graduates and staff and that has an impact on regional economic growth [12, 51, 52]. Besides, several research studies have also argued that universities can be a contributor to growth as a source of knowledge spillovers [39, 53, 54]. Universities are assumed to be important sources of localized knowledge spillovers due to their explicit focus on knowledge generation and dissemination.

The impact of knowledge spillover on regional development and the crucial role of the university in this phenomenon has gained a great level of importance in recent years.

It is crucial to study cross-regional student mobility in terms of university enrollment of national and international students since the human capital of new generations is one of the most important areas for exploration and development in advanced economies. King & Ruiz-Gelices [55] pointed out that worldwide student migration is an increasingly important phenomenon that requires attention from both policy and research perspectives. In addition to that, Dustmann & Glitz [56] stated that education and migration are so closely linked that it is almost impossible to separate them from each other. This linkage represents an important growth prospect in terms of knowledge and regional innovation.

Besides, the university plays a very important role in the development policies of a region, in the ability to innovate and attract "higher" human capital, and contributes to the evaluation of economic policies supporting entrepreneurship [57].

Regarding the connection between local context and innovation, most of the literature is based on patents and R&D as indicators of innovation. For example, Jaffe et al. 2000 [58] analyzed the geographic location of patent citations in order to show that knowledge spillovers are geographically localized. Moreover, Maurseth and Verspagen [59] conducted similar research for knowledge spillovers across European regions and came to the same conclusion. By tracking patent citations, these studies focused on the exchange of explicit knowledge. As for R&D, Harabi [60] investigated the effectiveness of different channels of R&D spillovers at the intra-industry level. The study observed R&D activities, reverse engineering, publications, technical meetings, interpersonal communication, and patent disclosures as possible channels for knowledge spillovers. The aforementioned study suggests that a firm's investment in R&D is the most important channel for spillovers. In addition, Florida and Kenney [61, 62] used venture capital data to document the geographic patterns of high-tech entrepreneurship and the social structures of innovation set by a venture capitalist supporting such geographically organized social structures of innovation.

We assume that the relationship between knowledge spillover, human capital, and local context is associated with regional development and the innovation process of the region itself. Furthermore, "higher" human capital from other countries is usually attracted to innovative areas to which it can contribute and from which it can learn, effectively participating in a virtuous cycle where a strong innovation system attracts skills, which make it stronger and, in turn, more attractive to human capital [63]. As a result, this relationship affects regional entrepreneurial investment and access to new financial tools such as crowdfunding.

Human capital has a great impact on the investor's decision and is one of the first aspects investors pay attention to before funding a company, as it is a key factor in determining a firm's success [64, 65]. We also know that the influence exerted by human capital is greater for young businesses compared to old ones [66, 67]. Human capital is a multifaceted concept, largely related to the capabilities and skills of the entrepreneurial team, leading to the success of new ventures, and their investors being remunerated for the uncertainty related to their prospects [3], but it is also interesting to assess the impact of territory and knowledge contamination on the access to financial tools such as crowdfunding.

2.2 Equity Crowdfunding and Regional Entrepreneurial Investment

In recent years, crowdfunding as a method of entrepreneurial financing has grown very rapidly. Recently, entrepreneurs have been using Internet platforms to appeal to the "crowd"; by listing and describing their investment or cause, entrepreneurs can reach a large audience where each individual provides a portion of the requested amount to fund their start-up using crowdfunding as an alternative to traditional venture capital financing [2]. Crowdfunding platforms have become diverse and specialized, and they increasingly target differentiated segments covering diverse forms. Donation-based crowdfunding is used to collect charitable funding in support of causes and projects. In rewards-based

crowdfunding, funders receive non-monetary rewards in exchange for their contribution. Debt-based crowdfunding offers a credit contract, while equity-based crowdfunding offers an equity stake in the target company. Our focus is on equity-based crowdfunding. Following Ahlers' [3, p. 955] previous definition we notice that the use of these financial tools has completely changed the original relationship between territory and start-up.

The role played by crowdfunding finance represents an alternative (or a complement) to more traditional funding sources such as debt finance and makes it possible to skip the common relationship between territory and entrepreneur. Although distant investors are common for publicly traded companies, theory predicts that investors in early-stage entrepreneurial ventures will tend to be local. That is because gathering information, monitoring progress, and providing input are particularly important to investors in early-stage ventures, and the costs of these activities are sensitive to distance, which encourages the entrepreneur to access financial tools such as crowdfunding. Most of the empirical evidence to date supports these claims [68–71]. But it is also interesting to note that in recent years this relationship has change as a result of the innovation process and the use of the Internet. This paper explores the role of knowledge spillover and human capital in the region as a driver of equity crowdfunding investment. The role of the territory has already been studied in terms of campaign success and access to the financial market, but the impact of the territory on the use of and access to financial sources such as equity crowdfunding is not yet known.

In general, capital access can be associated with the ability of the business to obtain an advantage from credit or loan offered by financial intermediaries [13]. Adequate access to external capital needs to be combined with elements internal to the business organization itself. As reminded by Green, Covin, and Slevin [72], entrepreneurial orientation may be a significant element in representing the architecture of firm management, but is also important to pay attention to external elements such as location and territory [73].

The role of territory in terms of geographical clusters has attracted much attention in the academic literature. A large number of studies have explained the reasons for regional and geographical cluster competitiveness and recognized that the very existence of the cluster is a distinctive feature of that region that positively affects its overall performance [74]. Specifically, geographical clustering has been show to encourage national, regional, and local competitiveness, innovation and growth and to sustain the competitive advantages of regions by fostering innovation [36, 75]. Prior studies have highlighted the significant effects of location advantages because regional networks prompt information flows [76], thus enabling spillover effects of start-up success and affecting the creation of new firms at the regional level [67, 77].

The relationship between territory and the use of alternative financial sources such as crowdfunding is quite new. Previous studies suggest that although crowdfunding mitigates geography-related friction [3], location influences crowdfunding outcomes: projects that were closer to banks attracted less funding from local investors [8], while those located where there is more creative population have a higher success rate [2]. Location effects are also manifested through local altruism or the promotion of projects that share similar values with local communities [78]. Recently, Giudici *et al.* 2018 [79] have shown that certain salient features of the geographical area where entrepreneurs reside influence the success of the crowdfunding projects they propose and have found that the

existence of social relationships among people residing in a specific geographical area increases the likelihood of success of reward-based entrepreneurial projects. Moreover, the nascent crowdfunding literature has highlighted the existence of a self-reinforcing pattern whereby contributions received in the early days of a campaign accelerate its success [80].

We know that the territoriality of a campaign influences its success because local investors invest relatively early and, consequently, this responsiveness affects the success and development of a campaign [10, 19], but we are not well aware of what encourages the development of a crowdfunding campaign in certain regions and what leads an entrepreneur to use creative finance tools in these regions rather than turning to the financial market. The present paper helps fill this gap by evaluating the influence of knowledge spillover in Italian regions. Thus, we posit:

HI: *The characteristics of the geographical area in terms of knowledge attraction positively affect the adoption of crowdfunding campaigns.*

Evidence exists that local characteristics affect entrepreneurs' ability to attract external financing [4, 81]. However, the crowdfunding literature is silent in this regard, even though it has shown that geography influences these Internet-based financing sources.

Besides, to understand the influence of knowledge spillover on the adoption of crowdfunding campaigns, we evaluate the impact of foreign students from other nations on each region in response to the following:

HII: *Regions with a high number of foreign students' flows are more likely to adopt alternative financing sources such as crowdfunding campaigns.*

The region is a highly relevant support space for firms' innovation process because of the need to have continuous interaction to exchange knowledge and collaborate in joint innovation projects with people from other regions and other countries. In this case, the heterogeneity of students from other regions and other countries represents an important mechanism of knowledge transfer [82]. We assume that a large and heterogeneous flow of inbound knowledge and human capital would promote and support the innovation process and the possibility to turn to alternative creative financial sources such as crowdfunding.

3 Methodology

3.1 Sample and Data Collection

We analyzed 435 crowdfunding campaigns from the most popular equity-crowdfunding platforms in Italy such as Mamacrowd and CrowdfundMe, which represent the main crowdfunding platforms used in Italy. Mamacrowd was launched in 2011, while CrowdfundMe was launched in 2013, and both platforms are authorized by Consob that plans to invest in innovative Italian projects such as start-ups and innovative SMEs ranking first and second, respectively, in the Italian equity crowdfunding market by transaction volume and number of campaigns. We examined the position of the proposing campaign and the development of the use of crowdfunding campaigns in the Italian regions.

Data were mainly collected from official ECF platform websites, but this research also relied on the integration of other data sources, such as reports, official business register databases, and National Student Clearinghouse (NSC) to explain the interaction between regions' knowledge flow and local crowdfunding development.

To recognize the role played by knowledge spillover and emphasize the importance of universities in regional development, student mobility was considered to assess the interconnection between regions. The National Student Clearinghouse database was used. NSC is an administrative archive where all the students enrolled in the Italian university system are registered. Data within the NSC database are submitted monthly by the Italian universities and all the students enrolled in a university during a given academic year, regardless of the year of the course, are taken into account. Our sample is based on more than 6,500,000 Italian students and focuses on 1,600,000 students who move from one region to another one and from another country to the region under consideration. They represent an uninterrupted channel for the transfer of scientific and technical knowledge among countries and regions [83, 84].

This study was conducted using the ordinary least squares method (OLS) to verify the research framework and hypotheses. We analyzed 20 Italian regions and crowdfunding campaigns during a 4-year period (2016 to 2019). Specifically, we analyzed data on campaigns listed on those two platforms from January 2016 to December 2019. Hypothesis testing was conducted using a panel data regression analysis model that aims to predict the extent of the strength of the effects of both independent variables on the dependent variable.

3.2 Operationalization of the Variables

The crowdfunding campaign is our unit of analysis. Our dependent variable is the campaign, and we have considered the total number of crowdfunding campaigns for each Italian region in the last 4 years. We examined 435 crowdfunding campaigns in the last 4 years. Specifically, 47 campaigns referring to 2016, 109 campaigns referring to 2017, 124 referring to 2018, and 155 referring to 2019 were analyzed. This trend represents an important growth in terms of the use of the crowdfunding campaign as a method of entrepreneurial financing in the last 4 years. This variable was measured by the logarithm of the ratio of crowdfunding campaigns in each region per the total number of enterprises in the respective region. This allowed us to analyze the number of campaigns based on the number of companies in the area.

Our model includes two independent variables: *students_regions* and *students_countries*. Both variables were measured by the interaction between each region and incoming student flow from other regions and other countries. These variables consider students enrolled in university courses at an Italian university. The sample analyzed ranges from 18 to 35 years. A total of 1,600,00 students were examined to understand the linkage between knowledge spillover and crowdfunding development within Italian regions.

Our first independent variable, students' region, is measured by incoming student flow from other regions in the region under consideration. As a proxy for inbound knowledge from other regions, we used the number of students from other regions over the population of the region itself. Knowledge spillover effects are significantly stronger when there is a critical mass of high technology [85] moderating the relationship between start-up and venture capital [86].

Our second independent variable, students' country, is measured by incoming student flow from another country to the region considered over the population of the region itself. They represent an uninterrupted channel for the transfer of scientific and technical knowledge among countries. In the most advanced countries, the number of foreign students enrolled in higher education has had a surprising growth rate over the last decade [86–88], influencing regional development in terms of innovation [90] and start-ups [91]. Both of our independent variables were measured by taking the log of the number of students over the population in the region.

In our regression model, we controlled for both region and campaign characteristics. More specifically, the model specification includes the following indicator as a control variable. Total firms considered the total number of firms registered in the Chamber of Commerce. Expenditure in R&D considered the expenditure of each region in R&D over the region's population. We also considered a Gross domestic product (GDP) of every region that represented the city under consideration. GDP is a monetary measure of the market value of all the final goods and services produced in a certain period. In addition, regarding the development of start-ups in each region, we considered New Firms with regard to the firm founded in the year taken into consideration over the total number of active firms over time based on the registration in the Chamber of Commerce.

Table 1 presents the summary statistics of the variables used in the regressions and Table 2 the correlation matrix related to this model.

Table 1. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Campaigns (log)	80	0.001	0.002	0	0.006
Students_Regions (log)	80	0.263	0.144	0.154	0.592
Students_Countries (log)	80	0.147	0.013	0	0.043
Total_Firms (log)	80	0.095	0.077	0.073	0.767
Expenditure_R&D (log)	80	11.197	4.31	4.713	21.854
New_Firms (log)	80	0.061	0.004	0.054	0.072
GDP (log)	80	83545	84505	4359	383175

Table 2. Correlation model

	Variable	[1]	[2]	[3]	[4]	[5]	[6]	[7]
[1]	Campaigns (log)	1						
[2]	Students_Regions (log)	0.281	1					
[3]	Students_Countries (log)	0.274	0.354	1				
[4]	Total_Firms (log)	−0.056	−0.136	−0.084	1			
[5]	Expenditure_R&D (log)	−0.001	0.228	0.431	−0.068	1		
[6]	New_Firms (log)	0.035	−0.177	−0.351	−0.039	−0.055	1	
[7]	Gross Domestic Public (log)	0.101	0.015	0.357	0.045	0.438	0.129	1

4 Results

The role of knowledge spillover in the relationship between crowdfunding and regional entrepreneurial investment has been explored in this paper. Our result shows that inbound knowledge measured in terms of student mobility from other regions has a significant effect on the use of crowdfunding campaigns in the region itself. Moreover, we evaluated the impact of transnational students in the region.

The empirical results are presented in Table 3. Table 2 reports the correlation between the variables, and the descriptive statistics are presented in Table 1. No major collinearity issues are detectable. To assess potential multicollinearity, we computed the variance inflation factors (VIFs). For each model (Table 3) the mean and maximum VIF are well below the threshold of 1,5. Therefore, we concluded that multicollinearity is not a threat to the validity of our results. Going beyond simple correlation, Table 3 reports the estimated results from regression.

Table 3. Regression matrix

	Model I	Model II	Model III	Model IV
Campaigns (log)				
Students_Regions (log)		0.001**		0.001*
		[0.001]		[0.001]
Students_Countries (log)			0.002***	0.001**
			[0.001]	[0.001]
Total_Firms (log)		0.002	−0,001	0,002*
		[0.001]	[0.001]	[0.001]
Expenditure_R&D (log)	−0.001	−0.002	0.006	−0.001*

(*continued*)

Table 3. (*continued*)

	Model I	Model II	Model III	Model IV
	[0,001]	[0,001]	[0,002]	[0,003]
New_Firms (log)	−0.001	0.002*	0.001*	0.001*
	[0.001]	[0.001]	[0.001]	[0.001]
GDP (log)	0.001	0.002	0.001	0.003
	[0.001]	[0,001]	[0,001]	[0.001]
No. of observation	80	80	80	80
R-squared	0.221	0.352	0.328	0.471

*Notes: Students DC, dependent variable. P < 0.100; * P < 0.050; ** P < 0.010; *** P < 0.001*

Model I in Table 3 illustrates the result of a specification containing only the control variables considered. Model II shows the effect of our firs independent variable, that is, incoming students from other regions, and provides support for the hypothesis H1 (*The characteristics of the geographical area in terms of knowledge attraction positively affect the adoption of crowdfunding campaigns.)* by showing a positive and statistically significant association between inbound knowledge as measured by student mobility from other regions to the region under consideration and the use of alternative financial tools such as equity crowdfunding in the region itself ($p = 0.006$, $\beta = 8.72$). In other words, we found that a region with a large amount of incoming knowledge from other regions is more likely to use crowdfunding campaigns as a financial method compared to other regions.

Besides, Model III in Table 3 provides support for our hypothesis H2 (*Regions with a high number of foreign students' flows are more likely to adopt alternative financing sources such as crowdfunding campaigns).* The large presence of incoming students from other countries positively affects the adoption of equity crowdfunding campaigns in the region itself ($p = 0.001$, $\beta = 6.24$).

As we can see in Model IV, a high presence of incoming students from other regions and other countries influences the use of equity crowdfunding campaigns as alternative financing method and increases the possibility to access the crowdfunding market. Evidence exists that local characteristics affect entrepreneurs' ability to attract external financing [4, 81]. We found that entrepreneurs in regions with a larger number of students from other regions and foreign students are more likely to use creative finance tools such as crowdfunding than regions with fewer incoming student flows.

5 Discussion and Conclusion

In this paper, we examined the role of knowledge spillover across the Italian regions and their impact in the use of equity crowdfunding campaigns for financing start-ups and projects. We found that student mobility and knowledge flow play a role in the relationships between crowdfunding campaigns and entrepreneurial financial sources in the region under consideration.

Our results show that inbound knowledge in the region, measured in terms of students from other regions, has a significant effect on the adoption of crowdfunding campaigns in the region itself. The wide variety of knowledge from other regions increases the innovation rate [92] and the technological development in the region itself [93, 94], which may stimulate entrepreneurs to use uncommon financial instruments such as equity crowdfunding.

Additionally, we also found that a flow of international students encourages the entrepreneurial mindset in the region itself to use financial sources such as crowdfunding. The diffusion of knowledge within the region is a phenomenon that increases economic development. The presence of students from other regions and other countries has always represented a flow of knowledge that contributes to the development of the region in terms of competitiveness [95] and performance [96]. The use of financial instruments such as equity crowdfunding is an example of how the variety of knowledge and the exchange of knowledge increases the possibility for people to follow and benefit from technological development.

5.1 Limitation and Future Research

This work is not without limitations. First, our study is restricted to the context of equity crowdfunding. An investigation of rewards-based crowdfunding, business angels, Initial Coin Offering (ICO), and venture cprevapitals might provide important insights into the role of knowledge spillover in accessing an uncommon and innovative financial source.

Second, we based our research only on Italy. Focusing on one single country ented us from capturing cultural, political, and economic differences in the use of financial sources like crowdfunding campaigns.

Finally, we are not aware of whether the campaign has been successful or not. However, this information should not hamper our findings because we were not looking at the outcome of the campaign but at the impact of knowledge and human capital flow on the adoption of crowdfunding campaigns by users to directly seek financial help from the general public (the "crowd") instead of turning to financial investors such as business angels, banks, or venture capital funds.

5.2 Theoretical and Managerial Implications

Our findings have interesting implications for the growing literature on crowdfunding, and more broadly for the entrepreneurship literature. Our findings indicate that a wide variety of inbound knowledge flow can serve as a driver for the development of crowdfunding and other alternative sources of financing.

This relationship can be linked to the natural relationship between entrepreneur and financial market and improve access to the new forms of financial channels. As we can see, this relationship improves start-up development because crowdfunding has the potential to democratize access to capital as it can be a viable option for entrepreneurs who have difficulty accessing traditional channels of financing [8].

These implications are strongly related to regional policies, and our results have several implications for regional development and innovation policies. Regions with

heterogeneity in knowledge and human capital are more likely to support the innovation process and the adoption of alternative financial sources such as crowdfunding. Therefore, it is important to understand the role that region attractiveness, in terms of knowledge flow, plays in supporting regional development [12] and what elements contribute to the development of a crowdfunding campaign in a certain area.

Students moving from a region or country are attracted to innovative areas to which they can contribute and from which they can learn, they may effectively be part of a virtuous cycle where a strong innovation system attracts skills, which make it stronger and, in turn, more attractive to human capital [63]. As a result, this heterogeneity of incoming knowledge flow participates in the development of the area itself in terms of innovation and, in this case, in the use of alternative financial sources such as crowdfunding. Several important factors impact the use of crowdfunding campaigns in the local context, such investment [97], entrepreneurial complexity [98], and financial access [16]. Despite its limitations, however, the analysis shows the importance of looking at incoming knowledge flows and calls for further research on the implications of different types of mobility and the resulting impact on crowdfunding development in the local context.

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It's Not Only What You Say but "How" You Say It: Linguistic Styles and ICOs Success

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Abstract. Digital technologies have created new alternative sources of entrepreneurial finance that create significant opportunities for start-ups and entrepreneurs. Among them, Initial Coin Offerings (ICOs) have attracted significant attention from the start-up community and from investors. Despite all the hype around ICOs and the growing number of new token offerings being launched on a daily basis, little is known about the characteristics of successful ICOs. This study aims to fill this gap in the literature by exploring whether and how the linguistic styles adopted in the white paper affects the success of an ICO as measured by the actual amount raised by the offering. Our results are based on a primary dataset of 131 ICOs completed between June 2017 and October 2018. Our results suggest that the use of precise language is positively associated with the amount funded while the use of a concrete language and more numerical terms is negatively associated with the amount funded. This study contributes to the growing literature on ICOs by providing novel insights into the role of the communication strategy adopted by token issuers.

Keywords: Initial coin offerings · ICOs · Entrepreneurial finance · Linguistic styles

1 Introduction

The increasing adoption of digital technologies has significantly transformed the way companies conduct their business, how they engage with different stakeholders, and how they raise funds [40, 43]. In recent years, a number of new sources of entrepreneurial finance have emerged providing start-ups with an unprecedented number of alternative channels to access capital and to finance their expansion [40]. Crowdfunding is probably the most known source of alternative finance for start-ups and can be defined as an

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online open call for the provision of financial resources from a group of individuals or organisations in the form of donation, or in exchange for future access to the product or some form of reward [6, 41].

The volume of capital put through crowdfunding platforms has been growing at a double-digit growth rate for a number of years [62]. The main reasons behind this success can be reconducted to three key features of online crowdfunding namely, the reduction of geographical and physical barriers to funding, the low barrier to entry in terms of minimum investment, and the possibility to attract funders who are not (or not only) driven by financial incentives allowing companies to potentially create a community around their project [2].

More recently, developments in blockchain technology have opened opportunities for bringing the idea of crowdfunding to a new level through tokenization. Initial token offerings, mostly referred to as Initial Coin Offerings (ICOs), are, in their essence, fully disintermediated and unregulated crowdfunding campaigns based on blockchain-based smart contracts [1, 40]. Even though ICOs represent a recent phenomenon, more than US$31 billion has been raised through ICOs since 2013 [53].

Despite to the fact that ICOs have attracted growing interest from researchers, investors, entrepreneurs and regulators, little is still known about the dynamics of ICOs from an entrepreneurial finance perspective and about the characteristics of those companies that successfully leverage ICOs for getting their project off the ground [20].

One of the main issues for potential funders is related to the embedded risk and the information asymmetry typically associated with investing in a new project [9, 63]. In order to reduce information asymmetry, entrepreneurs typically tend to disclose more information to potential investors [23]. However, the signalling theory [11, 56] suggests that *what* is disclosed is as important as *how* information is communicated as the actions undertaken by the project promoter(s) as it can send important "signals" to potential funders [13, 49]. This suggests that both the communication styles and the amount of information disclosed can reduce information asymmetry and potentially improve investors' attitude toward an ICO therefore increasing the likelihood of success [11, 57].

Recent studies on the determinants of ICOs success (see, for example, [1, 20, 21]) have mostly focused on various characteristics of token offerings. However, none of these studies have explored whether and how the linguistic style (i.e. *how* the information is communicated) affects the probability of success of ICOs campaigns.

Our study aims to fill this gap by analysing the effect of the linguistic style adopted in the white papers of 133 ICOs that were completed between June 2017 and October 2018 on the amount raised. The linguistic styles are analysed in term of traditional language components, the use of standard linguistic dimensions (e.g., word count), tone of communication, function words (i.e., those that primarily serve a grammatical function) and words that refers to cognitive styles [50, 52].

In line with our predictions, our results suggest that the linguistic style adopted in the white paper significantly affects the amount raised by ICOs. Specifically, our study highlights the need to pay attention not only to the "quantity" of the disclosure but also to its "quality" suggesting that specific linguistic styles boost the likelihood of success of an ICO.

The rest of this paper is organised as follows. In Sect. 2, we present prior literature on ICOs and on the role of information asymmetry in the fundraising process. In Sect. 3, we present the methodology and the data used in this study. Section 4 presents the results of the empirical analysis, while in Sect. 5 we discuss the results, research limitations, and suggest avenues for future research.

2 Literature Review

2.1 Initial Coin Offering

Initial Coin Offerings can be defined as open calls for funding promoted by organisations, companies, and entrepreneurs to raise capital (mostly through cryptocurrencies) in exchange for a *token* that can be used in the future to obtain access to products or services or sold online in the secondary market [1, 40].

ICOs can be seen as the combination of crowdfunding and blockchain technology. While the former has flipped the investment-to-investor ratio typical of start-up financing and has made the idea of peer-to-peer investment possible, the latter has somewhat simplified the start-up financing ecosystem by combining asset tokenisation and disintermediation. The concept of tokenization *per se* is not new in capital markets. In fact, physical and digital tokens have been around for a long time (e.g., currencies, credit-notes, equities, bonds etc.). In this context, the main novelty introduced by blockchain is the possibility to exchange digital tokens securely and in a fully disintermediated way [46].

Deloitte [15] highlights four key benefits associated with asset tokenization: (1) greater liquidity as tokenization allows traditionally less liquid assets to be traded on secondary markets; (2) faster and cheaper transactions thanks to the automation typical of smart contracts[1]; (3) increased transparency as the rights and responsibilities of the token holder are scripted within the token itself; and (4) lower barrier to entry into large scale investment thanks to a lower minimum investment and shorter investment periods.

There are four main types of tokens that can be built onto a blockchain and offered to investors [58]: (1) payment tokens which are essentially cryptocurrencies and can only be used as means of payment; (2) utility tokens which provide digital access to a digital application or service typically (but not necessarily) built on top of a blockchain; (3) asset tokens which represent assets such as an entitlement to dividends or interest payments and are somewhat similar to traditional securities; and (4) hybrid tokens which may combine different aspects of the other three types of tokens.

Tokens offered via an ICO are typically of the second type. As such, they do not qualify as securities and fall outside traditional regulatory frameworks [45]. The lack of clear regulation may be attractive for both project promoters and investors as there is less legal burden attached to this type of offerings, but it makes ICOs a controversial channel for raising capital due to the large presence of scams and the lack of investor protection [9, 24, 45].

[1] Smart contracts can be defined as "digital programs based on a blockchain consensus architecture that automatically implement their internal logic as certain preconditions are met, and which are also able to prevent unauthorised changes of their internal logic as a result of their decentralised nature" [36, p. 7].

2.2 The Determinants of ICOs' Success

Different measures of ICO success have been adopted in the literature such as hard or soft cap targets, token trading and amount raised [1, 24].

Token offerings can be used to finance (potentially) any kind of project, and they can be customised to meet the specific objectives of the founders and the requirements of target investors. Fridgen et al. [21] propose a taxonomy, that includes 23 relevant dimensions encompassing 62 characteristics to categorise the most common ICO archetypes. Several studies have explored the impact of some of these characteristics on ICOs success. Among the main characteristics, the size of the founding team has been found being positively associated with ICOs' success [1, 4, 39]. Other studies also suggest that utility tokens are more likely to attract funds compared to security tokens [20, 24, 25]. Interestingly though, empirical evidence seems to suggest that most utility tokens are actually purchased for speculative reasons rather than for future use [31]. Similarly, Lee et al. [37] find a positive relationship between the rating provided by third-party platforms[2] and the likelihood of success.

ICOs may also accept investments only from particularly countries or specific investors. Amsden and Schweizer [4] and Fisch [20] highlight how the lack of clear regulatory frameworks in some countries represents an important factor that influences the growth of this fundraising mechanism.

A number of regulators around the world have been trying to regulate token offerings in recent years in order to establish clear disclosure requirements and more protection for investors. Despite the effort undertaken so far, ICOs still remain characterised by a strong information asymmetry, opaqueness and all the risks typically associated with early-stage start-ups [1, 55].

2.3 Linguistic Style, Information Asymmetry and Investors' Perception

Information asymmetry often represent a major barrier to funding for start-ups and young companies [11, 44]. Most of the time, investors can only rely on a very limited set of information disclosed by the founding team who need to communicate effectively to convince funders about their legitimacy and potential [12, 38].

When it comes to token offerings, the white paper associated with a project is the main source of information. However, the extent, type, and quality of information disclosed in these documents tends to vary significantly from one project to another mostly due to the lack of clear disclosure requirements. This may ultimately result in suboptimal investment decisions or lower investments overall [3].

[2] Some token trading and market intelligence platforms provides a list of current and upcoming ICOs and assign them a rating based on their perceived quality, riskiness etc. For example, the Icobench.com website is one the main tracking list of ICOs that incorporates a dataset with more than 5,725 ICOs [27].

Prior studies leverage the signalling theory [11, 56] to explore the fundamental role of communication strategy (i.e. *what* and *how* information is disclosed) in reducing information asymmetry. Particularly interesting in the context of this study are those studies that focus on crowdfunding. Agrawal et al. [2], Davis et al. [14], Younkin and Kaskooli [61], and Di Pietro et al. [19] for example, have focused on the description of crowdfunding projects and their role in providing "signals" about the quality of the project to potential investors (e.g., quality of product, social networks, human capital of the entrepreneur etc.).

Parhankangas and Renko [49] focus more on *how* information is presented to investors and examine the relationship between the style of verbal communication and campaign success. The authors complement the signalling theory with the language expectancy theory [7, 8] which suggests that "by observing language behaviours, people develop expectations concerning appropriate communication styles employed by others and themselves" [49, p. 218]. Their results suggest that linguistic styles that make information more accessible and understandable and increase the perceived reliability of the promoters to the crowd are positively related to the likelihood of success of social campaigns but hardly matter for more commercial campaigns.

The literature on the relationship between linguistic styles and the success of crowdfunding campaigns is still quite limited. However, additional evidence on such a relationship is provided by Kaminski and Hopp [29] who demonstrate that linguistic styles that aim to trigger excitement, and are more inclusive, are better predictors of campaign success than firm-level determinants. Similarly, Anglin et al. [5] show that positive narratives and passion have a positive effect on the likelihood of success of a campaign.

Prior studies provide interesting insights into four main types of linguistic style and their relationship with investors' perception and funding success. Specifically, information communicated using a more *concrete* language are easier to process and to remember [42, 48, 54]. The use of more precise language instead communicates transparency and reliability [22, 28, 32]. Recent psychological research also suggests that people are more prone to help and participate in different initiatives if the language used evokes emotions and is more interactive [16, 17, 33, 54]. Finally, language that communicates psychological distancing (i.e. frequent use of the first person) may be perceived negatively in the context of crowdfunding or token offerings where potential investors may also invest to become part of a community [47, 60].

While several studies have investigated the implications of different linguistic styles on crowdfunding success and other business outcomes, no evidence has been provided so far about their impact on ICOs success. Our study aims to fill this gap in the literature by answering the following research question:

RQ: How does the linguistic style adopted in the white paper affect the amount raised by ICOs?

3 Sample and Methodology

We compiled our sample starting from a list of 231 ICOs completed between June 2017 and October 2018 as reported on Coindesk[3]. Different characteristics of each ICO were extracted from the white paper, the project website or from other publicly available data sources collected (e.g., ICObench, CoinMarketCap etc.). Despite the considerable effort in terms of data collection, several ICOs had to be excluded from our dataset due to missing data or because the white paper was no longer available. Our final sample included 133 ICOs.

In order to answer our research question, we employed the following OLS regression model:

$$\begin{aligned} Log(AmountRaised)_i = {} & \alpha + \beta_1 Concrete_i + \beta_2 Precise_i + \beta_3 Interactive_i \\ & + \beta_4 PsychDistancing_i + \beta_5 NumericalTerms_i \\ & + \beta_6 Tone_i + \beta_7 WordCount_i \\ & + \beta_8 PagesWhitePaper_i + \beta_9 ICOSize_i \\ & + \beta_{10} Utility_i + \beta_{11} ICObenchRating_i \\ & + \beta_{12} TaxHaven_i + \beta_{13} Github_i \\ & + \beta_{14} \%TokensOffered_i + \varepsilon_i \end{aligned}$$

Our dependent variable (i.e. our measure of success) is the natural logarithm of the amount raised. The model also includes two groups of independent variables: (1) our measures of different linguistic styles that were computed using the Linguistic Inquiry and Word Count (LIWC) software [49], and (2) other ICOs' characteristics [1, 20, 21].

Concrete is calculated as the sum of number of articles (i.e., "a", "an", and "the"), prepositions (e.g., "to", "with", "above") and quantifiers (e.g., "many", "few", "a lot") [35]. *Precise* is the analytical thinking score as calculated by LIWC which captures the degree to which people use words that suggest formal, logical, and hierarchical thinking patterns [51]. *Interactive* is equal to the number of questions reported in the text [49]. *Psych Distancing* is calculated using the frequency of the use of the first person singular ("I") and negative emotions [30, 59, 60]. *Numerical terms* is equal to the frequency of words that refer to numbers (e.g., "second", "third", "thousand", "million"). *Tone* is computed by LIWC and summarises the presence of both positive and negative emotions. A *Tone* score lower (higher) than 50 indicates a negative (positive) tone [10]. We also control for the overall number of words (*Word Count*) included in the white paper and the corresponding number of pages (*Pages White Paper*).

[3] https://www.coindesk.com/ico-calendar.

Following prior studies in the entrepreneurial finance literature, we control for several ICOs' characteristics that have been found to be associated with their success. *ICO Size* is the target amount of the ICO. *Utility* is a dummy variable equal to 1 if the token offered in the ICO is a utility token, and 0 otherwise. *ICObench Rating* is included to control for the overall perceived quality of each ICO[4] and ranges from 0 (low quality) to 5 (high quality). *Tax Haven* is a dummy variable equal to 1 if an ICO is launched from a country with very low tax rates [4, 18], and 0 otherwise. *Github* is a dummy variable equal to 1 if the code associated with the proposed solution is available on Github, and 0 otherwise. Finally, we control for the percentage of tokens offered to the public (*% Token Offered*). In fact, most of the companies avoid selling the total amount of tokens issued. Previous research argues that entrepreneurs' willingness to invest in their own venture indicates higher commitment and represents a signal of higher quality [20, 26].

4 Results

Table 1 reports the descriptive statistics for the variables included in our model. On average, the 133 ICOs in our dataset raised $6.96 million each with a maximum funding of $4.1 billion (EOS) and a minimum of $0.11 million (GoHelpFund). The linguistic style that reports the highest average score is *Precise* (average score 95.40) suggesting that the text of the white papers tends be highly analytical with complex and organised concepts [51]. The average value of *Tone* is equal to 66.02 (median 65.31) suggesting that white papers tend to convey more positive than negative emotions. However, there seems to be some variation in the dataset as some papers show an extremely positive tone (maximum value of 96.8) while others report a negative tone (minimum of 36.84). The variable *Concrete* report an average value of 22.80 with a maximum value of 31.98. This may be somewhat surprising as one would expect to see a higher value (i.e., a more concrete language). The descriptive statistics of both *Psych Distancing* and *Interactive* report average values less than 1.

Similarly, to previous studies (e.g., [20]), token issuers offer, on average, 52% of the total amount of tokens for sale with some issuers offering only 2% and others offering 100%.

Finally, it is worth noting that only 89% of the ICOs in our sample issued utility tokens, 17% are based in countries that have been classified as tax havens, and 62% have made the source code of the proposed solution available on Github.

[4] ICObench is considered one of the main sources of information for common investors [37].

Table 1. Descriptive statistics and data sources

Variables	Mean	SD	Min.	Median	Max.	Data source
Dependent variable						
Amount raised (log)	1.94	1.32	-2.21	8.00	8.31	Icobench.com
Independent variables						
Linguistic styles						
Concrete	22.80	3.67	2.68	22.97	31.98	White papers
Precise	95.40	2.04	86.53	95.84	99	White papers
Interactive style	0.70	0.22	0.03	0.69	1.38	White papers
Psych Distancing	0.74	0.35	0.08	0.7	2.3	White papers
Numerical terms	5.21	2.75	2.16	4.66	21.15	White papers
Tone	66.02	13.34	36.84	65.31	96.8	White papers
Word Counts	9,765	4,704	551	9,075	26,276	White papers
Pages White papers	40.66	16.78	8	40	99	White papers
Characteristics of ICOs campaigns						
ICO Size	43.77	363.33	0.03	9.02	4,200	Coindesk.com
Utility	0.89	0.32	0	1	1	Multiple*
ICObench Rating	3.50	0.67	0	3.6	4.6	Icobench.com
Tax Haven	0.17	0.38	0	0	1	Multiple*
Github	0.62	0.49	0	1	1	Multiple*
% Tokens offered	0.52	0.20	0.02	0.5	1	Multiple*

* Multiple sources: www.icobench.com, www.icodrops.com, www.tokenmarket.com, www.coindesk.com.

In order to make sure that multicollinearity does not bias the results of regression, we performed a correlation analysis. The results[5] show only moderate or low correlations suggesting that multicollinearity should not be an issue in our research setting.

Table 2 presents the results of our regression analysis. All models are estimated using heteroscedasticity robust standard errors. Specifically, we ran two separate models. A first model (Model A) which only includes the variables related to the linguistic styles, and a second model (Model B) which also includes the main determinants of ICOs' success as suggested by prior studies (e.g., [4, 20, 21]).

For each regression, we also calculate the average variance inflation factors (VIFs). All VIFs were below the critical value of 5 providing further assurance that multicollinearity is not affecting our research design [34].

The results in Table 2 show that precise language (*Precise*) is positively associated with the amount raised. This is in line with Parhankangas and Renko [49] who find that precise language is positively associated with the likelihood of campaign success. Surprisingly, *Concrete* is negatively associated with the amount raised by ICOs. This contrasts with the findings of Parhankangas and Renko [49] and may be due to differences in the type of investor that are attracted by ICOs compared to equity crowdfunding.

[5] Available from the authors upon request.

Table 2. OLS regression results

	Model A		Model B	
Variables	Coeff.	(SE)	Coeff.	(SE)
Linguistic styles				
Concrete	-0.048*	(0.024)	-0.059*	(0.030)
Precise	0.148**	(0.057)	0.168***	(0.058)
Interactive Style	0.479	(0.597)	0.298	(0.556)
Psych Distancing	-0.308	(0.375)	-0.405	(0.314)
Numerical Terms	-0.127*	(0.068)	-0.142*	(0.073)
Tone	-0.011	(0.011)	-0.010	(0.010)
Word Count	-0.000	(0.000)	-0.000	(0.000)
Pages White Papers	0.008	(0.013)	0.019**	(0.010)
Characteristic of ICOs campaigns				
ICO Size			0.002***	(0.000)
Utility			-0.015	(0.421)
ICObench Rating			0.248	(0.171)
Tax Haven			0.362	(0.250)
Github			-0.152	(0.252)
% Tokens offered			0.864	(0.549)
Adj. R^2	0.022		0.240	
Observations (ICOs)	133		133	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; two-tailed test.

The coefficients for *Interactive*, *Psych Distancing* and *Tone* are not statistically significant, suggesting that they do not affect ICOs' success. The presence of *Numerical Terms* in the text instead is negatively associated with to the amount funded. The coefficient of *Word Count* is not statistically significant while the number of pages is positively related to the amount founded. The number of pages in the white paper may proxy for the amount of information disclosed therefore this result may suggest that the quantity of information disclosed to the investors positively affect the amount raised by the ICO. Turning our attention to other ICOs characteristics, the results reveal that only the scale of the ICO is positively related to the amount raised. The coefficients of all other variables are not statistically significant.

5 Discussion and Conclusion

Our study leverages the signalling theory and the language expectancy theory to explore the relationship between the linguistic style adopted in the white papers and the amount

raised by ICOs. As such, this study contributes to the growing strand of entrepreneurial finance literature that focuses on ICOs by providing novel insights on the importance of the style of communication adopted by token issuers.

Our results suggest that the use of more precise language and the disclosure of a larger volume of information in the white paper has positive effects on the amount raised by the ICO. On the contrary, the use of more concrete language and numerical terms seems to have a negative effect on the amount raised.

The results of our study may be of interest for both academics and practitioners. Academics may benefit from novel insights on the importance of the linguistic style in the context of ICOs. Future research, for example, may explore additional characteristics of the text presented in the white paper, or explore the characteristics of the messages posted on various social media platforms. Future research may also compare ICOs and Security Token Offerings (STOs) to see whether major differences emerge.

Our findings may also be of interest for practitioners as they may provide them with clear guidelines in terms how to disseminate information to investors, and how to build legitimacy and trust around the proposed project. This is particularly relevant in the context of ICOs where new projects are promoted on a daily basis and where the large number of scams and low-quality projects that have been promoted in recent years may have made investors particularly suspicious.

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Exploring Socioemotional Wealth Debate: A Bibliometric Analysis

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Abstract. This study aims to explore the scholarly structure and trends in the scientific debate on socioemotional wealth (SEW) in family business studies. We analyse 294 publications focused on SEW published to date in any sources of the Scopus database. Using a bibliometric analysis, we identify the scientific community debating SEW in terms of publication activity for authors, journals and countries and the publication's impact measured in terms of citation for authors and per year. Moreover, to picture the main themes researched, we develop a co-word analysis on the most used keywords by authors using social network analysis tools. This paper provides a preliminary description of the state-of-art in SEW literature, identifying and potential future research directions for the consolidation of the literature on SEW.

Keywords: Socioemotional wealth · Family business · Bibliometric analysis · Social network analysis

1 Introduction

The management literature highlights that socioemotional wealth (SEW) approach can be considered as the "potential dominant paradigm in the family business field" [1] (p. 258). Since the seminal SEW model proposed by Gomez-Mejia et al. [2], this approach has been widely used by family business scholars in order to better investigate how and why family firms follow different logics than non-family businesses when making strategic decisions and choosing their policies. Just over ten years after its introduction in family business literature, the article of Gomez-Mejia et al. [2] received more than 700 citations in peer-reviewed academic journals [3].

The SEW theoretical construct captures "the non-financial aspects of the firm that meet the family's affective needs, such as identity, the ability to exercise family influence, and the perpetuation of family dynasty" [2] (p. 106) namely the essence of family firms that distinguishes them from non-family firms. From this perspective, the family firm's behaviour is driven by the intention to protect their SEW and "gains or losses in SEW represent the pivotal frame of reference that family-controlled firms use to make major strategic choices" [1] (p. 259) although it could be a disadvantage of other subjects that are not involved in the sphere of benefits related to SEW.

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Starting from the Gomez-Mejia's SEW concept, several other studies have been focused on the conceptual definition of SEW referring to an affective and socioemotional endowment [4] (or non-financial benefits), that family members invest in their owned firm end/or they reap by their control on the firm.

Over the years, several scholars have contributed to the development of the SEW approach and to a better definition of its theoretical construct. In particular, some studies have been carried out debating the concept of SEW and proposing its potential different dimensions [1], other studies have been focused on the way to measure the SEW construct proposing some alternatives for its operationalization (e.g. [5–7]) and finally, some other studies have been focused on its theoretical assumptions (e.g. [8]).

However, to date there is not a detailed and comprehensive literature review about the development and consolidation of SEW approach in the academic research, as well as about its relevance and influence in the relationship with other themes. To the best of our knowledge, the only systematic literature review was conducted by Jiang et al. [3] and on a sample of 421 papers published in peer-review journal that had published no less than five articles that cited the seminal study on SEW model developed by Gomez-Mejia et al. [2]. Specifically, their study was aimed to investigate how and why social psychological research can contribute to avoid reification in SEW research and to suggest future research direction in this field. In this perspective, their study shows the state of SEW research referring to the following aspects: a) how SEW is positioned in authors' theoretical arguments and contributions, b) how scholars argue about family members' SEW, and c) what are the content domains and approaches adopted by researchers to study SEW.

Our study aims to extend the existing literature review on SEW approach in several directions. First, the main objective of our research is to provide a comprehensive literature analysis of academic research on SEW in family business field adopting the bibliometric analysis method. We believe that the analysis of the state of the art on SEW could contribute to have a cleaner perception of the real relevance of the SEW approach in academic research and how it has contributed to the development of studies on family firms. In order to pursue this goal, we analysed the literature published to date on SEW on the database Scopus considering the following aspects: size and the development of the scientific production of the field, the impact and the evolution of the publication activity for authors, journals, and countries. Second, our analysis offers a conceptual map concerning the SEW theoretical construct and the theories and topics used in family business studies. Indeed, this study provide a bibliometric analysis that incorporate also the keywords co-occurrence analysis that has only recently been applied in some previous studies in the field of family business [9]. Finally, the overall interpretation of our results allows us to propose potential avenues for future research.

The remainder of the paper is organized as follow: in Sect. 2 we present the methodology adopted for the systematic and bibliometric analysis; in Sect. 3 we show and explain our results, and finally, we present our conclusion.

2 Method

2.1 Bibliometric Analysis and Data Collection

This study adopts a bibliometric analytic approach to investigate the development and the evolutionary trend of SEW research. This method, based on several measure of bibliographic data, allow us to create a structural image of the scientific literature process [10, 11] and to discover research networks and information not formally or explicitly defined [12]. Specifically, we employed the following types of technique: a) measure of publication activity in the research domain; b) citation analysis and, c) co-word analysis.

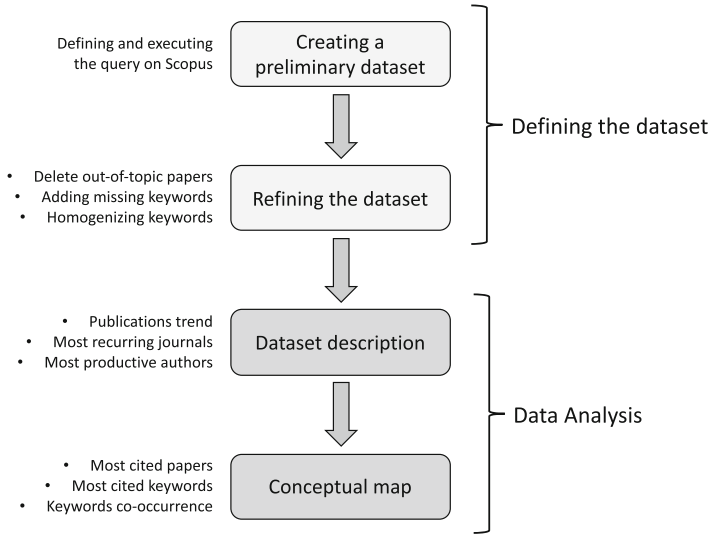

Fig. 1. Research protocol

To curry out our analysis we select the Scopus database that is the largest abstract and citation database of peer-reviewed scientific literature in social studies covering over 20000 major journals [13]. Our original dataset was determined using the keyword socio*emotional wealth to extract a broader collection of contributions published in English language until May 2020 and without any restrictions (e.g. publication source, type of contribution). For each document we extract the following information: author's name and institution, title of contribution, abstract, keywords, year of publication, sources title, and document type. Using these preliminary criteria, we obtain an initial sample of 298 documents. Before analysing the data, a refining phase was performed in order to exclude documents that are not related to our research focus and to clean and standardize the content of some fields in the dataset. First, we read the title, abstract and keyword of each documents in order to eliminate those that did not concern our investigation field. In this phase we excluded 4 documents. Subsequently, we harmonized the keywords terms used by the authors (e.g. singular or plural form used to indicate the same terms or the use of synonymous). In this case, we have replaced the author's

keywords indicating the same topic with a unique one. Moreover, as some papers in our dataset had not keywords, we assigned them to the paper based on its title, abstract and full text. After these phases, the resulting final dataset was composed by 294 documents. Figure 1 summarised our research protocol [14].

3 Results

In this section we report the main findings of the bibliometrics analysis of records associated to SEW research published until to May 2020. All the documents were systematized in the dataset to provide a complete overview of SEW literature. Table 1 describe in summary the characteristics of the dataset.

Table 1. Dataset summary

Timespan	2007–2020
Sources (Journals, Books, etc.)	113
Documents	294
Average years from publication	3.18
Average citations per documents	33.59
Average citations per year per doc	4.829
References	18.700
Document Types	
Article	258
Article in press	3
Book chapter	14
Conference paper	10
Editorial	3
Note	1
Review	5
Document Contents	
Keywords Plus (ID)	170
Author's Keywords (DE)	691
Authors	
Authors	578
Author Appearances	882
Authors of single-authored documents	16
Authors of multi-authored documents	562

(*continued*)

Table 1. (*continued*)

Timespan	2007–2020
Authors Collaboration	
Single-authored documents	16
Documents per Author	0.509
Authors per Document	1.97
Co-Authors per Documents	3
Collaboration Index	2.02

The results of the analysis performed on the 294 documents are described below. This analysis was developed in three steps: 1) indicators of publication activity (e.g. the number of researches published by authors, journals, countries etc.); 2) indicators of citations (e.g. the frequency of citation for authors and publications); 3) co-word analysis on keyword used by authors.

3.1 Indicators of Publications Activity on SEW Literature

Indicators of publication activity allow us to map the quantitative evolution of the literature on SEW. Figure 2 shows the trend of the papers published over the years.

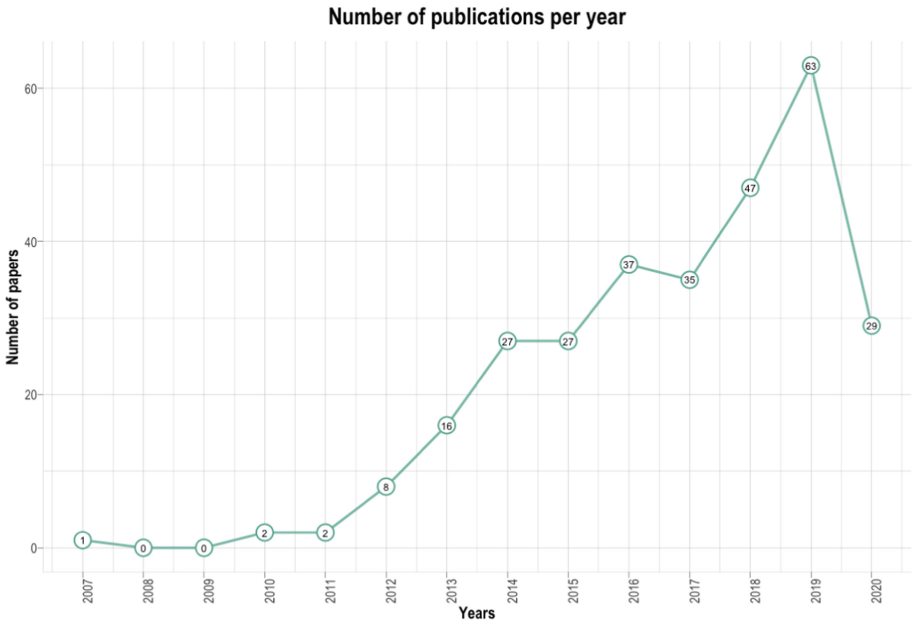

Fig. 2. Number of publications per year in SEW research since 2007.

The literature on SEW in family business is relatively recent but with a high and rapid development over the last few years. Indeed, from 2016 the number of publications increases exponentially, covering more than 70% of the total publications in the dataset. The 2019 was the most productive year with 63 publications. Moreover, the diagram shows in the increasing trend three different peaks, in 2014, 2016 and 2019 respectively.

Our results indicate that studies on SEW approach have been published in numerous sources (113 overall) but most of them (131 that is the 44.55%) have been published in ten scientific journals. Table 2 reports the ranking of the most productive journals (with at least five paper in the dataset) showing for each journal the number of publications in the dataset. The most productive journal is *Family Business Review* with 31 articles representing the 10.54% of the overall published studies, followed by *Journal of Family Business Strategy* with 28 papers and *Entrepreneurship: Theory and Practice* with 25 papers.

Table 2. Most recurring journals

	Journals	N. Articles
1	Family Business Review	31
2	Journal of Family Business Strategy	28
3	Entrepreneurship: Theory and Practice	25
4	Journal of Family Business Management	11
5	Journal of Business Ethics	8
6	Management Research	7
7	Journal of Business Research	6
8	International Entrepreneurship and Management Journal	5
9	Journal of Management	5
10	Review of Managerial Science	5
	Total	131

Based on our dataset we also analysed the author's productivity. Figure 3 reports the ranking of the most productive authors, on the basis of how many papers (at least 4) of the dataset are published by the same author. The figure shows that *Cruz C.* published the higher number of articles (14 papers) on SEW, followed by *Chrisman J, Gomez-Mejia L.R.* and *Kellermanns F.W.* with the same level of productivity (13 papers).

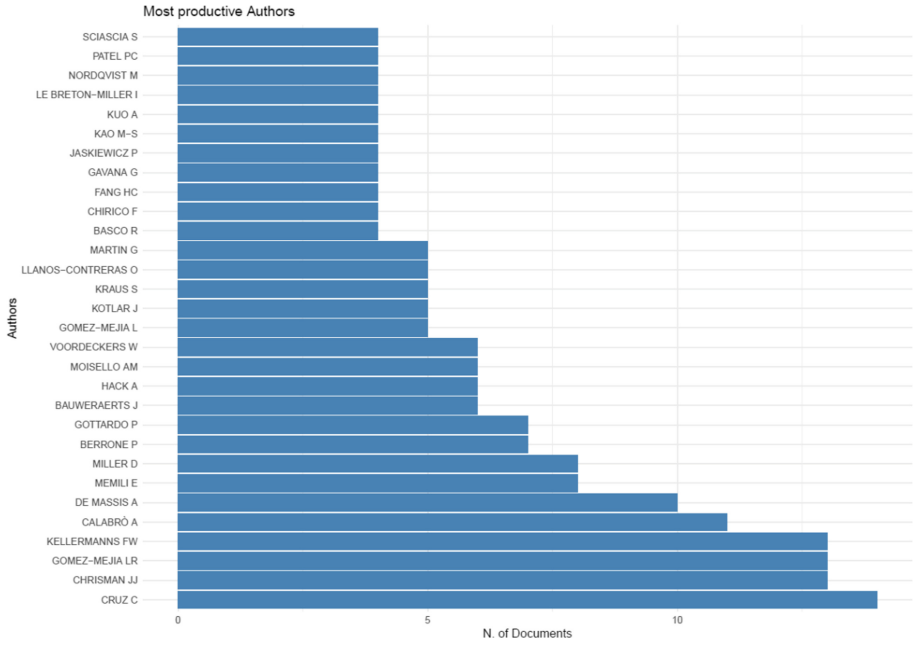

Fig. 3. Most productive authors.

Focusing on the affiliation of the first authors it is possible to have an overview about the productivity of the authors affiliated to institutions belonging to the same country and their level of collaboration with authors of other countries. Figure 4 shows both the *single country publication-SCP* (paper where the authors come from the same country – the light-blue bar in the diagram) and the *multiple country publication-MCP* (paper where the authors are of different countries – the red bar in the diagram). In the case of *MCP,* the publication is associated with the corresponding author's country and it could be considered as a measure of the collaboration level between the authors of the specific country with other scholars with foreign affiliation. Our results highlight that the development of the scientific debate on SEW is mostly localized in US and three European Countries. Specifically, 23 papers are associated to US, followed by Spain with 21 papers, Germany with 15 paper and Italy with 13 papers. For all the other countries there are less than ten papers. However, if we consider the case of *SCP*, we observe that Spain seems to be the more collaborative country among the first four.

3.2 Bibliometric Citation Analysis in SEW Literature

This study uses the bibliometric citation analysis to better understand the evolution of SEW research from 2007 to date. Indeed, this analysis allow us to define not only the intellectual structure of SEW research field but also the development of the field itself [15]. Citation analysis reveal who and/or what is cited, as well as the publication that contain the citation. The frequency of citations is an indicator of their qualitative value and importance in the respective research field [11, 16].

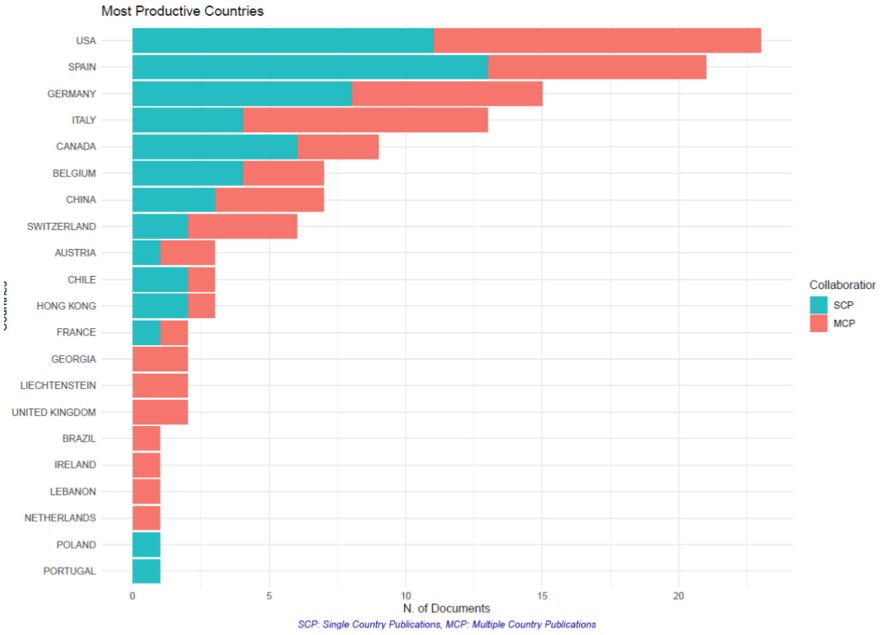

Fig. 4. Most productive countries.

Our analysis determined the most frequently cited publications in our timeframe and per year. Table 3 reports the most 19 publications cited (we select those with at least 100 citations) and Fig. 4 shows the total citation per article per year.

The most cited and influential publication is Gomez-Mejia et al. (2007) which received 1428 total citations. This is undoubtedly related to the fact that this publication is the study that proposed for the first time the SEW model and therefore, all subsequent research on the same topic or that have used SEW as theoretical approach or as a variable have cited it. The high scientific production following Gomez-Mejia et al. (2007) and the related citations demonstrate the relevance and the qualitative value that SEW approach has in the scientific community. The second most cited publication [1] has more than half of the citations of the first in the ranking. Moreover, we noted that the paper published by the two authors Gomez-Mejia and Berrone are the four most cited papers in the list.

Figure 4 integrates the information on citation trend showing the maximum, minimum and average number of citations for paper published in specific year. The figure highlights that in addition to the publication of Gomez-Mejia et al. [2], the papers that received most citations are those published in the temporal period that goes from 2010 to 2013 (we consider that the citations number should be influenced by the age of the publication). Moreover, considering also the data showed in Table 3, among the 19 most cited papers, the highest number of publications was in the year 2012. The use of the maximum and minimum citation number received by the papers published in the same years, give us the possibility to estimate the reliability of the average citation number (the green one). For example, in the period 2010–2013 the average citation number per

Table 3. Most cited publications on SEW

	Article	Total citations
1	Gomez-Mejia lr, 2007, Adm Sci Q	1428
2	Berrone P, 2012, Fam Bus Rev	742
3	Gomez-Mejia lr, 2011, Acad Manage Annals	707
4	Berrone P, 2010, Adm Sci Q	630
5	Chrisman Jj, 2012, Acad Manage J	516
6	Zellweger Tm, 2012, Organ Sci	311
7	Deephouse Dl, 2013, J Manage Stud	246
8	Cennamo C, 2012, Entrep Theory Pract	217
9	Patel Pc, 2014, Strategic Manage J	157
10	Gomez-Mejia Lr, 2014, Entrep Theory Pract	152
11	Pukall Tj, 2014, Fam Bus Rev	151
12	Kellermanns Fw, 2012, Entrep Theory Pract	145
13	Miller D, 2014, Entrep Theory Pract	140
14	Cruz C, 2012, J Bus Venturing	135
15	Miller D, 2013, Organ Sci	133
16	Cruz C, 2014, Entrep Theory Pract	121
17	Block J, 2013, Fam Bus Rev	107
18	Stockmans A, 2010, Fam Bus Rev	106
19	Naldi L, 2013, Entrep Theory Pract	101

year is quite high respect the other years thanks to the presence of specific publications receiving the highest number of citations (see the maximum value - the red line in the graph) affecting the average value concerning the specific year. This kind of graph should improve the interpretation of the citation trend respect the traditional graph based only on the average citation numbers per year.

3.3 Analysis of the Main Topics Covered by SEW Literature

In order to investigate the main topics debated by the contributions on SEW of our dataset, an analysis of the most used keyword by the authors in their papers was performed. Specifically, we applied the co-word technique based on the analysis of the co-occurrences of terms, keywords or subject headings [17, 18]. It allows us to define the state-of-art research in a scientific field, discovering the relationship between different themes and identifying the emerging research area [19, 20]. Figure 6 reports the eleven most frequently keywords used by the authors (we report only the keywords with at least 11 occurrences in the dataset). The most recurring keywords used in the publications of our dataset are "*socioemotional wealth*" and "*family business*" with 212 and

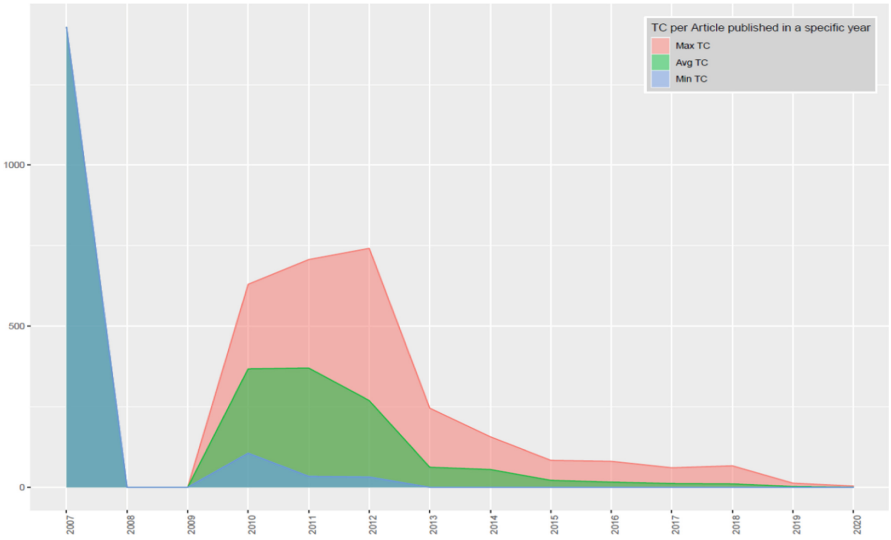

Fig. 5. Total citation per article per year.

204 occurrences respectively. Regarding the keyword "*family business"* occurrence, we need to make two main considerations: the first one is related to the fact that this keyword was used for replacing others in the dataset indicating the same concept, such as "family firms", "private family firms" and their singular forms (in the refining phase, all those keywords were substituted with the term "family business"); the second aspect is related to the fact that the SEW approach is a typical approach used to explain the family firm behavior, for this reason this specific keyword results to be the most used by the authors. In addition to these two keywords, the secondly most used ones are "*performance*" and "*corporate governance*".

As depicted in Fig. 5. *Socioemotional wealth, family business* and *performance* are used quite regularly from the year 2007 to date, even if, the keyword *performance* was not used in 2010 and 2011. The total absence of the years 2008 and 2009 in the graph is related to the fact that there are not publications in those years (see Fig. 2). Among the others, the keyword adopted by the authors more recently is *internationalization*, although it was used mainly between 2016–2018, having a declining trend in its use afterwards.

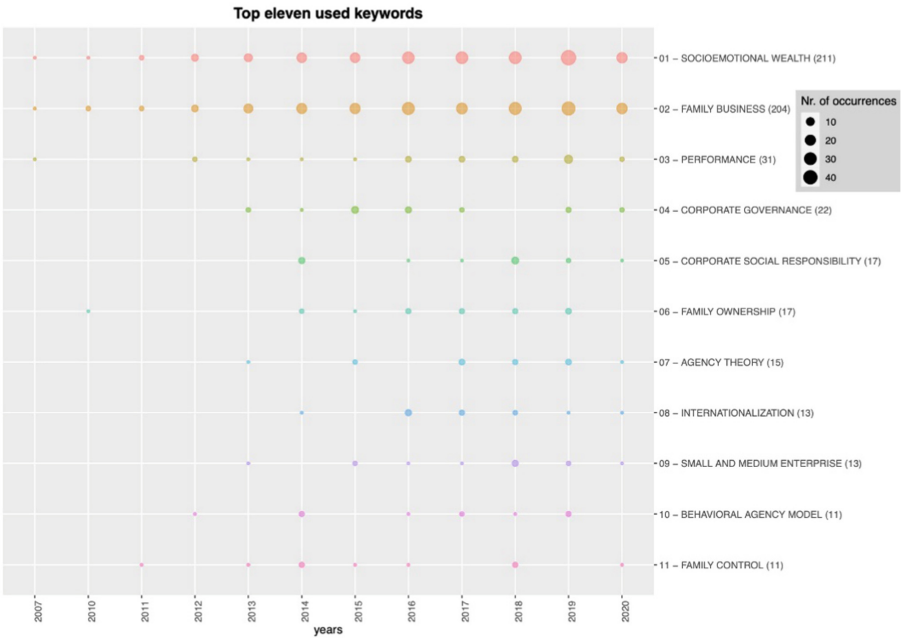

Fig. 6. The main ten keywords used in the dataset over the years.

The keywords analysis is used to have a more accurate information on the topics discussed in dataset. On the basis of the most popular keywords used in the dataset we create a graph based on their co-occurrences (Fig. 6). In the network, the keywords are the nodes and there is a link among two of them if those are mentioned together in the same publication (co-occurrence); the thickness of the connection is proportional to the number of contributions in which the pair appears (two at least).

Figure 7 shows the 41 most frequently used keywords and their connections. The size of each node (and its label) represents the occurrence of a specific keyword within the dataset.

The graph clearly shows the close connection between the two keywords "*SEW*" and "*family business*" and this is obviously determined by the fact that SEW is a theoretical model developed for to understand the family business behaviour. However, we also note the close connection between these two keywords and the keyword "*performance*", highlighting how there is an intense scientific debate on the relationship between SEW, family business and performance. The graph also highlights other important set of topics enriching the debate among those three keywords, such as "*agency theory*" and "*corporate governance*" (see the blue group of the nodes). Moreover, it is possible to recognize three other small subsets of topics connected with the two most recurring keywords, they seem mainly related to management (orange group), research and development (green group) and stakeholders (red group) issues. Finally, looking at the graph we can distinguish the set of topics connected to both the main recurring keywords (in

the center of the graph) from the ones only connected to SEW or only to family business (in the right or in the left side of the graph).

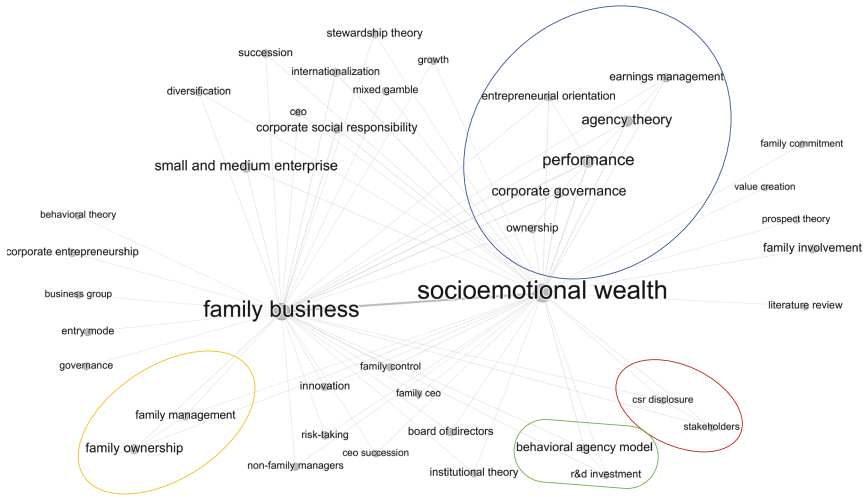

Fig. 7. Keywords co-occurrence graph.

4 Conclusion

This paper provides a preliminary analysis of the state-of-art and trends in SEW literature with the purpose to describe its patterns and to identify potential areas for future research. We use a bibliometric analysis of the scientific publication on SEW extracted from Scopus dataset. We performed our analysis using several measures and indicators in order to describe the evolution of the scientific debate on SEW and to outline the field.

Our results show that research on SEW approach is experiencing a great evolutionary phase as demonstrated by an increasing number of publications during the last years. This confirms the trend emerged in previous studies carried out in the general field of family business research which identified SEW as an emerging topics (e.g. Xi et al. [21]).

Concerning the production activity, ours results show that the debate on SEW is mainly developed in specialized journals of family business (*Family Business Review* and Journal of *Family Business Strategy*). This result differ from the ranking of the journal that welcome research on the broader theme of family business which, instead, is previously characterized by generalist journals (always after *Family Business Review)* (e.g. Benavides-Velasco et al. [22]). This result seems to suggest that research on SEW appears to be primarily aimed at scholars who are specifically interested in family business.

Moreover, a thorough analysis of the contents of the most cited article reported in Table 3, reveals that most of them are specifically focused of the theoretical dimensions, assessment, approach and the development of the theory of SEW, other articles relate SEW to others aspect of family firms behaviours, and a small parts of articles use SEW

as a theoretical lens for the development of their hypothesis or the argumentations in the paper.

Concerning the co-word analysis performed on the most used keywords by authors, our results suggest that there are some differences compared to some literature review on the general field of family business (e.g. Benavides-Velasco et al. [22]). Specifically, our study reveals that *corporate governance* and *performance* are the most used keywords (beyond *SEW* and *family business*) while in the general review the main theme is *succession*, even if issue of *corporate governance* is also among the most used keywords. This result led to a reflection on what issues the SEW can give better to explain the behaviour of family firms.

Our research also has some relevant implications for scholars, institutions, academic journal editors and family firms. First, our study suggests the relevance of the relations among topics (keywords), citations and journals for the development and consolidation of the SEW approach. This paper, by tracing the evolution of the studies on SEW can stimulate even more the development of the network among researcher, journals and academics. Second, our keywords co-occurrence analysis can represent a first starting framework on which to base for the development future literature reviews focused on the thematic clusters that develop around the SEW approach and that emerged from our analysis. This allows scholars to deepen their specific knowledge on specific topics related to SEW. Finally, for family businesses and consultants, this study highlights the importance of taking into consideration the dimension of the SEW (e.g. non-financial goals) when they want to understand the drivers of the behaviour of businesses characterized by family involvement. In fact, our analysis highlights how the theoretical construct of the SEW has contributed greatly to the development of the family business theory, through the analysis of its relationship with a series of different dependent variables (e.g. performance, internationalization, innovation, governance etc.) that have proliferated over time.

Our study is an initial step of our research project on exploring the characteristics of SEW discourse in family business. It presents some limitations which can serve as goals for future research. First of all, others bibliometric analysis can be applied to further develop this study in order to provide a more in-depth description of the structure of the SEW field, such as: co-citations analysis for investigating the main theoretical building blocks; the thematic map and thematic evolution for further analysing the topic and their relations discussed in the dataset recognizing emerging themes as well as declining topics. Secondly, the application of bibliometric analysis focused on the main topics connected to SEW debate, recognized by our analysis, can contribute to a wider understanding of the SEW relevance in family business studies.

Further research would also require investigating the relevance of the SEW approach with respect to different levels of family involvement in business, as well as taking into consideration the heterogeneity that characterizes family businesses. This would allow scholars and family businesses to better understand the weight and role of the socio-emotional dimension in strategic and operational choices. Finally, scholars could include these new topics into their research activities, recognizing new knowledge gaps, developing new research collaboration for addressing them.

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Does Self-attribution Impact on Investor Perception About Cryptocurrency Market Efficiency? The Mediating Role of Overconfidence

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Abstract. The paper aims to explore the self-attribution bias impact on investor perception about cryptocurrency market efficiency with mediating role overconfidence in the relation of self-attribution with perceived market efficiency. We opted to collect data via a convenience sampling technique by using electronic questionnaires and limiting our study to European cryptocurrency investors. Structural Equation Modelling outcomes indicate no significant impact of self-attribution bias on perceived market efficiency. Whereas it was found that overconfidence bias has a significant effect on perceived efficiency. Further, the decomposition analysis indicated the presence of the mediating effect of overconfidence in the relationship of self-attribution with perceived market efficiency.

Keywords: Self-attribution · Overconfidence · Cryptocurrency market · Perceived market efficiency

1 Introduction

The standard finance theories focus on the rationality and fundamental nature of any investment the investor makes but cannot explain the volatility of high speculative markets [1]. Investment and behaviour financial studies rely more on the behaviour of investors and how it impacts market returns instead of the fundamental principles of the business. At a time when blockchain networks began to gain prominence, bitcoin entered the market [2, 3]. Blockchain initially designed for the payment system. The amount of consumer-oriented purchases has increased in recent years [4–8]. Enterprises start to identify themselves as a payment system, but bitcoin users have found more new advantages for other purposes. From an investment point of view, this digital currency has an impressive feature and many possibilities, and which has already introduced in recent years. With bitcoin's success, cryptocurrencies have become a financial instrument in which people invest to increase their profits.

In recent year, cryptocurrencies literature has expanded due to an increase in investment which resulted in increased market capitalisation [9–11, 78]. Cryptocurrencies are

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highly speculative and volatile behaviours, that make them difficult to predict because they work on fundamental feelings that influence them more than others[12–14]. Initially, researchers began to discuss the factors and components of cryptocurrencies and how they contribute to the financial system presently in use [15, 16]. The massive increase in crypto currency trading has cause increase in the demand of cryptocurrencies due to which inflation is observed in the prices. This much growth in prices is may be due to behavioural biases, not because of the fundamentals.

In the behavioural finance spectrum, the growth and massive trading in cryptocurrencies are may be due to the irrational behaviour of investors. Also, low information availability and the sense of missing out the opportunity of profit-making are pushing them to invest in massive proportion and causing herding as well as a market crash. Behavioural and psychological biases play a vital role in generating anomalies in assets pricing, which may lead to inefficiency in the market [17–22].

The present study is based on individuals (i.e., investors) overconfidence and the variations in their confidence that may arise from another psychological bias self-attribution. The investor's overconfidence premise has been derived from the extensive body of knowledge and evidence from the experiments and cognitive psychological surveys that showed that individuals (i.e., investors) overestimate and attribute their abilities in different contexts. In psychological biases, overconfidence and self-attribution are considered to be a very critical and important factor playing a vital role in markets. Self-attribution refers to the tendency of crediting the success to one's talent and skills and blaming the failures to outside factors [23, 24]. This individual characteristic may often lead to overconfident instead of converging on an accurate self-assessment [17]. According to experimental psychologists and behaviourists, overconfidence refers to the tendency of individuals to consider themselves "above average" on positive characteristics [25], and it is a critical factor playing a very important role in the operations of financial markets [23, 26–28]. Previous studies also found overconfidence existence in different aspects of human and his behaviour, "perhaps the most robust finding in the psychology of judgment is that people are overconfident" [21, 22]. Overconfidence can explain some other anomalies such as trading patterns and their excessive trading prices [17, 28, 29], reversing of long-term funds [23], and excessive variations or volatility [17]. For instance, investors with high overconfidence levels are continuously engaged in spending their resources in acquiring more new and fresh information with this believe that can earn some abnormal and extraordinary gains. More precisely, overconfident investors expect to earn abnormal returns on the basis because they already invested a huge amount in acquiring new information [30]. Hence, they feel they are able to bring the stock's prices to their fundamental values by excessive trading in the market. Moreover, overconfidence bias causes investor to spend extra on research for getting more and more information and perhaps such overspending might not be only in one's self interest, it may be help full for passive investors too who can find and check now that the stock prices incorporated fully available information and markets are efficient [19, 31].

Previous studies have developed a model that shows how self-attributive, efficient, and inevitably overconfident novice traders take a high risk of investment [17], while

others focus more on the link between self-attribution and overconfidence with two settings that reflect the manager's convictions of future cash flows, showing that managers have a self-serving attribution that leads to overconfidence [24].

The present study investigates two critical questions. First, does self-attribution have an impact on the perceived cryptocurrency market? Second, does overconfidence is affected by self-attribution? and how overconfidence impacts on perceived market efficiency?

We target investors trading in equities and cryptocurrencies in Europe to better explain our research questions. The data collection started in early 2019 and finished between 8–14 months. Interestingly, 36.4% have more than 1 year of trading experience of crypto currencies and 63.6% has greater than 6 months but less than 1-year experience, which confirms the sample credibility to test hypothesis. Our outcomes indicate fitness of structural model, but insignificant significant impact of self-attribution bias on perceived market efficiency. However, results confirm the presence of mediating effect of overconfidence in the relationship between Self-attribution bias and perceived market efficiency. Further, the decomposition analysis highlights partial existence of mediating effect. Our study contributes in explaining the personal factors which motivates investors to invest in highly volatile markets and how their self-appreciation part of personality which translate into overconfidence and impacts individuals. Our study is one of the preliminary in field of behavioural finance which target cryptocurrency market and the investors.

2 Literature Review

2.1 Cryptocurrency and Market Efficiency

From past six decades, there is a debate among participants about market efficiency [32]. Efficient market hypothesis (EMH) states the prices of market securities reflect all available information. Furthermore, a strong market efficiency indicates that zero information is reflected by the prices of securities [33]. Also, when market information is costly, it is difficult for markets to be informationally efficient. Market prices randomly fluctuate and thus is difficult to predict their progress [34]. Similarly, same as standard finance theories and models, efficient market hypothesis also relies on some described assumptions. These assumptions include the rationality of investors, how information is perceived by all investors (i.e., in the same pattern or different ways), and if prices are closer to their fundamental values. Individuals can predict information and prices and this process enables them to make rational decisions [35]. However, decisions making are influenced by individual behaviour [12, 36] that in turn is influenced by personality traits [37–39]. However, individuals' preferences are different from the ideal rational individuals in multidimensional aspects [40].

In the recent two decades the global financial market has adopted technological innovations, which resulted in a modified mediator free transaction system. Cryptocurrency stands on these principles to provide mediator free payment system which reduce the cost and make the payment system quicker and more efficient [12, 41]. Bitcoin, one of the initial cryptocurrencies which gained the attention globally, has helped in transforming

the financial market. In 2008, bitcoin entered in the financial market as a digital currency/cryptocurrency and the digital payment system or mediator free transaction system has modified into a digital financial asset [12]. Starting from 2016, bitcoin has observed a gradual increase in investment which grabbed the attention of researchers, academicians, and policymakers. First studies primarily focused on determinants of cryptocurrency returns [42–44]. Subsequent studies, instead, considered the effect of clustering volatility [45–47], diversification, hedging, and herding behaviour [7, 12, 48]. The literature of cryptocurrencies based on standard finance theories and principles is expanding massively. However, there is a lack of studies that explore the investor behaviour perspective. Jalal, Sargiacomo, Zeb and Fayyaz [12] highlighted that though the cryptocurrency market is expanding quickly; however, it is difficult to explain through the rational principle of standard finance because individuals invest in highly risky investments that are not definable by fundamentals. From behavioural finance spectrum this may be due to irrational behaviour of the investors which is connected with their behavioural and personality part.

2.2 The Relationship Between Self-attribution Bias and Market Efficiency

Self-attribution bias is stated as individual tendency to credit all success resulted through combine efforts or individual efforts in his/her account and blame others for all sort of failures. The usual leads toward a misconception in such individuals that they started to believe that they are talented and outstanding [17]. The attribution theory states that individuals interpret some positive event occurrence as a proof of their better performance, talent and brilliance, events that interpret their actions to external stimulus. The behavioural and psychological literature evidence has highlighted that individuals take credit of their success on their own account and blame external stimulus for their failures [49, 50]. In household finance, self-attribution bias has been linked with individual overconfidence [28, 51]. Prior studies have highlighted the individual overconfidence affiliation with investment decisions because as the success in multiple investment increases, the investors' overconfidence grows [28, 52]. Other studies have linked overconfidence with diversification [26, 53, 54] showing that as overconfidence grows, there is an increased likelihood of in investment diversification. However, diversification is considered harmful to the consumers' financial welfare because it leads towards an initial performance increase and at subsequent difficulties in portfolio management because of the highly presence of systematic risks. It is believed that self-attribution bias misleads investors regarding their investment decisions and expertise which foster the excessive, uncalculated, without perception of market efficiency [23, 28]. Mushinada and Veluri [55] conducted a study on the Indian market to analyse investor's behaviour and the presence of self-attribution and overconfidence bias. They reported a positive association among self-attribution bias and investor trade performance is better in comparison to past, which confirms investors perception of market efficiency. Similarly, Kyle and Wang [56] and Odean [20] reported a negative relationship between self-attribution and perceived market efficiency, showing that the higher is self-attribution the lower is the perception of market efficiency. Above cited literature leads towards conclusion of negative relationship among self-attribution bias and market efficiency; thus, it is hypothesized that:

H_1: Self-attribution bias is negatively related to perceived cryptocurrency market efficiency.

2.3 The Relationship Between Overconfidence and Market Efficiency

Massive studies conducted in past has indicated that individual decision-making process is influenced by overconfidence [17, 19, 23, 26, 54, 56–59]. In terms of psychological judgements, overconfidence is defined as overestimation and perception of a concept and phenomenon which may influence the decision making choices [17]. In literature multiple outcomes of overconfidence bias has been identified. New entrepreneurial entries in market, and their failures are the example of overconfidence bias [60]. The behavioural and psychological perspective believes that behaviour influences individual decision-making, and each individual behaves differently as per its personality traits [12, 37–39]. Individuals preferences are different from the ideal rational individuals in multidimensional aspects [40]. Investors overconfidence can lead to irrational and excessive trading, whereas in managers this bias can increase their overtake intentions and activity [57, 61, 62]. Chen, Ross and Roll [50] have shown that overconfidence can leads towards in excessive trading in case of investors. Plous [63] said "in judgment and decision-making overconfidence is more prevalent and more terrible." Studies have also highlighted that managers who have overconfidence bias have higher expectation level as compared to those who are just confident, and these expectations when are not met influence them to commit frauds [64]. Overconfidence bias is measured under three dimensions i.e., overestimation, over-placement and over-precision. Overestimation refers to "overstating one's own ability" [65]. Over-placement meant "that whenever people think themselves as better than others" [65]. Finally, over-precision means that "it is the extreme certainty concerning the accuracy of one's belief" [17, 20, 28].

Prior studies were carried out to identify the impact of overconfidence bias and market efficiency. Overconfident investors face high risk due to the excessive trading [19, 20, 23, 60]. To measure the overconfidence massive investment, high risk associated with such investment can be used [28]. For instance, some authors considered the proposition that overconfident investors in the market are engaged in excessive trading and thus disturb market efficiency [21, 66]. Others examined overconfidence and its reaction to private signals and concluded that as a "consequence there created excess volatility and negative return autocorrelation" [20]. This indicates investor overconfidence leads towards misperception of market efficiency. Aligning with literature evidence it is hypothesize as follow:

H_2: Overconfidence bias is negatively related to perceived cryptocurrency market efficiency.

2.4 The Mediator Role of Overconfidence

Studies showed that self-attribution is strongly linked to overconfidence. Hirshleifer [23, 67] reports that over trust and self-assignment are static and dynamic counterparts. Self-attribution causes people to learn to become overconfident instead of converging on an accurate self-assessment. Gervais and Odean [17] have developed a model that

shows how self-attributive, efficient, and inevitably overconfident novice traders take a high risk of investment. Similarly, Feng Li [24] investigated the link between self-attribution and overconfidence with two settings that reflect the manager's convictions of future cash flows. The study showed that managers have a self–serving attribution that leads to overconfidence. Chen, Chang and Lee [68] analyse investments performance in 77 discriminatory IPO auctions in the Taiwan market by 6,993 investors, taking as representative of the number of IPO auctions in which investors place bids. This model for self–attribution predicts that former bidders are overconfident with successful initial bids and are likely to repeatedly bid and lead to lower performance. Gervais and Odean [17] claim that the degree of overconfidence declines with an investor gaining expertise. Investors gain experience through participation in the market according to their framework and therefore the level of experience depends both on the amount of time they spend in the market and the intensity of participation. Their research suggests that successful and inexperienced traders are overconfident. Locke and Mann [69] also say that traders with more experience are less inclined than their less experienced colleagues to take more risks after a time of abnormally good profits. In a study of overconfidence in financial markets, Menkhoff, Schmeling and Schmidt [70] found that investment experience and age have a significant impact on overconfidence and that as age and experience increase, overconfidence declines. Similarly, the Gloede and Menkhoff's [71] experiment shows that a person's working experience is accompanied by less confidence. Keeping all these in view we consider a mediating role of overconfidence in the relationship between self-attribution and perceived market efficiency assuming that:

H_3: Overconfidence mediates the relationship between self-attribution and perceived cryptocurrency market efficiency.

The research model depicted in Fig. 1 illustrates the core components of the study and how they are related.

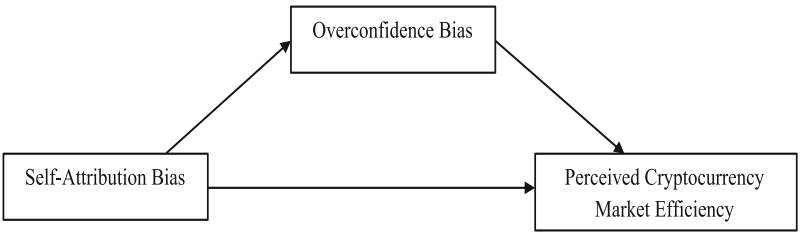

Fig. 1. Research model.

3 Methodology

Cryptocurrency markets are working without borders and as the currencies are not bounded by borders or by regions. Due to this globalised existence we opted to collect

data via convenience sampling technique by use of electronic questionnaires. However, we limited our study to European cryptocurrency investors, as outside the Europe cryptocurrency possession is considered as crime and is illegal. Data collection started in early 2019 and it took 8 to 14 months to collect data. In total we got 190 responses out of which 14 were not filled completely so were excluded from our study.

The sample is composed by 86.9% male respondents and 23.1% female respondents. Regarding the age, 51.7% percent of them have between 31–40 years old, 46.6% have more than 41 years old, 1.7% have less than 30 years old. Regarding the levels of education, 42% have an associate degree/diplomas, 32.4% have a bachelor's level degree, 22.7% have a master's degree, and 2.8% have a PhD level degree. Finally, we asked to mention if they have investment experience in cryptocurrencies; 63.6% have less 1-year experience of crypto-investment, 25% have 2–3 years of experience, and 11.4% respondents have more than 3 year of experience.

Perceived Market Efficiency is measured through technical analysis, on of item is "Active trading volume". Self-attribution is measured by shorter version scale of three items by Mishra and Metilda [72]. Overconfidence is measured by shorter version of original scale defined by Larrick, Burson, and Soll [65], Barber and Odean [28] and Odean [20]. All these variables are measured by Likert scale of five where "1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree".

4 Data Analysis and Results

We employed structural equational modelling (SEM) to analyse the data by employing R-Studio for this purpose. Before computing SEM, we checked common method bias (CMB). In order to avoid the CMB, we collected the data into two waves. In first wave we collected the data related to demographics and independent variable and in second wave dependent variable and mediator. Numerous authors recommended this method to avoid CMB [73, 74].Further, we empirically tested to trace any chances of CMB by applying correlation analysis. If study variables have correlation more than 0.90 it may be concluded as the presence of CMB in our sample the value is less than this criterion, so we can conclude that our data are free from CMB.

4.1 Measurement Validation

To check measurement validity, we tested convergent validity, discriminant validity of all latent variables. We calculated average variance extracted (AVE) to measure convergent validity and performed Fornell–Larcker test by taking square root of AVE to compare with correlation to confirm discriminant validity reported in Table 1. All items factor loadings were greater than 0.50 and average variance extracted is found is appropriate range as if AVE is greater or equal to 0.50 is acceptable, which is confirmed by taking square root of AVE and comparing it with correlation and it was found that correlation among latent variables are less than square root of AVE thus, convergent and discriminant validity of constructs is confirmed. Moreover, we checked VIF among self-attribution (SA) and mediator over-confidence (OC) and it is found that there is no multicollinearity. Also, the VIF in Table 1 confirms no presence of common method bias [75]. The results in

table indicates that Self-attribution is significantly negatively correlated with perceived crypto market efficiency ($r = -0.16$, $p < 0.05$). Also, Self-attribution bias is positively associated with over-confidence bias ($r = 0.45$, $p < 0.01$). Similarly, overconfidence is positively related with market efficiency i.e. $r = 0.29$, $p < 0.01$.

Table 1. AVE, convergent and discriminant validity and Correlations

	VIF	AVE	CR	Mean	S.D	SA	OC	ME
SA	1.00	0.51	0.80	3.77	0.63	**0.71**		
OC	1.00	0.52	0.76	3.76	0.36	0.45^{**}	**0.72**	
ME	–	0.50	0.78	3.97	0.57	-0.16^{*}	-0.29^{**}	**0.70**

Where, n = 176, "SA" = "Self-attribution", "OC" = Overconfidence", "PME" = Perceived Market Efficiency".
$^{**}p < 0.01$, $^{*}p < 0.05$.
Note: *"The data on diagonal is the square root of the AVE."*.

4.2 Structural Model

We applied structural equation model, to explore Self-Attribution Bias impact on investor perception about cryptocurrency market efficiency with Mediating role overconfidence in the relation of self-attribution with perceived market efficiency. Table 2 depicts standardised direct, indirect and to explain our hypothesis. The structural equational modelling is evaluated with measurement fitness with Root mean squared error of approximation (RMSEA), Comparative fit index (CFI), Tucker-Lewis index (TLI) and Standardised root mean squared residual (SRMR). RMSEA and SRMR value less than or equal 0.08 are considered as appropriate and nearer to zero, more appropriate the model is. Also, the value of CFI and TLI should be greater than 0.90 for fitness. Goodness of fit test indicates that our RMSEA = 0.026 which indicates our model is perfectly fit and SRMR = 0.053, CFI = 0.959 TLI = 0.911, means our model is appropriate.

Further variance inflation tests also indicate that model has no multicollinearity issues. The overall SEM explained overall total effect. But, to confirm mediation we need direct and indirect effects. Postestimation analysis, i.e. decomposition analysis, carried out to identify the direct and indirect effects to confirm mediation. Results reported in Table 2 explains the direct, indirect and total effect under mediation analysis. We hypothesised that self-attribution bias is negatively related with perceived cryptocurrency market efficiency. Results indicates the negative relationship, but is statistically insignificant ($\beta = -.09$, ns). Also, Self-attribution has significant positive impact on overconfidence ($\beta = 0.51$, $p < 0.01$). Also, we regressed overconfidence against perceived crypto currency market efficiency, before doing mediation analysis, it is found that overconfidence bias is negatively associated with market efficiency.

Further, mediation analysis in Table 2 in the presence of mediator in the direct effect among Self-attribution and perceived market efficiency of cryptocurrency market is significant, but it is reduced. The reduction in beta indicates occurrence of partial mediation.

Table 2. Linear and mediation analysis

Model 1			Model 2			Model 3			
Total Effect			Direct Effect			Indirect Effect		CFI 95%	
Path	Cofficient	S. E	Path	Cofficient	S.E	Path	Effect	LCI	UCI
SA → *ME*	−.09 ns	0.21	*SA* → *ME*	−.061**	.283	*SA* → *OC* → *ME*	.525*	.367	.211
Path	**Cofficient**	**S. E**							
SA → *OC*	0.51**	0.19							
OC → *ME*	−1.02**	0.28							
Where n = 176, S									

Also, indirect effect is significant which confirms the case of partial mediation. Further, to understand the strength of mediation we tried to observe VAF (variance accounted for). We found that our VAF values indirect effect is 583.33% which states mediation is partial [74].

5 Discussion and Conclusion

In the behavioural finance spectrum, the growth and massive trading in cryptocurrencies are may be due to the irrational behaviour of investors. Also, low information availability and the sense of missing out the opportunity of profit-making is pushing them to invest in massive proportion and causing herding as well as a market crash. Behavioural biases plays as very important role in generating anomalies in assets pricing which may leads towards inefficiency in the market [12, 21, 76]. We explored the self-attribution bias's impact on investor perception about cryptocurrency market efficiency, investigating the mediating role of overconfidence in the relation between self-attribution and perceived market efficiency. Cryptocurrency markets are working without borders and as the currencies are not bounded by borders or by regions. Due to this globalised existence we opted to collect data via convenience sampling technique by use of electronic questionnaires. However, we limited our study to European cryptocurrency investors, as outside the Europe cryptocurrency possession is considered as crime and is illegal. We found that self-attribution bias has a negative impact of perceived crypto currency market, but the result is statistically, insignificant. Kyle and Wang [56] and Odean [20] also reported negative relationship between self-attribution and perceived market efficiency. Means higher the self-attribution lowers the perception of market efficiency. Thus hypothesis 1 is not supported. Similarly, we found that overconfidence bias has a negative impact on perceived market efficiency indicating that hypothesis 2 is supported. Also, overconfident investors in the market are engage in excessive trading disturbing market efficiency [17, 28, 66]. Previous studies support our result. For instance, Hsu and Shiu [77] analysing investments performance in 77 discriminatory IPO auctions in the Taiwan market by 6,993 investors, show that bidders, which are overconfident with successful initial bids, are likely to bid and lead to lower performance repeatedly. Also, Mishra and Metilda's study [72] reported a positive relationship between self-attribution and overconfidence which aligns with our outcomes reported in Table 2.

Finally, the mediation analysis confirms that overconfidence mediates the relationship between self-attribution and cryptocurrency market perceived market efficiency. This due to the reason that self-attribution and overconfidence are related with each other [29, 72, 77]. When investors acquiring experience, the degree of overconfidence decreases. Investors gain experience by participating within their framework, and thus the level of experience depends on both the time and the intensity of their participation in the market [17]. Lower the experience higher the overconfidence and lower the understanding about market.

Above discussion leads towards the conclusion that self-attribution and overconfidence have a negative impact on perceived market efficiency which contribute in field of behavioural finance. These results support the theory of prospects and heuristic theories that advocate investors' inclinations to avoid losses potentials in risky situations that ultimately lead to wrong decisions. Irrational decisions can therefore lead to a market that either underreacts or overreacts. These two situations render the market inefficient. Investors cannot familiarise themselves with the idea of behavioural heuristics that exist in their nature and which have negative effects on market efficiency while making investment decisions. Based on our findings, we would recommend that investors attempt to identify, recognise and avoid the types of biases that exist in their character. Moreover, they should not invest on the basis of heuristics, but conduct a proper investigation of the investment opportunities available, develop investment criteria and meet investment objectives to achieve better investment opportunities.

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Transformation, Organizational Process and Procedures

Exploring Sustainable Value Creation of Industry 4.0 Technologies Within the Socio-technical Perspective: A Meta-review

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Abstract. Our study examines how the topic of sustainable value creation of Industry 4.0 employs the social-technical perspective. Sustainable value creation of Industry 4.0 is an emerging topic in the IS literature. The topic extends the IT value, a core topic of IS, focusing on the sustainable outcome of these leading-edge technologies adopted into the assembly line of manufacturing organisations called Industry 4.0. We conducted a meta-review of three systematic literature reviews of this topic from which we extracted 23 empirical case studies. We address this gap employing the socio-technical framework. The study revealed that the technical perspective in prominent in literature, but socio-technical perspective studies exist. We further propose research directions to make more socio-technical the discourse.

Keywords: Industry 4.0 · Sustainable value creation · Sustainability · Socio-technical perspective · Meta-review

1 Introduction

In 2019, Sarker et al. [1] launched a call to action for researchers and journals because the IS disciple is losing its distinctive trait - its axis of cohesion - the socio-technical perspective. The socio-technical perspective conceives the organisation is composed of social and technical sub-systems and advocated that they require joint optimisation to operate. The resulted interplay among the two systems delivers positive outcomes for the organisations [2].

Our study follows this study examining how the topic of sustainable value creation of Industry 4.0 (I40) employs the social-technical perspective. This topic is an emerging trend within IS research. I40 is an umbrella term referring to a set of advanced technologies – the Internet of Things, Robotics, Big Data, and Cloud Manufacturing – which are adopted into the assembly line within manufacturing organisations. The integration of I40 technologies deploys a programmable, interconnected cyber-physical system that automatically controls pieces of machinery in assembly lines. The way organisations use I40 technologies allows addressing the assembly line problems without human interaction [3]. I40 technologies extend the IS research since they differ from traditional technologies studied in IS – e.g. ERP and CRM - targeting the operational activities rather than

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administrative ones and allows to study how organisations exploit production process information [4].

Effective adoption of I40 technologies delivers various IT value in terms of increasing production process, higher quality products, less natural resource usage, and improved workforce conditions [5, 6]. IT value of I40 technologies is often evaluated in sustainability terms employing the triple bottom line. The triple bottom line is an analytical framework that allows studying how organisations address the three dimensions of sustainability: economic, environmental, and social. Under this perspective, the study if IT value creation, which focuses only on the IT impacts of economic performance, is named Sustainable Value Creation (SVC), thus embracing the environmental and social implications of I40 technologies.

To date, reviews summarised the SVC of I40 [7, 8] without assessing how the socio-technical perspective is employed. To address this gap, we make use of the socio-technical perspective framework by Sarker et al.[1], which is composed of 6 groups representing six facets of the socio-technical perspective. In type I and II, the social perspective is predominant over the technical one. In contrast, the technical perspective is predominant over the social one in type V and VI. In type III, social and technical components are considered additively. Finally, type IV represents the traditional socio-technical perspective of IS.

Therefore, we performed a meta-review analysis of three systematic literature reviews focusing on SVC of I40 from which we extracted 23 empirical studies of SVC of I40. Our study mainly answers the research question: "How does the Sustainable Value Creation of Industry 4.0 research embrace the socio-technical perspective?".

The contribution to the literature is twofold. We explore how researchers employ the socio-technical perspective in the SVC of I40, and we propose future directions for researches to increase the use of the socio-technical perspective.

2 Theoretical Framework

This section presents the discourse of sustainable value creation of Industry 4.0, the socio-technical perspective, and the socio-technical perspective framework.

2.1 Sustainable Value Creation of Industry 4.0

Industry 4.0 refers to a new and powerful industrial wave oriented towards digital and virtual technologies and is service-centred. The term "Industry 4.0" is derived from the German "Industrie 4.0" initiative launched by the German government in 2011. It points to ensuring the future competitiveness of the German manufacturing industry [9]. The principles of Industry 4.0 are the horizontal and vertical integration of production systems driven by real-time data interchange and flexible manufacturing to enable customised production [10]. Vertical interconnection means across several departments within an enterprise, and horizontal interconnection expresses digital information sharing across several partners within a supply chain, including the customer.

Industry 4.0 builds on several technological developments. The most significant components of Industry 4.0 are cyber-physical systems, the internet of things, cloud manufacturing, and additive manufacturing [3, 11]. Cyber-physical systems allow organisations

to integrate technologies enabling the self-decision making of technologies that afford to address mechanical issues without human interaction [3].

Industry 4.0 adoption is expected to deliver changes in economic, ecological, and social aspects [12, 13], which forms the triple bottom line of sustainability [14]. The study of how I40 adoption delivers sustainable value is called SVC. The main question underpinning the SVC value debate is whether and under which conditions I40 adoption delivers sustainable value to organisations. SVC extends the IT value study, a long-standing debate in the IS literature, which engaged scholars for a long time investigating the potential economic benefits consequent to organisational investments in IT [15–17].

2.2 Socio-technical Theory

Within the information systems literature, the Socio-technical perspective has introduced through two seminal articles by Bostrom and Heinen in the first MIS Quarterly, which presented the socio-technical theory [2, 18]. The socio-technical theory devises the organisation composed of social and technical sub-systems. The former sub-system embraces workers, their roles, and their rules. The latter sub-system includes tasks and technologies for accomplishing organisational activities [1]. The socio-technical perspective inherited the work system theory, which provides a perspective for understanding systems in organisations [19, 20].

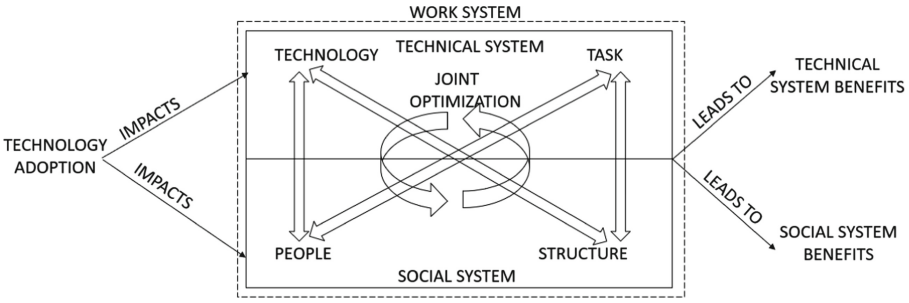

Fig. 1. Socio-Technical Model (adapted from Bostrom & Heinen, 1977a; Sarker et al., 2019)

Figure 1 depicts the socio-technical model to assess the organisational change triggered by technology adoption. The model views organisational systems as multivariate systems of two sub-systems, which are composed of four interacting and aligned components – task, structure, actor, and technology. During the technology adoption, socio-technical systems are open [21]. Therefore, systems need to adapt to their environment continuously to maintain the system state in equilibrium, where the four elements are mutually aligned.

The joint optimisation of both system stability involves stable relationships within and between the system components and its environment, which leads to improvements in both systems. In the technical systems, improvements concern a better performance and achieved economic objectives, whereas the ameliorations in the social system concern enhanced job satisfaction and higher quality of work-life [1, 22].

2.2.1 Socio-technical Framework

After a systematic literature review, Sarker et al. 2019 concluded that IT studies employ the socio-technical perspective in various ways. There are studies which privilege the social perspective over the technical perspective and vice versa. And studies which additively considers social and technical components as outcome antecedents and the traditional socio-technical perspective. The authors summarised the results in a framework composed of 6 types of studies in Fig. 2.

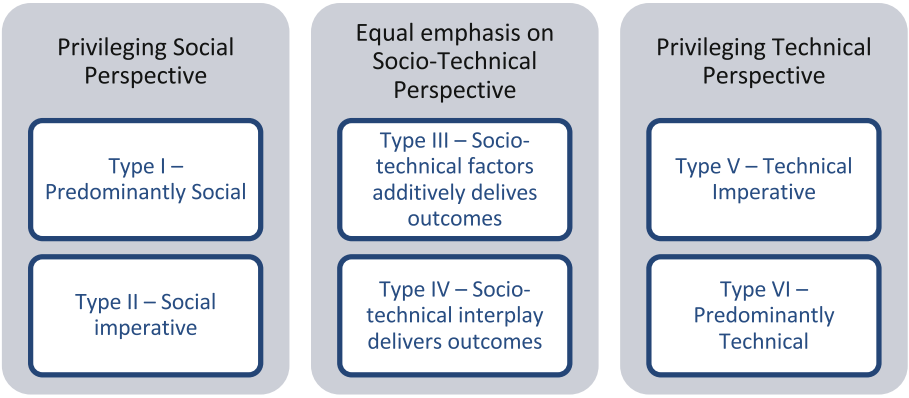

Fig. 2. Socio-Technical Framework

Type I "Predominantly Social": this group refers to studies where the investigation focuses almost exclusively on the social (including psychological, sociological, economic, or philosophical) aspects related to the phenomenon of interest, with technological or informational considerations serving as the context. Social components are the main driver for the outcome.

Type II "Social Imperative": this group refers to studies that consider technology a product of human choice and action. This perspective is closely related to the notion of "organisational imperative," where social aspects influence technological artefacts and their outcome [23].

Type III "Socio-technical factors additively deliver outcomes." This group refers to studies where social and technological factors additively deliver outcomes. Technical and social components are enabling factors to outcomes but without any sort of interplay.

Type IV "Socio-technical interplay delivers outcome": this group refers to studies where the socio-technical interplay clearly appears delivering outcomes. It is closest to the socio-technical perspective.

Type V "Technical Imperative": this group refers to studies where technology is a significant antecedent to social outcomes. In this conception, IT is viewed to bring structural, communicative, and decision-making changes in organisations a soft form of technological determinism.

Type VI "Predominantly Technical" group to studies where technology component is the sole precursor of the outcome. This body of knowledge is also known as design

research in the IS discipline. Here, the focus is on how to develop or improve the technical component.

3 Methodology

Meta-review refers to an analysis that combines results from many individual systematic literature review studies addressing the same research question. It is a valuable methodology for research synthesis [24]. We chose this methodology since several literature reviews of SVC of I40 appeared over the last years. Thus a meta-review allows us to summarise the findings. And to assess the state-of-the-art of socio-technical perspective of this topic. We performed a meta-review during February 2020. We searched literature review on SVC of I40 on Scopus and Google Scholar by the following keyword search: "industry 4.0" AND "literature review" AND "sustainability" OR "sustainab*" OR "sustainable value creation." We include the term sustainability because it is a close concept to SVC, and it is often used to indicate SVC outcome.

We limited the research within business and management studies and papers written in English. Scopus released 20 results. We read the title and abstract to check whether are literature review or different type of article – methodological, theoretical papers or literature review of diverse topics -. We include only literature reviews focusing on sustainability or SVC of I40 and excluding articles written in different languages from English. We reach a sample of 3 papers of systematic literature review. Therefore, we based meta-review on three literature reviews [7, 25, 26]. We thoroughly read the reviews extracting articles from references, which are empirical studies. We chose 23 empirical case studies of SVC in I40. We excluded the remaining paper since they are focused on different concepts. For instance, Piccarozzi et al. [26] review also I40 papers regarding production methods, business models or supply chain, while the remaining two literature reviews included several surveys or conceptual papers.

We examined empirical studies accordingly to the socio-technical framework [1], considering (1) how studies have enacted the presence of the social and the technical and (2) the relative outcomes.

4 Results

In this section, we present the meta-review results providing descriptive statistics of the results and distinguishing the results by the socio-technical framework.

4.1 Descriptive Statistics

The result of the meta-review includes 23 studies that cover a period from 2014 to 2019. Figure 3 portrays the publication trend of the meta-review. According to our results, the year 2017 is the most productive with ten published papers of empirical I40 articles.

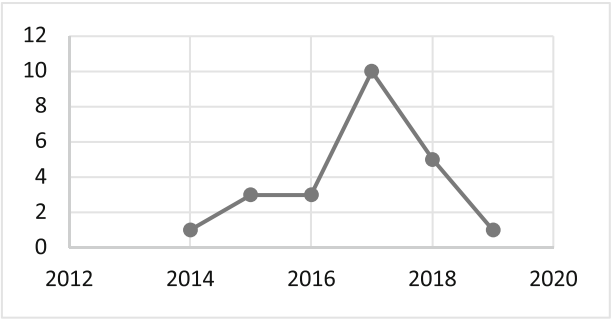

Fig. 3. Publication trend of meta-review

The meta-review includes four conference proceedings studies, two articles from the journal sustainability while the remaining articles come from engineering and information systems journals. Table 1 depicts details of journal publication.

Table 1. Journal publication details

Journal	Nr. of papers	Journal	Nr. of papers
Conference Proceedings	4	Sustainability	2
MECHANIKA	1	Int. J. Agile Systems and Man	1
Energies	1	Research-Technology Management	1
Intern. Journal of Production Research	1	Social Sciences	1
Intern. Journal of Innovation Management	1	Int. Journal of Production Research	1
AIChE Journal	1	Int. J. of Distributed Sensor Networks	1
Applied Science	1	Cluster Computing	1
Int. J. entrepreneurship sustainability issues	1	Engineering	1
Processes	1	Microprocessors and Microsystems	1
		Int. J. Advanced manufacturing techn	1

Figure 4 presents paper contributions by nations of the research team. China is the country which contributes with eight papers. Afterwards, we find European countries, especially Italy and Germany, contributing to an overall of 6 articles. We also saw three cross-country collaborations, namely, China and Canada, Estonia and Germany, and the UK and China.

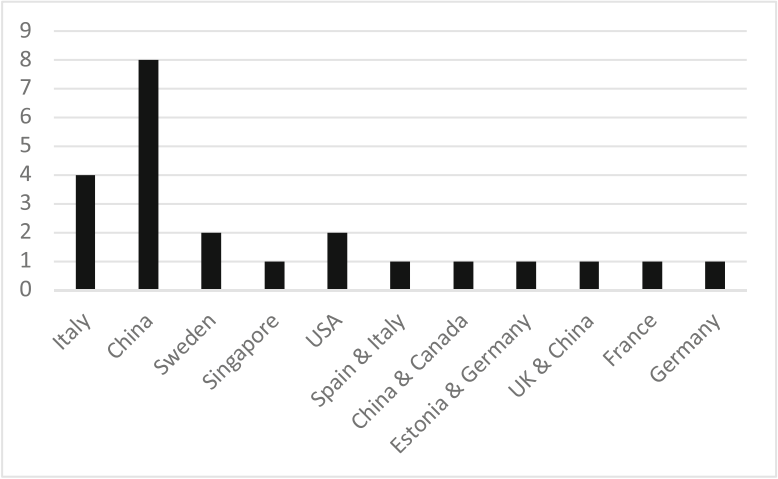

Fig. 4. Research teams by nations

Figure 5 depicts the most used keywords in the keyword section of the articles. I40 is the most used keywords (twelve times), while SVC does not appear. Instead, the keyword sustainability appeared five times, together with the keywords sustainable manufacturing (two times) and triple bottom line (two times).

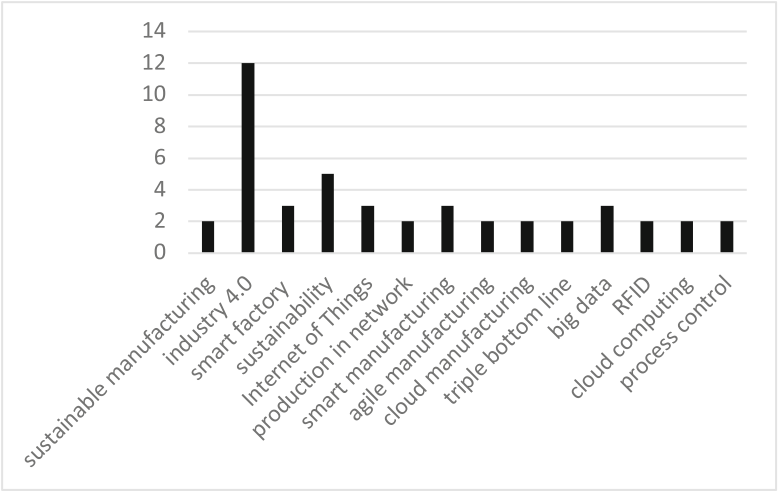

Fig. 5. Most used keywords in the keyword section of the articles (count 2)

4.2 Results

Figure 6 presents the results of the meta-review distinguishing papers by the socio-technical framework. Sixteen studies pertain to type VI where technologies are the main driver for delivering outcomes [27–42].

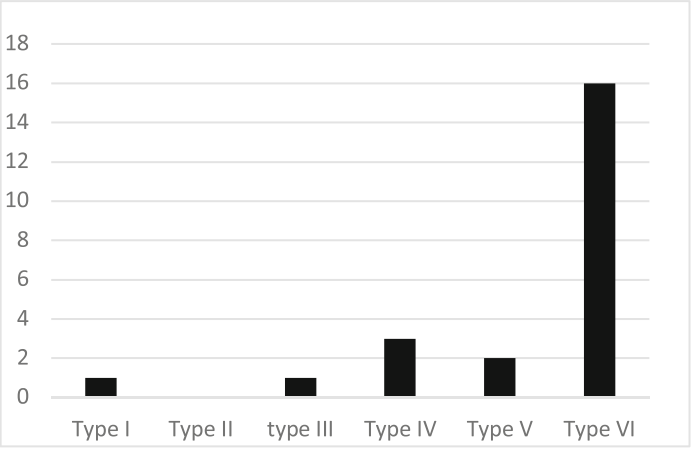

Fig. 6. Proportion of studies in different categories

Studies are devoted to studying how to improve technologies to increase the technical system outcome on organisational performance. Within the group, we found three main categories: design of I40 technologies, integration of two or more I40 technologies, and the deployment of the smart factory through the cyber-physical system. The category of design of I40 technologies includes coding algorithms for big data to improve production efficiency, delivering economic value for organisations [39]. The category of integration of technology includes studies in which I40 technologies are implemented in organisational units. In these studies, the focus remains on technology issues without considering social aspects. The outcome of these studies is also on the social and environmental dimensions. For instance, [43] presents a study where IoT adoption allows optimising the assembly line of a sole company. The IoT adoption reduces faulty products and improving workforce conditions through the monitoring posture and pace of workers. The last category concerns the smart factory deployment, where is deployed the cyber-physical system [32, 37]. In these studies, the foci are on integration issues of technologies, business process reengineering, and how technology can communicate. The outcome presented in the studies is higher than the other groups. The deployment of cyber-physical systems allows to deliver sustainable value in higher efficiency; reduction of natural resource usage and safer workplace.

Type 5 [44, 45] considers researches where technology is the main driver for social outcomes. These studies present broad I40 adoptions where the main focus is on technologies creating a new way of production, which impacted social system delivering outcomes. For instance, Yuan et al. [45] present an I40 adoption transforming an oil refining and petrochemical plant into a connected and information-driven I40 plant

environment. Using real-time and high-value support systems, I40 plant enables a coordinated and performance-oriented manufacturing enterprise. That responds quickly to customer demands minimising energy and material usage and increase safety at work automating unhealthy activities and monitoring plant status.

There is only one exemplary case for Type I [46], where users are the primary driver of I40 outcome. The case highlights managerial practices that allow I40 users to accommodate the acceptance of I40 technologies and their utilisation. Under this perspective, the study claims that I40 organisation should develop an organisational structure that provides users more autonomy through a matrix structure or a flat hierarchy. Moreover, leadership style should encourage an organisational climate for innovation and human resources practices – such as training courses or training on the jobs – that allows users to learn competences to use I40 technologies.

For Type 3 [8], we found exemplary studies where social and technical systems deliver benefits additively but without any sort of interplay. In the study [8], the authors present benefits and challenges of I40 adoption for the delivery of sustainable value creation where social and technical parts contribute to the value creation but without considering their integration.

In type 4 [12, 47, 48], there are the closest studies of the socio-technical perspective. The studies show the two sub-systems, the difficulties in the adoption process to reach the joint optimisations of sub-systems, and the socio-technical interplay whit consequent outcomes for both systems. In the study [12], I40 technologies are adopted in the assembly line where the low skilled workforce was employed. During the adoption, process technologies are integrated into the assembly line while the workforce attended vocational courses to work with technologies. The adoption was hard since I40 technologies required a workforce with higher informatic competences. The joint optimisation is reached where the workforce affords to use technologies which perform with a feasible speed. The socio-technical interplay concerns technologies producing the goods while the workforce supervises technologies and provides feedback to technology experts to maintain constant the production process. The study also explains that I40 delivered sustainable value creation and therefore benefits in the two work systems. In the study [47], the socio-technical interplay exists when the workforce employs data to maintain constant production and fix mechanical issues. In this study, I40 adoption delivers an outcome for the environmental dimension supporting circular economy practices. In the study [48], authors present adoption details for the social and technical systems. While technologies are integrated and adopted into the I40 plants, the workforce is informed regarding the adoption. Also, they attended courses to use the technologies. The interplay exists when the workforce affords to analyse data that are effectively retrieved from technologies.

5 Discussion and Future Directions

The results of the analysis show that the socio-technical perspective is not prominent within the SVC of I40.

From the descriptive analysis, we noted a lack of studies within the basket of eight IS core journals, which show that SVC in I40 is an emerging topic, but it is not a prominent

area of high-quality research of IS. We encourage scholars to engage the topic of SVC of I40 for two main reasons. Firstly, SVC complements the IT value topic embracing the discourse of sustainability. It is currently required for IT technologies to create value not only on the economic performance of the organisation. But they have to create value for the organisations addressing both environmental and social issues. This shift towards the interest of financial outcome to sustainability outcome is already in place in the IS discourse. New topics emerged recently – GREEN IS and ICT for sustainable development – in IS core conference, which includes track focusing on the sustainability of IS.

In contrast, others include sustainability as the core theme of the conference like ECIS 2020. Therefore, SVC topic allows for embracing sustainability topics holistically. Secondly, contrary to IS research, which mainly focused on ERP, CRM, and CSCW and how to exploit administrative data, I40 technologies are designed or equipped by sensors to acquire data regarding the production process. Therefore, I40 technologies pave the way to extend IS research exploring production process data generated [4].

Furthermore, I40 technologies allow exploring whether the building blocks of socio-technical systems have changed [49]. Similarly to the situation in which the researchers of Tavistock were to study the "longwall method" [50], I40 raised similar and more articulated concerns regarding the technology impact on the social systems within the production process since decision-making automation of technologies may supplant workforce activities. So far, these social aspects have not studied yet. Accordingly, for these reasons, we encouraged IS scholars to start analysing the topic of SVC of I40. Although the technical perspective is prominent in the review, we noticed these studies argued that there is a need to embrace the classical socio-technical perspective, including workers in the adoption process. For instance, Prause et al. [42] present a failure adoption of I40 where the main problems were the lack of social systems inclusion during the adoption.

Furthermore, we noticed that the technical perspective is prominent due to the early stage of I40 technologies. Most of the studies concentrate their effort to check the feasibility of I40 technologies, whether they can be developed and integrated. Therefore, to make the research more socio-technical, a turn is required from the focus of technology integration towards the adoption of technologies. The integration includes the implementation of only technical systems, while adoption includes the implementation phases where technical systems and social system are optimised to reach an effective utilisation.

Despite type III and IV focused on the technical and social outcome, the remaining studies consider the I40 adoption as a vehicle to reach technical outcomes without considering the social outcome, that is, I40 technologies that allow an efficient production process reducing energy usage. Further studies should link social goals from the beginning. This is twofold beneficial. Firstly, for a socio-technical point of view, it aims at the humanisation of the workplace, which is the first socio-technical purpose. Secondly, to embrace the social dimension of sustainability concerning organisational attitude to improve workforce condition, which is the less studied within the review.

Finally, further studies should concentrate on investigating the remain socio-technical concepts that remain unclear within the discourse of SVC of IS: the role

of workers and where the socio-technical interplay exists in an I40 context. The few socio-technical studies of type IV group present workers – the primary user of I40 technologies – with a hybrid role between manual workers and maintenance workers while the interplay consists in the supervision of technologies or the analysis of data to address mechanical issues of technologies. However, these studies are not enough to shed light on these two concepts.

6 Conclusions

In the study, we analyse how studies employ the socio-technical perspective of the discourse of Sustainable Value Creation of Industry 4.0. We performed a meta-review of three systematic literature reviews selecting 23 empirical case studies, which became our research sample. The technical perspective is prominent in the literature. Thus we propose future directions of research to make the topic more socio-technical.

The study proposes implications for practitioners since they can use the meta-review as a blueprint for I40 adoption and I40 integration to reach a sustainable value in which several best practices of I40 adoption and integration are highlighted. We acknowledge that the study has limitations. Based on three systematic literature reviews, there is the possibility to have omitted empirical case studies of SVC of I40.

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Digital Metamorphosis Competencies as a Human-Centric Approach to Digital Transformation: An Instrumental Collective Case Research

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Abstract. This paper investigates the managerial competencies played at different phases of digital metamorphosis projects. We define digital metamorphosis as the socio-technical counterpart of digital transformation in organizations, where the former focuses more on people's skills, managerial attitudes and organizational behaviours rather than on mere technology innovation. We applied an instrumental collective case research method, aimed at understanding whether managerial competencies were present and how they configured during projects ranging from consumer services to organizational digitization. We collected data of six digital projects with semi-structured interviews carried out in six companies, featuring heterogeneous sectors, size and technology adoption levels. For each project, we asked which competencies were expected in each project phase, and which of them were observed instead. We recorded relevancy ratings and contextual insights about their successful application during the projects ongoing. We report our findings and discuss them in the vein of questioning concepts like fixed managerial roles, traditional project management and design methods in organizations. We argue that all of these concepts may be challenged by the metamorphosis of practices, people skills, and projects design that the new wind of digital disruption is weaving.

Keywords: Managerial competencies · Digital metamorphosis · Digital transformation · Digital maturity

1 Motivations and Background

Since the early days of digitalization, transformations occur at different points, levels and pace in organizations. Digital transformation is the most adopted concept currently being defined as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial 2019, p. 118), which practically inflects in "a process wherein organizations respond to changes taking place in their environment by using digital technologies to alter their value creation processes" (Vial 2019, p. 119).

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Despite the above generalization of the word "transformation" to both social and technological ambits, we would like to focus into the digital discourse about the duality inherent to socio-technical transformations (Bostrom and Heinen 1977), and propose the concept "digital metamorphosis" to highlight the difference with digital "transformation". In Table 1, we propose few terminological hints to make these two concepts diverge through their properties, we would like to spend some more words hereafter to introduce this difference. We may state that digital "transformation" relates to the "what" is being transformed, to the atomic (and possibly rule based) steps of a process whose objects are "cold" (i.e., finalized, cf. Latour), and whose target are information, technologies and procedure that become digital, in the sense that they are codified into, managed and controlled by IT artifacts. Digital transformation is an "explicit" process and, as such, can be transparent, observable and objective. At the opposite, we relate digital "metamorphosis" to the "whom" is being transformed. We intend digital "metamorphosis" as an organic and systemic transformation of "hot" (i.e., continuously ongoing, cf. Latour) and "implicit" processes acting at different levels in a whole organism, or body, which determine a "qualitative change" only observable at the systemic level. We intend this change to be "embodied" into an organism, which can be an entire organization, and hence opaque, irreducible and subjective (Clegg 2000).

Table 1. A comparison of properties making in a socio-technical perspective.

Heading level	Digital transformation	Digital metamorphosis
What	Technology	People
Perspective	Objective/technical	Subjective/social
Granularity	Atomic	Systemic
Kind of change	Traceable/transparent	Complex/opaque
Entities under exam	Tools	Competencies

In this paper, we adopted the perspective of the "digital metamorphosis" and, in particular, we propose a lens of analysis of whether and how managerial competencies are present and should be revised in digital metamorphosis projects. To this aim, we took as unit of analysis digital metamorphosis projects that have been deployed in organizations. These organizations were instrumental collective cases (Baxter and Jack 2008; Stake 1995), which were analyzed to understand the competencies required in projects of digital transformation. We applied instrumental case study research, since we chose to analyze only one aspect (managerial competencies) of one project per organization taken into exam. By choosing this method, we are aware that cases are only instrumental and not comparable, or that they are only partially comparable through the properties of each project in each organization. The focus of our study is that of gaining insights of managerial competencies through these lenses.

To this aim, we first analyzed the literature related to managerial competencies and to technology maturity models in organizations (Ravarini et al. 2020). In both, we found a research gap inherent to a unified vision of the managerial competencies that are necessary in different phases of digital transformation. Regarding managerial competencies in digital transformation, researchers are mostly tied to the concept of managerial roles, among which the Chief Digital Officer (CDO) and the Chief Information Officer (CIO) are the ones mostly taken under scrutiny (see for example Peppard et al. 2011, and Tahvanainen and Luoma 2018). Whenever competencies are analyzed, they are confined to specific sectors (Mavlutova and Volkova 2019), and they are neither detailed (Weber et al. 2019), nor taken extensively (Obradović et al. 2018). On the other hand, technology maturity models frame the development of projects into a set of phases, but the competencies needed at each phase are scantly taken into exam (see for example the digitization maturity model for the manufacturing industry supply chain developed by Kotzler in 2017), and never put in the spotlight for integrating the two visions that sociotechnical perspectives bring to the foreground. Our idea was to address this research gap by delving into the phases of a digital project, from its inception to its go live, to look at what managerial competencies were considered either expected or observed in real projects in enterprises. In this way, we aim at filling gaps related to the lack of definition and association of competencies, with the consequent gaps in information for resource allocation in each project phase, lack of team configuration and recombination, lack of good resource planning, continuous learning and organizational change. In particular, our study poses the following research questions:

- What are the managerial competencies in digital metamorphosis projects and what are their contextual scopes?
- Are managerial competencies all equally relevant in each phase of a digital metamorphosis project?
- May competencies be sieved into "core" and "nice to have"?
- Were all of the expected competencies in some phase of the project also observed?
- Are competencies all vertical to a project phase or crossing the whole project?
- What are the managerial roles that are necessarily taking part to projects and/or project phases?

The paper is structured as follows: Sect. 2 provides details about our method of identification of managerial competencies, digital projects phases to frame the projects analyzed, as well as the method exploited to investigate the cases. In Sect. 3 we report and discuss the findings, and in Sect. 4 we draw conclusions, current limitations and future directions.

2 Method

As introduced above, in this study we adopted the instrumental collective case study research method (Baxter and Jack 2008; Stake 1995). Six digital metamorphosis projects were our unit of analysis. Organizations (cases) where these projects took place were only instrumental to gain insights about managerial competencies, in order to refine

the theory about digital metamorphosis in organizations. Our findings are referencing the external constructs of managerial competencies (Baxter and Jack 2008), hence the several projects in organizations are to be considered as instrumental and collective cases (Stake 1995). Our theory about managerial competencies was the outcome of a literature study about managerial roles facing digital transformation in enterprises (Ravarini et al. 2020). The outcome of this study was a list of managerial competencies enacted into digital metamorphosis projects, reported in Table 2. The unit of analysis phase model that we adopted along the study of the cases is described in Sect. 2.2. The method used for collecting data was that of the semi-structured interviews to managerial roles, who were responsible of a recent and prominent digital metamorphosis project carried out in their organization. The main topic of the interviews were the managerial competencies put into play in each phase of the project at hand. For each competence and for each phase of the project, we asked respondents to give an expected relevancy rating of that competence in that phase and an observed relevancy rating of the same competence in that same phase (see Sect. 2.3 for details on the interview part).

2.1 Managerial Competencies: Definition and Theoretical Background

According to OECD (2005), a competence is "more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context" (Ilomaki et al. 2011). For this reason, we argue that one of the effective ways for assessing competencies is to observe them in their dynamics and relationships with other competencies, i.e., in real case scenarios, where the knowledge, skill or experience of people may be (as said above) "mobilized". As introduced above, in this study we investigated the managerial competencies identified in (Ravarini et al. 2020) and reported in Table 2.

Such competencies had been the result of a broad literature review spread along three fields of research. A first, very classical field that we reviewed is the vast area of information system strategy (Fitzgerald 2013; Hess et al. 2015; Westerman et al. 2014). A second field deals with digital transformation at the organizational level, within the rich stream of research that falls under the name of technology capability models. Within the stream we found recent articles mentioning – though marginally – the competencies required to enable such transformation (Brooks 2015; Klotzer 2017). The last research field concerns the evolution of the role of the CIO (Chief Information Officer), possibly confronted with the role of CDO (Chief Digital Officer). The literature on this topic is particularly fertile in recent times, and provides numerous indications of the competencies needed by these organizational roles (Peppard et al. 2011; Tienan et al. 2016; Westerman 2013), but shows at least two critical limitations. First of all, these competencies era generally related to the whole organization, which we believe is a unit of analysis too complex to allow a clear view of the relationship between competencies and success of the transformation. Second, the papers focused on the CIO role lack to consider the possibility that a broader range of organizational roles (and thus a broader range of competencies) might be essential for the success of a digital project. To cover these gaps we joined the outcomes of the three research fields and proposed the framework shown in Table 2. There, some competencies refer to knowledge or expertise about an organizational or a technological aspect of the enterprise; some others refer

to technological or operative skills; other are recalling soft skills and leadership. The broader the spectrum of competencies analyzed, we argue, the lower their granularity may be, and the more their relationships, interactions and spontaneous clusters may be made explicit.

2.2 The Unit of Analysis

The unit of analysis of our study were digital metamorphosis projects. To delve into each project, we referenced each phase as reported in Fig. 1.

The phases were all taken from the framework of Brooks et al. (2015) for the development of a healthcare business intelligence maturity model. Only the disposition of the two phases "Evaluate" and "Communicate" were moved by making them crossing all the previous four phases, meaning that in our model they are always active, and the relevancy of the competencies as-signed to them were to be considered as a whole project relevancy. Each phase may be briefly defined as follows: the "Identify" phase (F1) refers to the monitoring of technological trends, with the aim of evaluating applicable digital scenarios; the "Define" phase (F2) regards the setting of the technological tools and the human resources for starting the project; the "Design" phase (F3) has as scope the technology and organizational design of the digital project; the "Develop" phase (F4) refers to coordination of resources, costs, and times up to the Go Live of the project; the "Evaluate" phase (F5) deals with knowledge of the risks, impacts, and consequences of the project; and the "Communicate" phase (F6) regards whatever kind of relationship maintained with any of the stakeholders of the project during the project ongoing.

Fig. 1. The phase model of a digital metamorphosis project.

2.3 The Interviews

In this study, each competence was operationalized as an item to be validated as follows: we asked to our informants to rate the a) expected and b) observed level of each competence in each of the six phases of our reference model (Fig. 2). The rating was based on the following differential scale: no relevancy (0); very low relevancy (1); low relevancy (2); medium relevancy (3); high relevancy (4); very high relevancy (5). The semi-structured interview was divided in two main parts. In the first part, respondents were asked to describe the project from their point of view. The second part of the interview was driven by a canvas, where a list of competencies and the six phases of the project were shown to each respondent in tabular form. The list of competencies

followed the alphabetical order. This order was chosen to avoid influencing the respondent by putting competencies in some suggesting context (e.g., the one of managerial activity), with the risk of hindering the objectivity of the judgement on the focus of our study: the competence alone. In this way, the only biases were limited to the novelty bias or to the fatigue bias that may have shown at the beginning of the interview and at the end of it, respectively. These biases were managed by reshuffling items in random order at each new interview. At the end of each interview, we asked the interviewees to specify which were all the organizational roles involved in each phase of the project.

Table 2. The managerial competencies identified in and enacted in digital metamorphosis projects.

Competencies Group	Competencies included (full names in Fig. 3)
Analytical Data Management (A)	C1, C2
Project Management (PM)	C3, C5, C8, C13, C19
Coordination Management (C)	C4, C7, C9, C12, C14
Change Management (CM)	C6, C16, C25
Business Process Management (BP)	C10, C20, C21, C23, C24
Technological Management (T)	C11, C18, C26, C27
Operative Management (O)	C15, C17, C22

3 Results and Discussion

After launching a call for digital metamorphosis research among our proximity business partners, we identified six organizations that were heterogeneous for business sector and size. We carried out a total of 14 semi-structured interviews, in the period February-June 2019. For each interview, we asked the respondents to give a rating for each competence of our list of twenty-seven competencies. More precisely, we asked to express two ratings: a) how much relevant one competence was expected to be in each phase of the project under exam, b) how much relevant that competence has been observed in each phase of the same project. All of the interviews were recorded and then transcribed with NVivo Transcription[1], and partly adjusted by hand (e.g., by reporting the name of each participant beside any speech part).

The projects and organizations analyzed in our research were classified in the diagram of Fig. 2. This schema borrows "Organizational levels" and "Technological levels" from the maturity model of Schumacher et al. (2016), focused on Industry 4.0 digital readiness; and the Kotzler et al. (2017) digital maturity model for the manufacturing sector. All of the six projects analyzed had different targets, goals, and organizational as well as technological levels. In particular, the project carried out by the enterprise in the "media

[1] https://www.qsrinternational.com/nvivo/nvivo-products/transcription.

publishing" sector was aimed at introducing an ERP for managing operations. That is a quite traditional project of digitization, which occurs at the operations level, and hence we classified it at the bottom and leftmost areas of the above schema, respectively. The second project taken into exam regarded the digitalization of the "manufacturing I" catalogue of core products, made in order to automatize request for quotations practices. This catalogue included many spare parts and complex configurations of products.

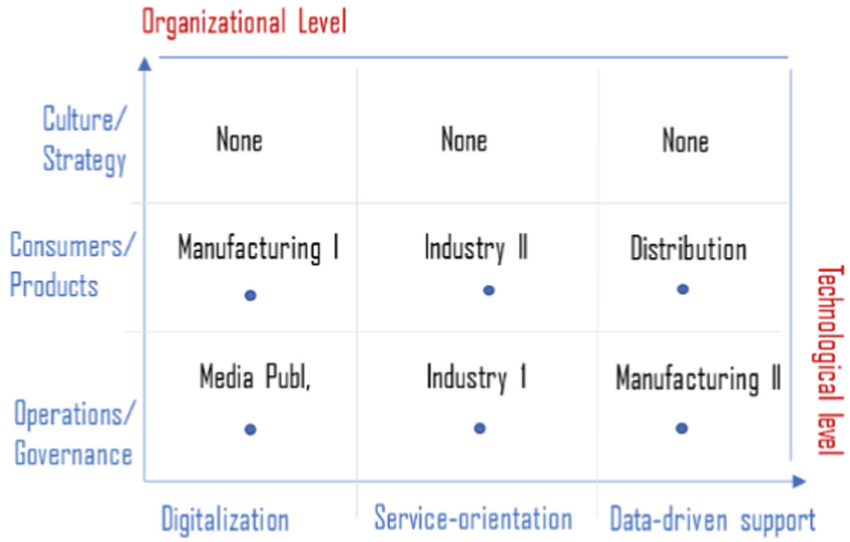

Fig. 2. A systematization of the digital metamorphosis projects taken into exam.

Managing offers by hand was very demanding, and often constrained sales people work. This project aimed at preventing them from doing mistakes when assembling prices of spare parts for unstandardized client requests, so that they could focus more on promoting sales and less on backend work. As this is a product innovation project, we put it at the mid level of our organizational dimension; on the other hand, since it was an internal product innovation, we placed it at the bottom of our technological dimension. The third project analyzed regarded "industry I" advanced software development and deployment, by digitization and standardization of operational software life cycle steps. The organization exploited an existing framework for software deployment. For its nature, we classified this project at the bottom level of our diagram (since it was an internal governance project) and at the mid level of the technological dimension (since it exploited an advanced software development paradigm).

The fourth project was carried out by the "industry II" organization. This project aimed at providing customers with a request for quotation device at their offices. This was classified as a mid range project both in terms of organizational level (its target was the external consumer) and technological level (its technology logic was service-oriented). The fifth project under exam was that of "manufacturing II", who conceived an advanced data-driven support device for the maintenance of its production implants. For this reason, the project was classified as low level in terms of organizational level

(as it was operations oriented) and at very high level in terms of technological level. The last project was accomplished by the "distribution" company. This project aimed at profiling consumers and at offering services based on advanced data mining techniques. It was classified as mid organizational level, being it oriented mainly to customers, and at high technological level, being it fully data-driven.

3.1 Quantitative Results

The competencies rated by the respondents were first analysed individually, then grouped in formative managerial activities, to carry out an aggregate analysis. Cronbach alpha was computed for each formative grouping, for both the "had been" (expected) and "has been" (observed) ratings collected in the interviews. The reliability coefficient resulted above 0.70 for each aggregation. Regarding the individual analysis of competencies, the results show that the competencies exploited more often were those related to Business Process management for the "Manufacturing II" project, as well as "focus on results" for the "distribution" project, and "develop trust relationships within the project team" for the "industry II" project.

Regarding the average relevancy for both the expected and the observed ratings, there was a 47% of the ratings that did not change between the expected and the observed groups, the 39% of the total ratings were higher than expected, and the 14% of ratings that were perceived as highly expected had fallen short of expectations. These latter were: the two competencies related to the Analytical data management; the competencies "knowledge of the business processes" and "identify the main critical issues affecting BPs" of the Business process management group; "communicate effectively the results achieved" and "drive the whole organization towards the focus on results" of the Coordination management group; "manage possible delays" and "monitor cost and timing of the project" of the Operative management group; "allocate the resource of the team" and "build a structured project plan" of the Project management group; and "monitor the technological trends and their potential" and "knowledge of the strategic impact of the technology to exploit at best its potential" of the Technological management group.

Regarding the project phases, the number of organizations who rated the competencies as relevant in each phase are reported in Fig. 3 (leftmost heatmap). From this view, it results that competencies mentioned 4 times in a phase were considered relevant to some degree by all of the organizations involved. They were: "knowledge of the business process to facilitate integration" for the "Design" phase; "communicate effectively the results achieved" for the "Communicate" phase, and "allocate the resources of the team" for the "Define" phase.

On the other hand, competencies never perceived as relevant from organizations in specific phases were: "identify the main critical issues of the BPs" for the "Develop" and "Communicate" phases; "become spokesperson of the transformation" for the "Design" phase; "communicate effectively the results achieved" for the "Identify", "Design" and "Develop" phases; "let the business perceive the potential of the DT carried out" for the "Define", "Design" and "Develop" phases; "knowledge of the organizational structure and strategic objectives" for the "Develop" phase; "monitor cost and timing of the project" for the "Identify", "Define" and "Communicate" phases; "allocate the resources project team" and "build a feasible project plan" for the "Evaluate" and the

"Communicate" phases; "manage the project team" and "motivate the team" for the "Identify" phase; "integrate the technology chosen for the project with the existing IS", "monitor the technological trends and its potential" and "knowledge of the requirements derived from the digital technology involved" for the "Communicate" phase; "knowledge of the requirements derived from the digital technology involved" and "knowledge of the strategic impact of the technology involved to exploit at best its potential" for the "Develop" phase.

The lack of relevancy of technological management competencies in the "development" phase may suggest that a strong technological awareness was a prerequisite for the implementation of projects, rather than a current requirement of the development phase. In general, for the "Identify" phase the most relevant activities were those of the Project management; for the "Define" phase, they were those of the Business Process management as well as those of the Coordination management. In the "Design" phase the most relevant competencies included those of the Business Process management, of the Project Management and of the Technological management. In the "Develop" phase the most relevant competencies included those of the Operative management and those of the Project management. The "Evaluate" phase showed that the Change management activities were the most relevant; and the "Communicate" phase included more competencies from the Coordination change management, as well as the "focus on results" single competence. These ratings may suggest a strong separation of concerns of the kind existing between "soft skills phases" (e.g., in the "Communicate" phase) and "hard skill phases" (e.g., in the "Develop" phase), at least for some phases and for some group of competencies.

Detailed occurrences of the number of times that competencies were rated as relevant by phase groups and by technological levels are reported in the rightmost heatmap of Fig. 3. The descriptive statistics of the competencies ratings, for both the expected and the observed relevancy ratings, are reported in Fig. 4. These statistics were summarized by grouping competencies by managerial activities, and pair-wise phases grouped by the supersets: "Pre", which contains the Identify (F1) and Define (F2) phases, and stands for "preliminary phases of the projects"; "Core", which contains the "Design" (F3) and "Develop" (F4) phases; and "Along", which contains the "Evaluate" (F5) and "Communicate" (F6) phases and stands for "crossing the whole project". Each group is represented by two adjacent charts, respectively: the one of the expected and the one of the observed ratings. The range of ratings is represented by the box plot areas, while the average, the 1° and 3° quartiles, and the minimum and maximum are represented by numbers. The box plots show which group of competencies were rated as more relevant along the three supersets, for the two sets of ratings (expected and observed). From this analysis, it can be observed that the Analytical data management competencies are very relevant in the "Evaluate" and "Communicate" phases, i.e., and, hence, along the whole project (minimum relevancy rating 2); the Business process management competencies were, on the contrary, very relevant in the "Pre" and "Core" phase, although less relevant then expected (both the "Pre" and "Core" average ratings of observed relevancy were below the "Pre" and "Core" expected relevancy); Coordination management competencies were less relevant in the "Core" phases, with respect to all of the other phases, and Change management competencies were also very relevant but at the "Core" phases

(both expected and observed averages above 2 for "Pre" and "Along" vs average below 2 for "Core").

This may suggest that, although Coordination management and Change management should be relevant throughout the project, the same "separation of concerns" observed above at single competence level also arose in this view. Project management competencies were low relevant in the "Along" (both the expected and observed average ratings are 1), whereas, on the contrary, Operative management was very relevant "Along" the whole project (with average relevancy of 3 for both expected and observed ratings).

The Technological management competencies were more relevant in the observed "Core" than in the expected one (average ratings of 2.50 vs 2 relevancy, respectively), and equally relevant in the expected as well as observed "Along" phases (comparable average ratings).

			Number of organizations using that competence in that phase						N. of times compet. are rated by tech level and group								
									Pre			Core			Along		
Id	Gr	Competence	F1	F2	F3	F4	F5	F6	Low	Med	High	Low	Med	High	Low	Med	High
C1	A	analysing data to evaluate the results achieved	2	1	1	1	5	1	1	2	0	1	0	1	2	1	3
C2	A	Data-driven decision-making	4	1	3	1	2	1	1	2	2	1	0	3	3	0	0
C10	BP	identify the main critical issues affecting BPs	5	5	2	0	4	0	3	4	4	2	1	2	0	0	0
C20	BP	re-design the BPs according to the DT project	1	1	5	2	2	2	0	2	1	1	0	0	2	1	3
C21	BP	understand how a potential sol. solves critical issues or improve BPs	4	2	2	1	4	1	2	0	4	2	2	1	0	0	0
C23	BP	knowledge of the business processes	3	5	3	2	2	1	3	0	1	1	1	2	1	0	3
C24	BP	knowledge of the business processes to facilitate integration	2	2	6	2	1	1	2	1	1	0	0	0	2	2	4
C4	C	become spokesperson of the transformation	3	2	0	1	1	5	2	2	3	2	3	4	0	2	2
C7	C	communicate effectively the results achieved	0	2	0	0	2	6	1	2	0	1	3	2	1	1	3
C9	C	drive the whole organization towards the focus on results	1	3	3	3	3	2	2	2	2	1	1	0	1	2	1
C12	C	let the business perceive the potential of the DT carried out	4	0	0	0	1	4	1	2	2	3	2	4	0	1	1
C14	C	manage all the stakeholders of the project	5	3	2	1	2	4	1	2	2	0	0	0	2	0	3
C6	CM	commit the organization making the users aware of the change	3	1	1	3	1	3	3	2	1	2	4	4	0	2	3
C16	CM	minimize the resistance to change	1	2	2	2	2	2	1	2	1	1	2	0	1	2	3
C25	CM	knowledge of the organizational structure and strategic objectives	5	2	2	0	3	1	2	2	2	1	2	2	1	2	2
C15	O	manage possible delays	1	1	1	4	3	2	1	1	1	1	1	2	2	0	2
C17	O	monitor costs and timing of the project	0	0	2	3	4	0	0	0	0	1	2	2	1	1	2
C22	O	focus on results	2	3	3	3	3	5	0	3	1	0	1	2	1	0	0
C3	PM	allocate the resources of the team	1	6	3	2	0	0	2	1	1	1	2	1	1	0	1
C5	PM	build a feasible and structured project plan	0	2	4	1	0	0	0	0	1	2	2	3	1	0	3
C8	PM	develop trust relationships within the project team	2	4	5	4	2	2	0	3	1	0	1	2	1	2	2
C13	PM	manage a project team	0	3	5	5	2	3	1	1	1	0	3	3	3	1	4
C19	PM	motivate the team	0	3	1	3	1	1	1	2	2	0	1	4	1	0	2
C11	T	integrate the technology chosen for the project with the existing IS	2	1	5	4	2	0	1	1	2	2	2	4	0	0	2
C18	T	monitor the technological trends and their potential	4	2	2	1	1	0	2	2	2	0	1	1	1	1	2
C26	T	knowl.f the requirements derived from the dig.tech. Involved	2	3	4	0	2	0	1	2	2	2	1	1	1	0	1
C27	T	knowl. ofstrategic impact of technol.to expolit at best its potential	3	1	1	0	3	2	1	1	2	1	0	0	2	1	2

Fig. 3. From the left: number of organizations who rated a competence as relevant (either in terms of expected or observed relevancy) by project phase; number of times that competencies are rated by technological level (low, med, high) and by phase grouping.

This last result may again suggest the "separation of concerns" attitude also observable for the Coordination and Change management competencies, which seem to exhibit a specular relevancy with respect to the Project management and the Technological management competencies.

3.2 Qualitative Results

The roles involved in the projects analyzed are characterized by different roles "granularities" and technological level. These roles may suggest that for low organizational level projects higher hierarchy roles are involved (CxO level, HR, Marketing Manager), and the opposite is observed for higher organizational level projects (IT managers, BU managers, and the like). This may also suggest that low level organizational projects are traversing the whole enterprise, being them at the operations/governance level, whereas

product and consumer oriented projects have a more limited organizational scope when compared to the former ones.

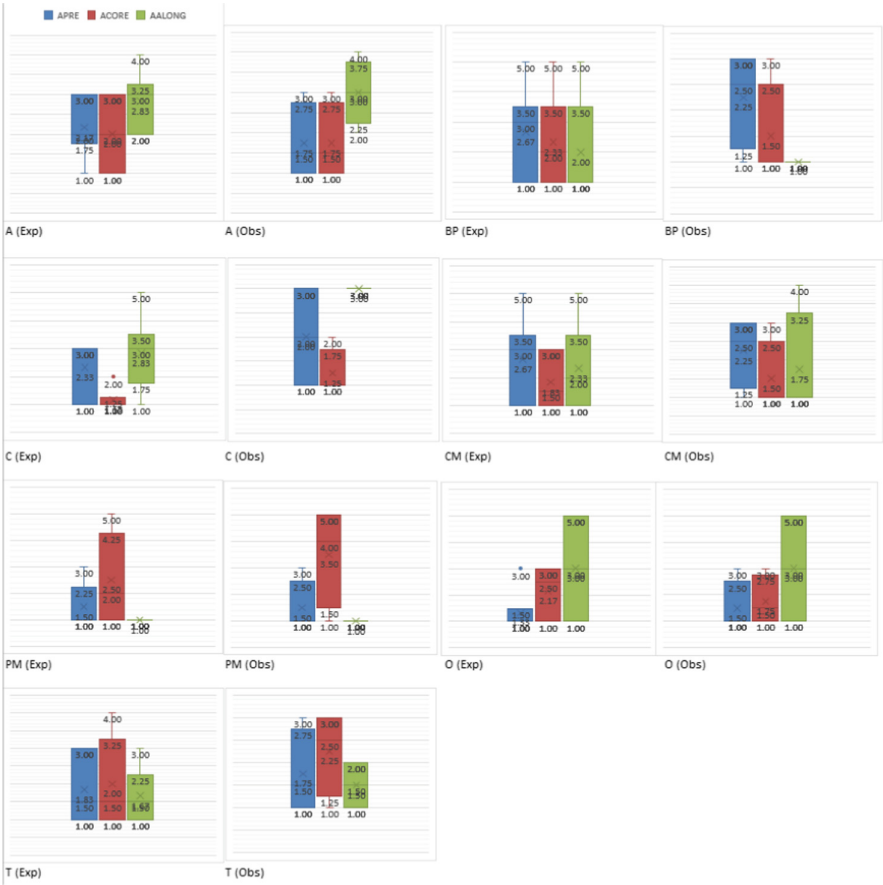

Fig. 4. Ratings boxplots, grouped by phases supersets ("Pre", "Core", and "Along").

From the point of view of the technological levels, results show that at the lower technological level both CxO and IT roles were involved, as well as Business Managers; at the service-orientation level the more involved roles were those of the CxOs and IT; and at the higher technological level CxOs, business and marketing roles and domain expert roles were involved. Organizational patterns of digital metamorphosis projects were also exemplified the following passages of our interviews:

> *"during digital transformation project what you are looking at were solutions. You do not realize until it is quite done that what you needed to focus on were problems!" (interview 3)*

On the other hand, the technology push that goes in the complementary direction with respect to "organizational introspection" may have also driven technological change in the cases analyzed. In terms of competencies this was translated into a

> *"need for soft skills such as flexibility and adaptation, rather than technological expertise. […] Technology change fast; what stays on is the core attitude of people to stay in symbiosis with it" (interview 10)*

Likewise, in order to face the forthcoming integration challenges, such as *"robotics and development operations" (interview 10, participant 1)* what the analyzed organizations considered was that (Table 3)

Table 3. Roles involved in the projects analyzed, by project phase. "Ibid" stands for "same as above", "M" stands for "Manager", "adv" stands for "advisors", "cod" stands for "coders", "usr" stands for "user".

	Media pub	Manuf. I	Industry I	Industry II	Manuf. II	Distribution
F1	CxO, Adv, BU M	Sales M, Prod M, CIO, IT M	CTO, IT Expert	CxO	President & Innov M	IT M & BU Own
F2	CxO, Adv	Same as above	CTO, IT Expert, PM, Integrat M, Dom expert	IT M	IT M & IT Experts	IT M & BU Own, Marketing, Cust Eng, PM
F3	CxO, Adv, BU M	Sales M, Prod M, CIO, IT M, Cod	CTO, IT Expert, PM, Integrat M, Dom expert, Usr, CM experts	CxO	Same as above	Marketing, Cust Eng, PM, BU An, Market Special, E-comm
F4	CxO, Adv	Same as above	IT Expert, PM, Cod	Same as above	Marketing & other CxO	Same as above
F5	ibid	Sales M., Prod M, CIO, IT M, Cod, Usr	IT Expert, PM, Integrat M	IT M, Sales M	BU M & teams	IT Man & BU Own, Marketing, Cust Eng, PM
F6	CxO	Sales M, CIO, IT M, Cod	PM, Integr M, Comm IT team	Same as above	HR M, Usr	Same as above

> *"soft skills are worth investigating because they are and will be a trait of human evolution. They are an asset for future generations. They will mobilized IT roles into new configurations, and will determine the difference between knowing-how*

[a technology work] and 'knowing where and when' [a working technology is available]" (interview 14)

Concerning the IT roles in organizations, what emerged from the interviews was that

"IT people should stay beside users, they should communicate with business, know the art of negotiation, integrate their competencies in strong alliance with demand management to take on transversal and incremental projects, rather than huge leap forward projects" (interview 1)

This need for IT-business blending was deemed an important strategy to minimize the resistance to change that may work as a strong "show stopper" of digital metamorphosis projects, where

"continuously capturing signal of change discomfort is becoming even more part of the evaluation of a digital project" (interview 10)

In this regard, being communicatively effective became cornerstone of the success of digital metamorphosis projects in the organizations taken into exam (interview 1). In particular, storytelling was a communication strategy that seemed to work at both ends of the IT-business knot:

"knowledge of the business processes should be in the DNA of this [IT-business] tie. The trust relationships that flow among the project team members are founded in communication ability and these should flow as blood in complex projects of the kind we are talking about" (interview 7)

A final point that emerged from interviews was related to the importance of moments of hybridization of teams with disparate competencies as

"you literally never know from which direction in the team the right idea at the right moment (either hard or soft) will come up" (interview 13)

Overall, the results analyzed may suggest that the more both the organizational and technological levels raises in organizations the more faceted competencies were necessary over the entire project life cycle. The results may also suggest that a mix of competencies was expected for digital metamorphosis projects of different kind and level. Furthermore, not the whole mix of competencies seemed to follow the same distribution for the whole duration of the project, rather some competencies were thickened in some phases and some others were thinned along the whole project. Overall, Business Process management, Project Management and Coordination management were relevant in three out of six phases, while Technological management and Operative management were relevant only in the central phases of projects (see Fig. 3, leftmost heatmap).

4 Conclusions

This study aimed at identifing the managerial competencies that organizations put into play in digital metamorphosis projects.Our literature analysis raised some gaps in terms

of an integration of perspectives about managerial competencies and digital metamorphosis in organizations. We carried out an instrumental collective case study research where our unit of analysis were digital metamorphosis projects of varying organizational and technological level, and configured a project phase model and a semi-structured interview canvas to analyze the cases at hand. Thanks to our research, we could frame projects according to a spectrum of managerial competencies, and to a relevancy continuum ranging from the very first phases of a digital project to the cross-cutting and final ones. Our results suggest that there is no "size fitting all" recipe, and that digital projects of different organizational and technological levels may bring very different competencies configurations. This may suggest that relying on fixed roles or look for even more specialized digital figures may not bring to the expected results: a more situated and lighter approach should instead be cultivated at different organizations levels and within transversal digital teams where business, IT and operations are seamlessly blended together and competencies are redundant to each, so as to achieve the necessary and sufficient mix to achieve digital goals.

4.1 Limitations of the Study

A first limitation of this study regarded the roles of the perople interviewed, either in terms of being limited to the lead roles in the project and in terms of role levels. This was due to the unavailability of employee or simple users, both for the necessity to restrict the study to a conven-ient sample, and to internal policies of the organizations. A second limitation of our study was the number of cases under exam, which allowed us to cover the research partially. This limita-tion is partly amendable with future extensions of our investigation to other enterprises and projects.

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Open Innovation for Digital Transformation in Low- and Medium-Tech SMEs: Analysis of Pre-competitive Collaborative Projects

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Abstract. Digital transformation poses different challenges to small- and medium-sized enterprises (SMEs). Governments and policymakers are launching several initiatives to engage SMEs in open innovation (OI) and to promote collaborative models oriented to facilitate the adoption of new digital technologies. However, most of the OI literature focuses on large companies and high-tech start-ups and we have little evidence about the barriers to OI in low- and medium-tech SMEs. This paper develops a multiple embedded case-study on seven Italian R&D pre-competitive collaborative projects in the domain of Industry 4.0. We have collected semi-structured interviews, triangulated with participant observation and document analysis to develop an exploratory analysis to individuate the barriers to OI in low- and medium-tech SMEs in inter-organizational projects. We classified barriers in four different dimensions (administration/finance, organization, strategy, and collaboration), analyzing every dimension in detail.

Keywords: Digital transformation · SMEs · Inter-organizational projects · Open innovation · Barriers

1 Introduction

Digital transformation is nowadays calling on firms to face great challenges but also great opportunities [1, 2]. Digitalization offers unprecedented opportunities also for small and medium-sized enterprises (SMEs) and for those sectors which have been traditionally considered slow-growing [3, 4]. However, to address digital transformation, SMEs are required a set of skills, capabilities, and financial investments that they do not own by themselves. Innovation activities need to be conducted in partnership with other stakeholders such as universities, R&D institutes, large companies, incubators, and other SMEs [5, 6], stimulating the transition from closed to open innovation (OI). Hence, SMEs are increasingly called to face the inherent tension of depending on external partners while having limited resources to manage such OI processes [7]. However, despite the importance that SMEs assume as leading forces in economies [8], little is known about how SMEs adopt OI to leverage digital transformation and to boost growth and competitivity [6, 9]. From the first theorization by Chesbrough [10],

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the body of literature on OI has in fact attracted the attention of several scholars [11–13] who have been mainly focused their attention on high-tech and/or large companies as early adopters of this strategic approach to innovation [14–16]. Only recently, the field of investigation of OI has assumed SMEs as an area of inquiry [17–19]. Due to their specific characteristics, SMEs, in fact, cannot benefit from open innovation in the same way as large firms [20–23]. On the one side, compare to large companies, SMEs traditionally lack human and financial resources, managerial and technical skills, and know-how and technological assets [21, 24–28]. On the other side, they usually have greater flexibility and reactivity [25, 26, 29, 30]. Governments are recently developing an increasing number of policy actions at both international, national, and regional levels which are oriented to promote low- and medium-tech SME involvement in innovative inter-organizational collaborations [1, 31, 33]. Most of these initiatives fail to meet the expectations, especially when R&D is focused on the pre-competitive exploration phase. Laying the groundwork for a deep reflection on the dark sides of OI [24, 28]. However, despite the relevance of this issue, the existing literature is still silent about the barriers that prevent low- and medium-tech SMEs from realizing the expectations related to their involvement in innovative inter-organizational projects. The purpose of our work is to develop an exploratory study on seven different collaborative pre-competitive R&D projects in the field of Industry 4.0. Each project was implemented in a Northern Region of Italy and it was structured around the collaboration between SMEs and several heterogeneous actors such as large companies, start-ups, research organizations, technology providers, and regional government as the funder of the initiative. We adopted a multiple embedded case-study to investigate the barriers preventing traditional SMEs from an effective adoption of OI practices in inter-organizational collaborations to leverage disruptive technologies for innovating their processes. We have individuated, through an iterative process matching previous theory and empirical evidence the main barriers and the related macro dimensions (administration/finance, organization, strategy, and collaboration).

This study contributes to the body of literature concerning SMEs and OI. More specifically, it aims to shed light on the barriers to low- and medium-tech SME engagement in effective OI, in the context of collaborative pre-competitive R&D projects. This context of analysis is relevant since SMEs are traditionally oriented to engage in collaboration in the commercialization phase of a technology rather than its experimental and pre-competitive phase [34], leaving space for reflections on why SMEs struggle to engage in pre-competitive R&D collaboration. The body of literature on OI has traditionally focused its attention on providing evidence that OI works [10, 35–40] while limited attention has been paid to the barriers which can emerge in innovative collaboration practices. This study aims at providing new evidence to this emerging literature stream [6, 24, 28]. The study also provides new knowledge to the body of literature on project management and digital transformation. The main contributions will be analyzed in detail in the last section of this work.

2 Theoretical Background

2.1 Digital Transformation in SMEs

The increasing diffusion of new digital technologies is reshaping the competitive landscape in many industries. The development of ever more sophisticated and advanced information and communication technologies (ICTs) offer SMEs the opportunity to rethink their business models, by creating or modifying business processes, culture, and customer experiences to meet changing business and market requirements [8]. By integrating into industrial processes digital technologies such as the Internet of Things, SMEs can generate value and achieve a competitive advantage from analyzing and managing a huge amount of data, with possible positive impacts on product and/or process innovation [41, 42]. The wave of digital transformation is raising 360-degree reflections on the possible organizational and managerial implications that derive from technological progress. In fact, it is not technologies that create value in themselves [43] but their integration within a clear corporate strategic vision [44], where the term transformation refers to the organization and its structure, culture, and capabilities. Li et al. [45] have recently identified six key aspects to build digital capabilities. Among them, a focal role is played by R&D and innovation. Given the difficulties that SMEs would face in relying solely on individual R&D, governments are launching initiatives combining the paradigm of OI with that of digital transformation in order to create real innovation ecosystems where people, organizations, and sectors can foster co-creation [1, 46]. Actually, the complexity of the competitive landscape, characterized by greater costs of technology development, lower returns from R&D investments, and a shorter life cycle of new technologies [47–49], encourages SME managers to increasingly explore innovative collaboration for exchanging knowledge [50].

2.2 Barriers to OI in SMEs

Most of the studies on OI and innovative collaboration have dealt mainly with large enterprises active in R&D-intensive industries. Only recently this stream of literature has started opening up to SMEs in order to gain a deeper understanding of how the management and organization of innovation is developing in these companies and how they can leverage their flexibility to gain benefits from OI [17, 30, 51]. SMEs have traditionally characterized shortage of resources in terms of know-how and technological assets, financial and human capital resources, and managerial and technical skills [21, 24–28]. Moreover, when inter-organizational collaborations are at stake, other criticisms, such as knowledge leakage, inadequate network composition, goal incongruence, and proximity come to light [27, 33, 52, 53]. The first seminal work to analyze barriers in SMEs adopting OI has been carried out by van de Vrande et al. [28]. They collected data from a large sample of Dutch companies that had developed an innovation in the past three years that could either be product-, process-, organizational-, and marketing-related. The main results of the quantitative analysis showed that organization and corporate culture-related issues that typically emerge when two or more companies are working together are clearly the most important barriers, followed by availability of time and resources, and administrative burdens. Previously, Chesbrough and Crowther [49] had

already identified as hampering factors the not-invented-here (NIH) syndrome and the lack of internal commitment. Another study that has analyzed the factors hindering the adoption of OI in SMEs is that of Bigliardi and Galati [24]. Based on a survey on 157 Italian SMEs, they have identified four main categories of barriers (i.e., knowledge, collaboration, organizational, and financial and strategic). As a result of cluster analysis, Bigliardi and Galati [24] found that the main barriers perceived by knowledge-intensive, high-tech, and/or highly innovative industries are those related to the knowledge domain. Dufour and Son [29] moved a step forward, and after individuating in the literature four potential barriers, namely corporate culture, networking, organizational structure, and knowledge management systems, they applied the theoretical framework to a single case-study to provide insights on how to overcome these barriers by analyzing the diverse organizational changes undertaken by the company. Ullrich and Vladova [54], instead, proposed a weighing and decision process framework as a conceivable solution approach to increment projects' chances of success.

2.3 Inter-organizational Projects and Pre-competitive R&D

The previous literature is still insufficient to have a complete e detailed picture of the factors which hinder the adoption and the implementation of OI in SMEs. The analysis of the literature shows that the barriers to OI in SMEs are still under-investigated. Van de Vrande et al. [28] and Bigliardi and Galati [24] have shown how specific OI practices and/or specific SME characteristics (e.g., size and sector) can generate different barriers, opening the way to more detailed reflections and in-depth case studies which focus on specific aspects related to the challenges SMEs undertake when engaging in OI, especially in inter-organizational projects. Most of the time, in fact, inter-organizational projects are structured and coordinated following logics that are more suitable for large companies that for SMEs, with the result that SMEs tend to occupy weaker network positions and to depend on partners' strategies instead of having control over the direction of their OI efforts [55]. Greater attention should be paid to SME involvement in horizontal collaboration, which is typically adopted by SMEs at the exploration stage of R&D collaborations [27, 56]. Traditionally, SMEs are more oriented to the commercialization phase of a technology rather than its experimental and pre-competitive phase [34]. SMEs engaging in vertical collaboration usually achieve better performance in terms of innovation outcomes [57]. However, despite the difficulties in translating and exploiting research output successfully from research organizations in horizontal pre-competitive collaborations [21], SMEs will be increasingly called to engage in these partnerships in order to be competitive in an even more complex and globalized environment. The ability to invest in research projects that involved universities, even if they are generally riskier, longer-term oriented, and more centered on the transfer of knowledge than other projects [34], would help SMEs to adopt seize new opportunities and achieve long-term sustainability. This issue is crucial in the domain of digital technologies. SMEs may in fact integrate their lack of know-how and technological assets, financial and human capital resources [6, 27, 28] by entering into partnerships with universities, technology providers and research organizations that, through experimental research and technological development, may help them to innovate their processes. Previous studies have

highlighted how challenging is for SMEs to effectively innovate by adopting new digital technologies [42], however, how technology-driven innovation can be pursued by SMEs in collaborative OI contexts and what are the related barriers is quite an under-investigated issue, especially the organizational aspects Taking this opportunity, this paper aims to answer to the following research question: "What are the main barriers that hinder collaboration for digital innovation in low- and medium-tech SMEs engaging in inter-organizational pre-competitive projects?"

3 Methodology

3.1 Research Design and Context

We have been adopted an exploratory qualitative approach to gain a more accurate picture of the dynamics of social relations that take place in inter-organizational projects, by examining the phenomenon of interest in its real-life context [58, 59]. To deepen our understanding of the barriers, we needed a qualitative methodology able to produce in-depth and illustrative information shedding light on the various dimensions of the phenomenon under analysis, representing the views and perspectives of multiple actors [59, 60]. A multiple embedded case-study on an Italian regional plan has allowed to collect data from seven inter-organizational projects based on horizontal collaboration and to focus on SMEs as a unit of analysis. The projects were built around multi-partner collaborations among large companies, start-ups, SMEs, technology providers, research organizations, and universities for jointly exploration stage R&D activities. The choice of a multiple case-study as design of this research allows following a replication strategy which provides a strong basis for theory building [59, 60]. The seven projects, part of a regional plan launched in 2015 in an Italian Northern Region, had the aim to stimulate manufacturing SMEs' industrial research and experimental development in the field of Industry 4.0. This regional government selected for the seven projects a budget of € 39,200,000.00.

The selection was made after having screened all the R&D pre-competitive Italian regional plans on Industry 4.0 launched in 2015. According to the selection criteria, the projects had to be: pre-competitive, oriented to SMEs, based on multi-stakeholder collaboration, and cross-industry.

Italy represents an interesting set of investigation due to the high number of SMEs which represents the 99% of enterprises active in the Italian economy [61]. Italian Regions are investing huge sums to stimulate the R&D propensity of SMEs. Moreover, the constitutional reform of 2001 has conferred to Italian regions a greater number of competencies regarding enterprise and innovation policies in order to facilitate peripheral governments' responses to local needs with the aim to speed up the diffusion of experimental projects, stimulating in this way, the academic interest [31, 32].

3.2 Data Collection

We used multiple sources of evidence in order to triangulate data and to increase the richness of information [59]. First, we conducted semi-structured interviews with SMEs

and the other stakeholders of the project (policymakers, technology providers, large companies, universities, and research organizations). Data saturation was reached after 27 interviews, in line with previous case-based research [62, 63]. We selected the key informants by following a purposive sampling technique and according to their knowledge and availability [64]. In order to ensure naturalness, participants to the interviewees were only made aware of the overall research purpose, without revealing specific questions and preventing them from coming up with the answers in advance [65]. We have conducted the interviews face-to-face or via skype by one research and a second one was in charge to take field notes and scrutinized the behavior and the approach of the interviewee in answering questions. The same researcher was responsible for the transcription of the interviews. The protocol comprised a series of open-ended questions which was adapted according to the nature of the interviewee, in compliance with the two main issues addressed in this work: the barriers to OI in SMEs in the specific context of inter-organizational pre-competitive projects and the possible project-level organizational responses to mitigate and/or overcome these barriers.

The data from the semi-structured interviews were then triangulated with data from observations (participation to the steering committees, management consultancy, visits to companies for field inspections) and document analysis (project reports, company websites, and documents provided by the interviewees).

3.3 Data Analysis

The coding process is considered as the hermeneutic unit of analysis of the transcribed interviews, the field notes from observations, and the collected documents and texts [66]. We carried out the analysis with the assistance of Atlas.ti software. Data analysis followed an iterative process of matching emergent themes from the empirical data with the existing prior literature [67]. The first step to be conducted was the open coding. In this phase, two researchers generated a comprehensive list of codes and memos from the transcribed interviews by individuating any possible barrier hindering the effectiveness of the OI processes of SMEs. Next, a process of pattern searching was followed which resulted in the identification of second order themes emerging from the open codes and based on the inductive reading of the data and the integration of the emerging categories with the previous studies on SMEs and OI processes (axial coding; see [68]. This process allowed to combine the perspective of OI with the perspective of digital transformation, on which explicit research has not yet been developed. A final step consisted in the individuation of organizational responses at project level to deal with these barriers.

4 Results and Discussion

In the data analysis we have individuated ten main barriers, then grouped into 4 macro dimensions (administration/finance, organization, strategy, and collaboration) that are analyzed in depth in this section.

4.1 Administration/finance

These experimental projects have given rise to the creation of complex consortia, with a large number of heterogeneous actors. As a result, monitoring from the funding body is essential. Publicly funded projects are in fact generally characterized by high bureaucratization [28]. Many of the actors involved in the projects have recognized that a decrease in tasks and deliverables, with a consequent decrease in documentation and reporting, could reduce the efforts of many SMEs, especially for those companies that have simplified accounting systems and limited human resources to devote to the project. The manager and CEO of a SME (SME4) highlighted as he experienced "*the greatest difficulties in managing the administrative/bureaucratic part of the project*".

The projects leveraged public funding to incentivize SMEs to participate in these projects. Financial constraints are in fact one of the most recurrent barriers to OI in SMEs [28]. Indeed, this barrier had been already identified by previous studies on innovation management in SMEs [69, 70]. The main objective of publicly funded regional projects is to stimulate the innovative potential of SMEs by providing financial resources that can allow investments to be made for the introduction and development of new products and processes [32]. The provision of financial resources is strategic to lower the risk of failure in collaborative projects [71, 72] and it is even more significant in the domain of Industry 4.0, where the investments in digital technologies to enable innovative production processes, mechatronics, and robotic systems for advanced manufacturing requires massive outflows of financial resources [42, 73]. The presence of financial incentives reduced the financial barriers, however, delays in the provision of funds represented a relevant concern, especially in those projects which have been extended for a further period of 3 to 6 months due to the difficulty in completing the project objectives. The deferred payments required monetary disbursements which SMEs are not always able to manage by themselves. This significant drainage of the financial assets was perceived strongly from those SMEs which had not a project portfolio and/or those SMEs which used the money for ordinary operations, underlining limited innovation orientation.

4.2 Organization

Most of the SMEs involved in these projects did not have enough human resources to devote to the project. Human resources represent one of the focal points when collaborative innovation is at stake. SMEs suffer endemically of lack of human resources to dedicate to the projects due to their small size [20, 23, 28, 74, 75]. Technical projects such as those centered on Industry 4.0 technologies need people with the appropriate skills. The founder and CEO of a SME (SME9) recognized that *"it was challenging to interact with such diverse and well-prepared actors when instead we had little time and few resources to devote to the project"*. Previous literature has already highlighted that SMEs need human resources with technical capabilities [28, 76] and managerial skills in order to effectively create value through the implementation of new technologies [51, 77].

Some of the SMEs involved in these projects are still tied to organizational and cultural logics that do not allow to fully benefit from collaborative innovation devoted to the adoption of new digital technologies within companies. Indeed, a sort of resistance

to change has emerged which was manifested in a limited learning capacity. This was reflected in a reduction in the commitment both in terms of intensity of interaction with the external partners and internal support for the project activities. SMEs have traditionally been recognized as characterized by greater flexibility and reactivity due to their small size [25, 26, 30], but there are still many cultural resistances rooted in attitudes of NIH syndrome and path dependency [29, 49]. Most of the SMEs have shown reduced absorptive capacity, understood as the ability "to recognize the value of new information, assimilate it, and apply it" [78]. While, on the one hand, the projects allow SMEs to recognize valuable external technologies through technology intermediation [79], on the other side, SMEs show a limited ability to appropriate these external technologies. Even whether the previous literature has highlighted that stakeholders such as universities and research centers can help SMEs in developing the ability to appropriate technologies [80], there is still a huge amount of SMEs which have inefficient knowledge management systems to take advantage of participating in collaborative projects [29]. Many times, the managers find it difficult to recognize the importance of change course and they continue relying on old-fashioned management logics. This behavior can be detrimental to the survival of the company. The innovation program manager of a TP (TP1) remembered that *"a company had to buy a press to improve the productivity of their plant and at each steering committee they used to communicate that they were forced by some contingencies to postpone this purchase. They have never been able to understand the potential of that investment. At the end, the reason they bought the press seemed to be related to the necessity to use the funds from the government instead of really improving their production processes"*.

Another recurrent problem experienced by the partners of the project was the slowness and the ineffectiveness of SMEs in transferring data. This is not only due to a sort of reluctance to transfer information, but also to evident deficiencies in the information systems that made it difficult to obtain and communicate data to the other project's stakeholders.

4.3 Strategy

Compared to previous studies, which reported successful cases in which the strategies of SMEs were closely connected to their OI activities and the collaboration between large companies and SMEs was positively evaluated [23], our research has found that there are still many problems and that SMEs, especially the more traditional ones still lag behind. In fact, many SMEs struggle to combine innovative activities with their daily tasks and do not have a clear understanding of the objectives of their collaboration, nor the resources they must put in place to obtain satisfactory results and actively contribute to the development of the network. Our findings, aligned with Radziwon et al. [77], show that the availability of money could be a decisive factor regarding joining a collaborative project, but it does not necessarily play a significant role in motivating SMEs to be more active in the project. On the contrary, this can stimulate opportunistic behavior and free riding among partners. Collaborative practices, especially in R&D pre-competitive projects, take long to result in fruitful outcomes [23] and most of the SMEs show short-term outlook which may affect negatively their engagement, with the consequence that they only focus on receiving the public funds, reducing their efforts and seeing the

projects as an end instead of a mean to leverage Industry 4.0 and collaboration as a way to innovate.

The lack of familiarity with technologies 4.0 pushed many SMEs to join in these projects lacking clear ideas. and specific research trajectories. Most CEOs had no clear ideas about the difference between process and product innovation and they saw the projects as a way to improve competencies not directly related to the main aim of the projects.

4.4 Collaboration

The partners of the various projects were selected by following a cascade mechanism. A project leader (LC2) told us that "*we have selected a hard core of partners that we already knew and who enthusiastically joined our project. After that, we allowed a fairly large group of SMEs to participate in the project without mutually knowing each other. Unfortunately, many of them have proved unprofessional, some have failed during the project, others have abandoned*". Lack of prior mutual understanding can represent a critical issue especially when this lack of mutual knowledge is not counterbalanced by high levels of individual experience. The difficulty of coordinating a network of different actors, in fact, has been exacerbated in these projects by the presence of companies that are not accustomed to deal with digitalization and collaborative innovation. Moreover, the less experienced SMEs have also shown a tendency to underestimate the work of the other actors and the time required to perform some tasks. These problems are amplified when the distance between partners is greater. Boschma [81] identifies five forms of proximity that are considered essential for effective collaboration: cognitive, organizational, social, institutional, and geographical proximity. According to his perspective, innovation and interactive learning may be hampered by too little or too high proximity. More recently, academic contributions started focusing on the specific domain of SMEs. Jaspersen et al. [53] investigated partner proximity preferences for process innovation, while Kapetaniou & Lee [82] narrowed the focus on the geographical dimension of SMEs, underlining the critical role of the spatial aspect of open innovation in SMEs. The project we analyzed were developed at a regional level, so the geographical dimension of proximity was low. Even whether the results of Jaspersen et al. [53] show that SMEs prioritize geographic openness over regional clustering when process innovation is at stake, we found that SMEs were positively influenced by regional proximity. The more critical issues, instead, are related to the other dimensions, namely the cognitive, organizational, social, institutional, since SMEs are very different from the other actors in terms of knowledge, cultures, modes of organization, or bureaucratic elements [28]. This often leads them to cover peripheral positions in the network and to benefit less from innovative collaboration [83].

A summary of the major findings and related quotations is summarized in the Table 1.

Table 1. Barriers resulting from data analysis

Quotation	Barriers	Category
TP2: "The project involved a huge number of tasks and deliverables placing many SMEs in difficulty as they had to devote specific human resources to the project reporting"	Administrative burdens	Administrative/Financial barriers
SME4: "Our project has undergone an extension of 6 months because some work packages had not yet been completed. We relied in part on those funds to pay our employees at the end of the month"	Delays in funding	
SME4: "We are a small company, you know, as founder of the company I took care of following the project directly but as you can imagine is not easy to find the time"	Limited and/or unskilled human resources	Organizational Barriers
U1: "SMEs tend to be strongly focused on their day-to-day activities. That is fair…but they cannot separate the two activities. Who is going to follow the project also needs to be involved in the operational activities of the company"	Modest learning capacity	
U3: "We had to build a dashboard of indicators and we needed some specific data that we never received. The problem was not that they did not want to give them to us, but it was that they just did not have those data"	Lack of infrastructure	
TC1: "Unfortunately, as most of the public funded projects I joined, I see too much companies, especially the smallest ones, focusing more on get the money instead of really pursuing innovation"	Opportunistic behavior	Strategic Barriers

(*continued*)

Table 1. (*continued*)

Quotation	Barriers	Category
TC2: "If you enter a project more out of curiosity than out of intention to innovate your company, you will hardly get a result. Lack of clear lines of research and inaction are unfortunately some common elements that we have found in this project"	Lack of clear ideas	
SME8: "We joined the project after being invited from a university with which we were already in contact but we did not know the project leader"	Lack of prior mutual knowledge	Collaboration Barriers
SME8: "We collaborated with actors very different from us […]. I do not deny that we expected more from them"	Underestimation of partners' efforts	
SME5: "Coordination problems with large companies are amplified by different languages They also leverage different and slower decision-making processes"	Proximity issues with large companies	

Source: *Authors' Own Elaboration*

5 Conclusion

5.1 Implications of the Study

The literature on innovation in SMEs has traditionally recognized that innovation processes are hampered by many factors such as lack of financial resources, issues in recruiting specialized workers, and small innovation portfolios so that risks associated with innovation cannot be spread [28, 84, 85]. These elements have given rise to reflections on how to facilitate innovation paths in SMEs, especially in the recent era characterized by disruptive changes concerning new digital technologies. With this purpose, the academic literature on OI opened its doors to SMEs as an area of inquiry. However, previous studies have focused heavily on the positive aspects of OI, neglecting the negative ones. Indeed, few studies have analyzed the barriers to OI in SMEs [24, 25, 28]. Our work contributes to this under-investigated stream of studies by developing a qualitative study that focuses its efforts more on identifying the "why (not)" and the "how" rather than the "how much". With this aim, we developed a multiple embedded case-study on seven regional inter-organizational projects oriented to industrial research

and experimental development as a part of the Italian Industry 4.0 programme. More specifically, we individuated four main dimensions (administration/finance, organization, strategy, and collaboration). Therefore, the contribution is not only reserved for the body of literature on OI and inter-organizational relationships in SMEs but also to project organizing and project management literature. Moreover, this study adds to the emerging body of knowledge regarding digital transformation and SMEs [42, 86], in the context of horizontal collaboration among industry, university, and government for pre-competitive R&D in Industry 4.0 [87]. Previous literature has in fact stressed that horizontal collaboration in pre-competitive projects is more difficult to manage than vertical collaboration in the R&D commercialization phase. Our framework therefore analyzes barriers to OI in SMEs, shedding light not only on the financial and strategic aspects of collaborative innovation, but also the organizational ones [88].

5.2 Limitations and Further Developments

Despite the novel insights gained from this research, the study is not free of limitations. First, although the qualitative methodology extends the previous knowledge on the dynamics on traditional SME engagement in OI, a mixed method could further enrich the results by combining analytical and statistical approach. Second, this study develops its analysis over time along with the whole duration of the project, from the beginning to the end. However, when digital transformation and inter-organizational relationships are at stake it would be interesting to monitor SMEs over time also after the end of the project. Future studies should address this gap by further extending the longitudinal perspective.

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Exploring the Discourse on Digital Transformation in the Domain of Non-profit Organisations

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Abstract. Digital transformation is a highly debated subject in several fields. However, only a few studies discuss digital transformation focusing on non-profit organisations. This paper seeks to develop a taxonomy based on a systematic overview of the literature examining digital transformation in non-profit organisations over the last decades. This is the initial step of a research project which aims to investigate the impact that digital transformation has on non-profit organisations. For this research step, we initially identified the dataset of contributions discussing the topic under investigation. Then, we refined the initial dataset, restricting the corpus to 111 papers. The resulting dataset was used to develop the taxonomy. By adopting a conceptual and empirical analysis, we identified the following five dimensions (and their relative values): *Digital Aim*, *Scope*, *NPO Relevance*, *Digital Technology*, *Business Aim*. Finally, for every dimension, one single value was assigned to each paper, proposing a useful taxonomy for classifying the contributions investigating digital transformation in non-profit organisations over the last decades. Furthermore, focusing on a subset of dimensions (*Digital Aim, Scope, NPO Relevance*), we summarize some preliminary results.

Keywords: Digital transformation · Non-profit organisation · Literature review · Taxonomy-based framework

1 Introduction

Over the last decade, different studies have investigated the phenomenon of Digital Transformation (DT) in heterogeneous contexts and different scopes [1–4]. Several literature reviews have attempted to analyse this phenomenon [5–9]. The debate on digital transformation includes a wide range of industrial sectors, discussing several organisation and societal implications [10–13]. This paper intends to contribute to this stream of research, considering the context of Non-Profit Organisations (NPOs). Salamon and Anheir [14] provide a structural/operational definition of NPOs, defining them as formal, private, non-profit distributing, self-governing and voluntary organisations [14]. NPOs are commonly acknowledged for their central involvement in social issues [15–18]. Concerning their business aim, NPOs are usually recognized as promoters of the

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development of welfare and general health [18–21]. Moreover, NPOs are organisations that usually act to support society in the event of a crisis, emergency or disaster [22–25].

Very little is known about the phenomenon of digital transformation in the context of NPOs [10, 11]. This contribution seeks to investigate the characteristics of DT in the environment of NPOs. Therefore, we have developed a taxonomy [26] as a *theory for analysing,* in line with Gregor's suggestion concerning the nature of theory in IS [27]. First, we performed a literature review to increase our understanding of the phenomenon of digital transformation in the NPO scenario [28, 29]. Afterwards, we identified the dataset of contributions discussing the topic under investigation. Then, we refined the resulting dataset employing it to develop the taxonomy [30]. By adopting a conceptual and empirical analysis, we identified the following five dimensions (and their relative values): *Digital Aim*, S*cope*, *NPO Relevanc*e, *Digital Technology*, *Business Aim*. Finally, for every dimension one single value was assigned to each paper, proposing a useful taxonomy for classifying the contributions discussing digital transformation in non-profit organisations over the last decades.

The paper is structured as follows: the next paragraph reports a review of the theoretical background concerning DT and NPOs. In the methodology section we describe the approach adopted to develop the taxonomy. Afterwards, we provide the proposed framework describing the dimensions and their values. In the last section, focusing on a subset of dimensions (*Digital Aim*, *Scope*, *NPO Relevance*), we summarize some preliminary results, providing discussion and conclusions.

2 Theoretical Background

Academics and practitioners generally acknowledge DT as an IT-driven phenomenon [1, 6, 13, 31]. Such phenomenon often implies the adoption of new digital technologies for fostering an organisation change [8, 32–34] or for further developing business opportunities [35–37]. DT usually affects organisation resources, processes, people and their interactions [38–44], reshaping, in some cases, the organisation structure [45–47]. The extent of the organisation change depends on the kind of intra- and inter-organisational connections in the business environment [48, 49]. Among other definitions, Vial describes DT "as a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" [2]. Specifically, for this contribution we adopt Vial's definition of DT in order to analyse the phenomenon of DT in the context of NPOs.

Although NPOs are considered a well-established global phenomenon [50–52], there is no common definition of NPOs in the literature, where different terms are often used interchangeably [53–55]. For this research, we adopt the structural/operational definition of NPOs provided by Salamon and Anheir [14, 18, 56], where they identify the following five main characteristics for NPOs:

1. Formal: NPOs are institutional realities, having a specific organisational form.
2. Private: NPOs are institutionally separated from government.
3. Non-profit-distributing: it represents the social utility objective; NPOs' aim is opposite to that of profit-seeking business [57–59].

4. Self-governing: NPOs are able to control their own businesses.
5. Voluntary: NPOs are characterized by a voluntary impulse [14, 56, 60].

Moreover, NPOs are required to reinvest their profits to pursue social utility aims [24, 25, 54]. Likewise, they offer collective goods and services for mutual benefit or charitable purposes [22–24]. Other contributions define NPOs through the "welfare mix" framework [15, 16, 61, 62]. This framework distinguishes NPOs from public/private, formal/informal and for-profit institutions. Furthermore, it also depicts NPOs as alternative organisations to public and private organisation in the provision of social services [15].

Another aspect recently arising in the literature on NPOs is related to their sustainability. The overall trust perceived by the stakeholders on NPOs' activities, including their social utility aims and their non-profit impulse, seems to positively affect their sustainability [63–65]. Citizens and communities are the central stakeholders of NPOs, since they are directly involved in NPOs' objectives [16, 66, 67]. Whereas the achievement of publicly desirable outcomes usually involves multiple stakeholders, the interactions between those actors can generate community co-production initiatives [61, 68–71]. Nowadays, new forms of value creation and co-production are generating hybrid organisations [72]. Hybrid organisation refers to heterogeneous arrangements, partnerships or pacts among different organisations (public, private as well as NPOs) combining and integrating their characteristics, functions and resources [62, 73, 74]. These hybrid organisations could potentially benefit from the digitalisation of the value creation process [2, 49, 75–77]. For example, some changes could be pushed by the use of internet connections and digital interaction, such as web channels [2, 78–82].

The aim of this research is to provide a taxonomy for classifying different organisational arrangements involving NPOs, also considering other organisational and technology aspects. [30, 83–86]. The next paragraph describes the research protocol adopted to develop this taxonomy.

3 Methodology

Among the different theories recognized in the field of Information System, this research contribution is in line with what is defined as a *theory for analysing* [27]. This theory fosters the description and categorisation of a subject of interest as a basic theory, in order to explore a specific phenomenon where little is known [87–89]. Specifically, our analysis seeks to provide an understanding by summarising the commonalities found among discrete observations [90], through the analysis of the content of a set of papers. Afterwards, categories and commonalities are used to develop a taxonomy, which should be revised until it begins to be exhaustive [27].

This study is developed using a mixed methodology as described in Fig. 1. The first stage of the research protocol concerns the dataset definition and description. We developed the literature review in line with the Mayring's "ideal type" review process as described by Rowe [29]. This review process is composed by four steps: (i) collecting material, (ii) descriptively analysing the dataset gathered, (iii) selecting structural dimensions and categories based mainly on theory, and (iv) evaluating and interpreting

evidence in depth. Our study applies the first two steps of this method [29] in order to complete the first stage of our research protocol. For the second stage we followed the approach by Nickerson et al. [26] (see Fig. 1). Since this research is intended to create a taxonomy of the literature discussing DT in NPOs, the taxonomy development process proposed by Nickerson et al. seems to be particularly appropriate.

The taxonomy development process described by Nickerson et al. [26] consists in iterating two approaches of analysis of the papers in our dataset, namely the empirical-to-conceptual approach and the conceptual-to-empirical approach. These iterations should be run as a loop until the placement of phenomena into categories appears clear, [27, 87]. For categorizing the papers of our dataset, we needed to identify a set of dimensions with their relative values. The identification of the dimensions and their possible values was based on previous IS studies [27, 91–93] or defined and refined recursively analysing the paper in the dataset [26, 30]. A combination of approaches could be used for the taxonomy development process, allowing to systematically code the gathered contributions [89, 94].

The taxonomy development process was performed by setting the characteristics of the objects of interest for the taxonomy [26, 30]. The meta-characteristics were represented by the research keywords, DT and NPOs. At the same time, the ending condition of the iterative process (empirical-to-conceptual approach vs conceptual-to-empirical approach) was defined. The ending condition of the process requires the definition of exhaustive dimensions and their respective values. It is noteworthy that the exhaustiveness of such dimensions and values is achieved when the values are used aptly to classify a sample of articles. Then, we ran the iteration of the two steps of analysis, reshaping dimensions and values until we reached the ending conditions. In performing the taxonomy development process, dimensions and values have been tested through a compatibility check with the papers under investigation. This process is aimed at obtaining mutual and collective exhaustiveness. Moreover, it ensures that each contribution is assigned one value for every dimension. Therefore, no contribution could acquire two different values for the same dimension. Finally, the characteristics of the dimensions and their values are in agreement with the definition by Nickerson et al.: the dimensions and values are conciseness, robustness, comprehensiveness, extendible and explanatory [26].

Thus, every dimension contributes to investigate the nature and scope of each paper, while also keeping track of the specific issue debated. Figure 1 shows the research protocol, providing some details for every stage.

The first stage of the research protocol involved data collection and identification of a congruous source of scientific literature. The Scopus database was used to collect relevant contributions since this database is widely used by academics and practitioners in the field of social studies [85]. In line with the research goals, two variables represent the research keywords: *digitalisation* and *non-profit organisation*, and at least one relation among the words must occur. The research keywords "digit*" and "no*profit" were used for performing the query. We used wildcards for improving the research by including plurals, grammatical and spelling variations. Finally, the query looked for the two research keywords in the following three paper fields: author keywords, title and abstract.

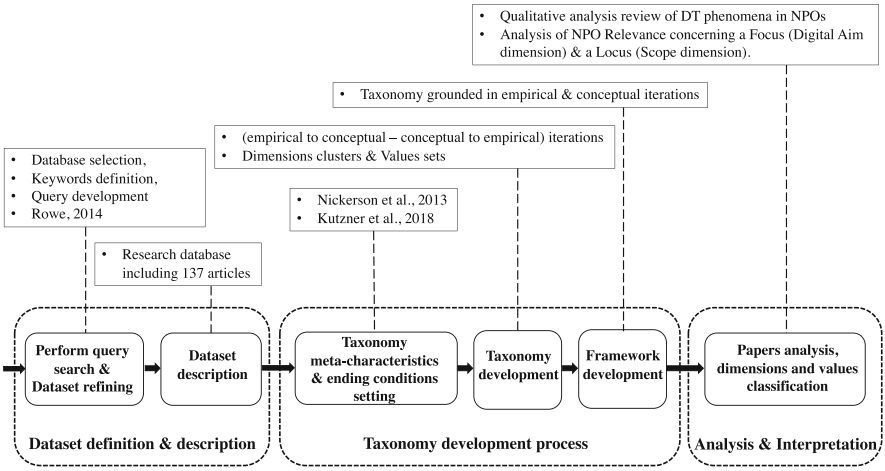

Fig. 1. Research protocol

As a preliminary result, the initial dataset comprised 233 contributions. A pronounced trend shows an increasing interest in the subjects over the last decades, with the 50% of the results being written in the last five years. We restricted the dataset by selecting only articles from scientific journals, in order to develop a reliable taxonomy. In doing so, we refined the research query applying the "ar" document type parameter. Noting different languages used for some contributions, including Spanish (4), German (1), Hungarian (1) and Russian (1), we considered a second exclusion by setting the language parameter as "English".

The refined dataset includes 137 contributions, last updated in late May 2020. In the next paragraphs, we provide a general overview of the whole dataset by summarizing the main information presented in Table 1. Afterwards, we briefly describe the trend of publications also comparing the trend of the initial dataset with respect to the one composed by selected articles (see Fig. 2). Then, we report the most productive journals.

Exploring the dataset, we have observed that the publication year of the papers in the dataset starts from the 80s to the present day, as shown in Fig. 2. However, a great number of scientific contributions was published mainly in recent years, depicting an increasing interest in the DT phenomena in the context of NPOs. Based on the publication trend, it is possible to recognize three clusters in line with the last three decades. The first cluster includes contributions published between 1991 and 2001, the second one encompasses papers published between 2003 and 2013, while the third one comprises articles published from 2014 to the present day. The latter also represents the most productive period (over 60% of the total number of publications).

We used the AJG (Academic Journal Guide) rating score to analyse the source of publications. The Chartered Association of Business Schools (CABS) releases the rating score, which assesses the quality of journals, determines the excellence of business research, and the relative status of different business specialisation. This analysis relies on the last published guide (AJG 2018), which classifies journals in one of five categories (e.g. 4*, 4, 3, 2, 1 where 4* is the top level) distributed into twenty-two different fields of

Table 1. Dataset main information.

Description	Results
Documents	233
Sources (Journals, Books, etc.)	195
Author's Keywords	617
Period	1983–2020
Average citations per document	6.631
Authors	587
Single-authored documents	98
Documents per Author	0,397
Authors per Document	2.52
Article	143
Book	8
Book Chapter	16
Conference Paper	38
Conference Review	8
Note	2
Review	17
Short Survey	1

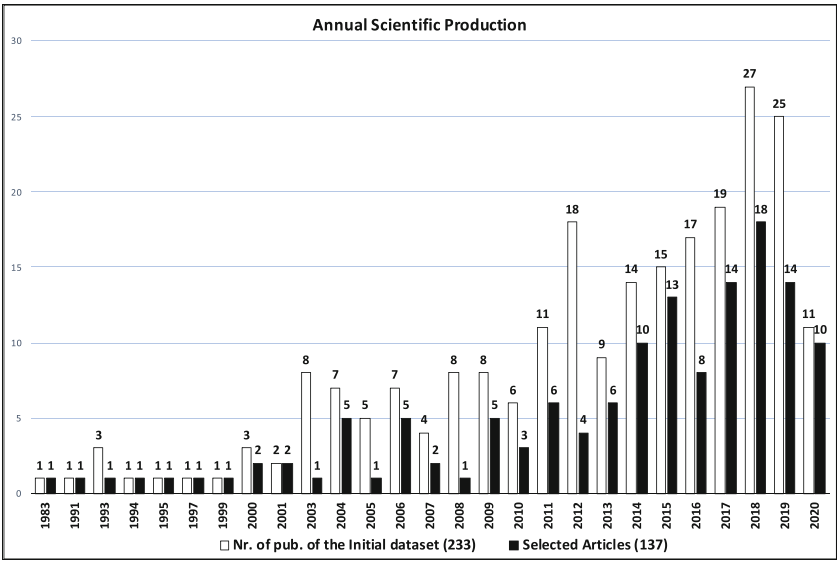

Fig. 2. Number of publications per year relating to digital transformation & non-profit organisations since 1983

study [95]. As a result, we identified 114 different journals in our dataset, where only 19 belonged to the AJG list. The most productive journal is *Non-profit and Voluntary Sector Quarterly* rated 3 in the AJG, with 5 out of 137 articles (3,64%), followed by *Voluntas: International Journal of Voluntary and Non-Profit Organisation*, with a rate of 2 in the AJG (4 papers; 2,92%), *Non-profit Management and Leadership* rated 1 in the AJG (3 papers; 2,2%). Considering the journals having only two publications, *Computers in Human Behaviour*, with a rate of 3 in the AJG (2 papers; 1,46%) and *Information Technology for Development* rated 2 in the AJG (2 papers; 1,46%) belong to the field of information management. Finally, the majority of AJG's fields of study appearing in our dataset are *Sector*, *Marketing* and *Information Management,* followed by *Organisation Studies*, *Psychology* and *Strategy*, highlighting a multitude of approaches adopted in investigating this specific phenomenon.

4 The Taxonomy Development Process

This section provides the description of every stage in the development of the taxonomy. This process requires several iterations between two main approaches, that is, empirical-to-conceptual and conceptual-to-empirical [26, 30], until it meets the specific ending condition (as described in Sect. 3). The iteration of these two approaches aims to define the objectives and to understand scopes and elements of the contributions, with particular attention to the organisations, environments and stakeholders involved. The *empirical-to-conceptual* approach consists of getting back and forth through the contributions in order to determine a subset of objects that need to be classified (dimensions). As the understanding increases over the iterations, the common characteristics of these objects (e.g. values) are defined. The *conceptual-to-empirical* approach is based on the conceptualisation of the taxonomy dimensions without the examination of the current objects. This is a deductive process based on the ability of the researcher to adopt prior theoretical contributions in order to identify relevant dimensions with their values, in accordance with the specific dataset [26]. For this approach, in this paper we consider specific IS studies in shaping dimensions and their values [27, 91–93].

This taxonomy development process required five iterations to identify the dimensions and their relative values. Before starting the process, the meta-characteristics (concerning DT and NPOs) and the ending condition were set. The description of the five steps is provided below.

The first step of the taxonomy development process adopted the empirical-to-conceptual approach. We ran this iteration to develop a comprehension of the subjects in line with the closest understanding of our dataset. Since we noticed that some contributions did not fit our research agenda, we further refined the dataset to better calibrate the taxonomy in the specific domain. For example, a study using one of our keywords without a meaningful purpose concerning this research, was considered as an off-topic contribution. As a result, we identified 26 off-topic papers, while the other 111 contributions provided appropriate empirical evidence. Thus, for the next steps we considered the refined dataset consisting of 111 articles.

The second step of the taxonomy development process employed the conceptual-to-empirical approach. We considered some theoretical frameworks [30, 45, 91, 96] to draft

the first comprehension of some characteristics of the phenomenon under investigation, discussed in our dataset [93]. We then identified the following five dimensions (with their values in parenthesis): 1) *focus of a contribution* (legacy, comparative, digital), 2) *field* (defined, not defined, transversal), 3) *method* (qualitative, quantitative), 4) *domain* (internal, external, generic), and 5) *typology of a contribution* (empirical, conceptual).

The third step again followed an empirical-to-conceptual approach. We performed a second review of the papers and a first classification of the contributions, refining the dimensions and values originated in the previous iterations. In this step, we tried to refine the dimensions in order to better support the analysis of DT initiatives in NPOs. The following four dimensions were identified: (i) *Digital*, (ii) *Scope*, (iii) *NPO Relevance* and (iv) *Digital Element*. The definition of the values for each dimension required a deeper analysis. In order to complete this step, the authors of the present paper closely interacted in order to refine the set of values assigned to every dimension (for example, assuring that each value had an objective meaning, avoiding the overlapping of their definitions).

The fourth step of the taxonomy development process adopted the conceptual-to-empirical approach. We further reviewed the literature to evaluate the dimensions and their values generated in the previous step [91]. We focused specifically on the NPO context, investigating the drivers and characteristics of DT phenomena [2, 13, 85]. As a consequence, we obtained significative insights from the digital business strategy theory [45] and the nature of digital technology theory [2].

The fifth and last step adopted the empirical-to-conceptual approach. At this point, we refined dimensions and values in an exhaustive way. Therefore, the taxonomy development process ended since the ending condition had been achieved. In this step, we refined meaningless dimensions, and we also refined some values. In particular, we redefined the *"Digital Element"* dimension by changing it to *"Digital Technology"*, and we also provided a new set of values to finalise the "*NPO Relevance*" dimension. Moreover, we added a new dimension and relative values since we formerly pursued a theoretical consolidation. We introduced the *"Business Aim"* dimension like an extra focus to distinguish the *"Digital Aim"* from the *"Business Aim"*.

Figure 3 describes the taxonomy development process, previously mentioned in the research protocol, providing further details. The next section describes dimensions and values, also providing the framework originating from this taxonomy development process.

4.1 The Taxonomy-Based Framework

The framework in Table 2 outlines the proposed taxonomy. In line with the research purpose, each dimension identifies a unique focus. These dimensions are: *Digital Aim*, *Scope*, *NPO Relevance*, *Digital Technology* and *Business Aim*. The *Digital Aim* and the *Digital Technology* dimensions aim to foster an understanding about the business element, and the technology involved in a DT phenomenon. The *Scope*, *NPO Relevance*, and *Business Aim* dimensions, on the other hand, are intended to promote a comprehension about the operational business level, the position of the NPO in its business environment, and the main aim of the NPO, respectively. Each of these dimensions should facilitate an understanding of possible configurations of the DT phenomenon within an NPO.

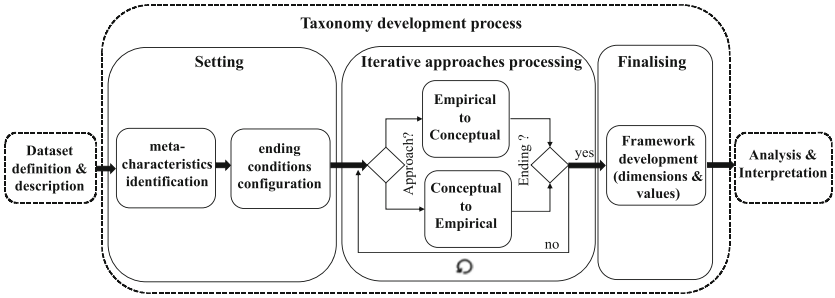

Fig. 3. Taxonomy development process

The *Digital Aim* dimension is built on the theory provided by Bhardwaj et al. [45]. The digital aim stems from the increasing interconnection among products, process and services, as a fusion between IT strategy and business strategy. Digital technologies (viewed as combinations of information, computing, communication, and connectivity technologies) affect business strategies, business processes, firm capabilities, products and services, and key interfirm relationships in extended business networks. Consistently to Bhardwaj et al., the *Digital Aim* dimension is intended to pursue the business elements affected by a DT phenomenon. Therefore, we developed a suitable set of values where each value covers a specific business element. In summary, the involvement of all business elements are included in the value "Digital Organisation Change". The involvement of a business process is highlighted in the value "Digital Process". The involvement of products and services is underpinned in the value "Digital Resource". Lastly, we defined the value "Digital Interaction" concerning the involvement of key interfirm relationships. This study does not include "firm capabilities" elements [45] due to lack of empirical evidence on the basis of our dataset.

The *Digital Technology* dimension is adapted from the contributions of Vial [2] and Bhardwaj et al. [45]. *Digital technologies* refer to an overarching sequence of relationships among two or more technologies [2]. The combination of these technologies is crucial for analysing a DT phenomenon [45]. In conformity with these authors, the *Digital Technology* dimension is intended to pursue the technology employed by a DT phenomenon. We first selected the values from Vial's contribution in order to provide a reliable set of values for this dimension. Afterwards, we refined them on the basis of the empirical evidence, analysing the contributions of our dataset. As a result, the set of values is as follows: "Social media", "Mobile", and "Analytics" (based on Vial's contribution); "Software Application", and "Digital Device" (based on empirical evidences); "Platform & Ecosystem". The latter includes technologies such as cloud, website or global infrastructure. Furthermore, we did not consider the Internet of Things (IoT) since we did not find this technology throughout the empirical evidence.

The *Scope* dimension aims to examine the operational business level involved in a DT phenomenon. We identified four operational business levels by analysing the contribution collected, and we used them as values. The values are: "Individual", "Business Unit", "Whole Business", and "Amongst Inter-Organisation Business". The *Scope* dimension allows to keep track of the specific "locus" affected by the DT.

The *NPO Relevance* dimension aims to understand how and to which extent NPOs are involved in a debate concerning a DT initiative. Since we observed that literature refers to NPOs in a DT debate to different extents, this dimension seeks to recognize all the possible relationships between an NPO and other organisations involved in a DT phenomenon (in line with our empirical evidence). Several contributions discussed the DT phenomenon in NPOs with regard to more than one organisation (not only NPOs). For example, some contributions articulated a "multi-layered" DT phenomenon, over Public Administration, for-profit enterprise and non-profit organisation as well. For this reason, we then defined a set of values for each possible relationship, also considering their direction. The first value "Non-profit Organisation Centred", is the only one not representing any relationship since it is assigned to papers where the NPO is the unique organisational form taken into consideration. This value describes the central relevance of an NPO discussed in a specific set of contributions. The following values identify five different relationships which have been recognized analysing the contributions in our dataset. One value identifies the relationship between a "Public Administration and an NPO". A second value classifies a twofold relationship and collaboration between "Business (as for-profit organisation) & NPO versus Public Administration & NPO and vice versa". A third value identifies a partnership; therefore, the relationship is intended between an "NPO and any other organisation". A fourth value defines the relationship between the collaboration of a "Public Administration and an NPO versus Business to Customers". The last value identifies a multi-layered relationship used to recognize the reference to the "Hybrid Organisation" [62]. Each one of these values aims to understand how literature refers to NPOs in a DT debate. Specifically, these values support the investigation of the relationships among different business involved in addition the NPOs that are always included anyway.

Lastly, the *Business Aim* dimension is used to explore the business aim of a NPO pursued or supported by a DT initiative, discussed in the dataset. As a result, each value classifies a specific business aim which should be self-explanatory. These values are: "Crowdfunding", "Crowdsourcing", "Knowledge Sharing", "Education", "Community Development", "Co-production", "Knowledge Management", "Social Value Creation", and "Organisation Development".

Table 2 shows the resulting taxonomy-based framework, which consists in the refined dimensions and their values. For each value a short description is provided together with the tag used for classifying the contribution in the dataset (see Appendix B).

5 Discussion and Conclusion

This paper represents the first step in a research project which aims to investigate the role that digital transformation has in the context of non-profit organisations. As a result, we developed a taxonomy in order to improve our understanding of this phenomenon, also supporting further investigations. This paper mainly represents a theoretical contribution, that is the development of a rigorous taxonomy [26], providing a *theory for analysing,* in accordance with Gregor's definition [27]. We then deployed the taxonomy classifying the papers in our dataset by using the defined dimensions and their relative values. Appendix B "*Papers analysis, classification of the articles*" reports the classification

Table 2. Taxonomy-based framework of dimensions and related values.

Dimensions	Values	Tags	Values Explanation
Digital Aim	Digital Resource	DigRes	Involvement of products and/or services in a DT phenomenon
	Digital Process	DigProc	Involvement of business process/es in a DT phenomenon
	Digital Interaction	DigInter	Involvement of key interfirm relationships in a DT phenomenon
	Digital Organisation Change	DigOrgChange	Involvement of all the business assets in a DT phenomenon
Scope	Individual	Ind	Individual operational level involvement in a DT phenomenon
	Business Unit	BusUnit	Business Unit operational level involvement in a DT phenomenon
	Whole Business	WholeBus	Whole Business operational level involvement in a DT phenomenon
	Amongst Inter-Organisation Business	InterOrg	Inter-Organisation operational level involvement in a DT phenomenon
NPO Relevance	Non-profit Organisation Centred	NPcentred	Central relevance of an NPO involved in a DT phenomenon
	Public Administration → Non-profit Organisation	PA2NP	relationship between a P. A. and an NPO involved in a DT phenomenon
	Business & Non-profit Organisation ↔ Public Administration & Non-profit Organisation	B&NPvsPA&NP	twofold relationship and collaboration between different businesses involved together in a DT phenomenon
	Non-profit Organisation → Partnership	NP2Partner	relationship between an NPO and any other organisation involved in a DT p.
	Public Administration & Non-profit Organisation → B2C	PA&NPtoB2C	relationship between the collaboration of a P. A. and an NPOs versus Business to Customers involved together in a DT phenomenon
	Hybrid Organisation	HybridOrg	"multi-layered" relationship as a Hybrid Organisation in pursue a DT p.
Digital Technology	Social Media	Social Media	Social Media employed/or developed through a DT phenomenon
	Platform & Ecosystem	Platform	Platform & Ecosystem e employed/or developed through a DT phenomenon
	Software Application	SoftApp	Software Application employed/or developed b through a DT phenomenon
	Mobile	Mob	Mobile employed/or developed through a DT phenomenon
	Digital Device	DigDevice	Digital Device (hardware and software) employed/or developed through a DT p.
	Analytics	Analytics	Analytics employed/or developed through a DT phenomenon
Business Aim	Crowdfunding	CrowFund	Crowdfunding aim pursued/supported through a DT phenomenon
	Crowdsourcing	CrowSour	Crowdsourcing aim pursued/supported through a DT phenomenon
	Knowledge Sharing	KnowShar	Knowledge Sharing aim pursued/supported through a DT phenomenon
	Education	Edu	Education aim pursued/supported through a DT phenomenon
	Community Development	CommDev	Community Development aim pursued/supported through a DT phenomenon
	Co-production	CoProd	Co-production aim pursued/supported through a DT phenomenon
	Knowledge Management	KnowMgt	Knowledge Management aim pursued/supported through a DT phenomenon
	Social Value Creation	SocValCreat	Social Value Creation aim pursued/supported through a DT phenomenon
	Organisation Development	OrgDev	Organisation Development aim pursued/supported through a DT phenomenon

of the collected contributions, where each paper (represented by its specific ID) has one and only one value for every dimension. Additionally, Appendix A "*Articles in the revised dataset*", reports the list of all the contributions analysed providing an ID number, authors, title, journal source and year of publication for every paper.

The proposed taxonomy could be used as a tool for supporting the understanding of circumstances and scenarios concerning DT in NPOs. Moreover, by combining two or more dimensions, it is possible to explore different features and aims discussed in a specific set of contributions. As an expository instantiation of the use of the taxonomy-based framework, we propose a preliminary analysis of the literature on non-profit organisations debating DT issues by using a subset of the defined dimensions (*Digital Aim*, *Scope*, *NPO Relevance*). This analysis can provide some insight into the characteristics of the discussion on digital transformation phenomenon in the contributions strongly focused on NPOs.

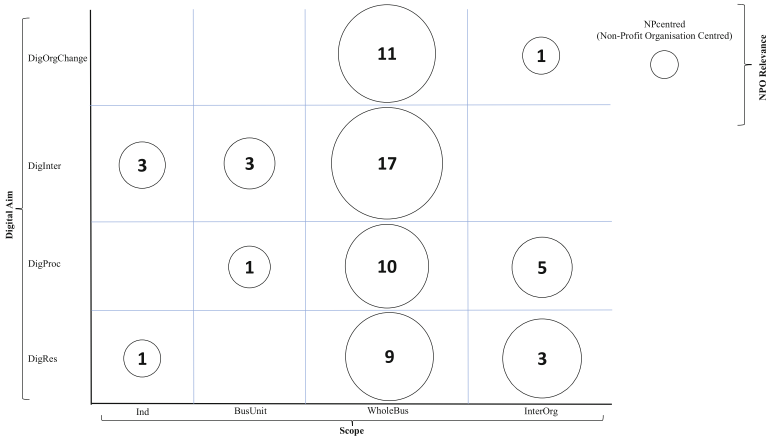

Fig. 4. Number of contributions discussing a DT phenomenon in relation to non-profit organisations (only "NPcentred") considering the Digital Aim (the focus) and Scope (the locus) dimensions.

Figure 4 shows the resulting diagram combining three specific dimensions: *Digital Aim* (the focus), *Scope* (the locus) and the degree of *NPO Relevance* (using only "NPcentred" value). Looking at the diagram, it appears that digital transformation initiatives in NPOs mainly affect the whole business (the *Scope* value), focusing firstly on developing digital interaction (the *Digital Aim* value). As a further step, it is suggested to further analyse the selected contributions that share the same value for every dimension considered, in order to discover further commonalities.

Finally, limitations could be identified in bias on the outcomes of this research, since the interpretation of the present authors may differ from that of other researchers. The specific focus on NPOs may represent a further limitation of this study since we investigated only NPOs within the wide third sector field. Therefore, a further literature review process is recommended in order to enlarge the focus on the whole third sector field. However, further research could test the taxonomy proposed in the development

of a similar or complementary research project. Incidentally, it could be interesting to integrate the taxonomy in order to investigate other business issues, such as sector and business size, cultural and political implications, national regulations influence or similar matters.

Appendix A: Articles in the Revised Dataset

ID	Authors	Title	Journal	Year
1	Alampi A.	The future is micro: How to build an effective micro-influencer programme	Journal of Digital and Social Media Marketing	2020
2	Qu H., Steinberg R., Burger R.	Abiding by the law? Using Benford's law to examine the accuracy of nonprofit financial Reports	Nonprofit and Voluntary Sector Quarterly	2020
3	Van Dijck J., Jacobs B.	Electronic identity services as sociotechnical and political-economic constructs	New Media and Society	2020
4	Li P., Men L.R., Yue C.A.	An exploratory study of stewardship for Chinese nonprofit organisations	International Journal of Nonprofit and Voluntary Sector Marketing	2020
5	Lima V.M.A., Dos Santos C.A.C.M., Rozestraten A.S.	The arquigrafia project: A Web collaborative environment for architecture and urban Heritage Image	Journal of Data and Information Science	2020
6	Hyde F	Harry's most important work	Marketing Theory	2020
7	Rojas-Torrijos J.L., Caro-González F.J., González-Alba J.A.	The emergence of native podcasts in journalism: Editorial strategies and business opportunities in Latin America	Media and Communication	2020

(*continued*)

(*continued*)

ID	Authors	Title	Journal	Year
8	Seo H., Vu H.T.	Transnational nonprofits' social media use: A survey of communications professionals and an Analysis of organisational characteristics	Nonprofit and Voluntary Sector Quarterly	2020
9	Crittenden L., Haywood A.	Revising legacy media practices to serve hyperlocal information needs of marginalized populations	Journalism Practice	2020
12	Sher S.T.H., Su N.M.	Speedrunning for charity: How donations gather around a live streamed couch	Proceedings of the ACM on Human-Computer Interaction	2019
13	Fisher J.	Digital games for international development: A field theory perspective	International Communication Gazette	2019
14	Ferrucci P., Painter C.E., Kalika A.	How market orientation and ethics affected coverage of marijuana legalization	Newspaper Research Journal	2019
15	Manlove J., Whitacre B.	An evaluation of the connected nation broadband adoption program	Telecommunications Policy	2019
16	Levenshus A.B., et al.	"I thought they'd do more": Conflicting expectations of crowdfunding communication	Journal of Communication Management	2019
17	Kahne J., Bowyer B.	Can media literacy education increase digital engagement in politics?	Learning, Media and Technology	2019

(*continued*)

(*continued*)

ID	Authors	Title	Journal	Year
18	Piatak J., Dietz N., McKeever B.	Bridging or deepening the digital divide: Influence of household internet access on formal and informal volunteering	Nonprofit and Voluntary Sector Quarterly	2019
19	Chang E.	Beyond workforce preparation: contested visions of 'twenty-first century' education reform	Discourse	2019
20	Adams M.B., Johnson M.A.	Acculturation, pluralism, empowerment: Cultural images as strategic communication on Hispanic nonprofit websites	Journal of International and Intercultural Communication	2019
21	Nageswarakurukkal K., Gonçalves P., Moshtari M.	Improving fundraising efficiency in small and medium sized non-profit organisations using online solutions	Journal of Nonprofit and Public Sector Marketing	2019
22	Ferrucci P., Nelson J.L.	The new advertisers: How foundation funding impacts journalism	Media and Communication	2019
23	Akimova O.E., et al.	The methodology of decision support for the entrepreneurial sector in the information asymmetry of the cyber economy	Contributions to Economics	2019
24	Zhou H., Ye S.	Fundraising in the Digital Era: Legitimacy, social network, and political ties matter in China	Voluntas	2019
25	Kuhn B.M.	China's commitment to the sustainable development goals: An analysis of push and pull factors and implementation challenges	Chinese Political Science Review	2018

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ID	Authors	Title	Journal	Year
26	Lee C.I., et al.	The effect of digital breast tomosynthesis adoption on facility-level breast cancer screening volume	American Journal of Roentgenology	2018
27	Garcia A.A., Le Dantec C.A.	Quotidian report: Grassroots data practices to address public safety	Proceedings of the ACM on Human-Computer Interaction	2018
29	Kim Y.M., et al.	The Stealth Media? Groups and targets behind divisive issue campaigns on facebook	Political Communication	2018
30	Yoo S.-C., Drumwright M.	Nonprofit fundraising with virtual reality	Nonprofit Management and Leadership	2018
31	Kim J., Gray J.A.	Palliative care experiences and needs of Direct care workers	Journal of Palliative Medicine	2018
32	Smith J.N.	The Social Network? Nonprofit constituent engagement through social media	Journal of Nonprofit and Public Sector Marketing	2018
33	Konieczna M.	Evolving, rather than policing, the Boundary: A case study of the development of the center for public integrity	Digital Journalism	2018
34	Kantar R.S., et al.	Internet-based digital simulation for cleft surgery education: A 5-year assessment of demographics, usage, and global effect	Journal of Surgical Education	2018
35	Barrett M., et al.	AIR Louisville: Addressing asthma with technology, crowdsourcing, cross-sector collaboration, and policy	Health Affairs	2018
36	Yang A., Saffer A.	NGOs' Advocacy in the 2015 refugee crisis: A study of agenda building in the digital age	American Behavioral Scientist	2018

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ID	Authors	Title	Journal	Year
37	Gaffield C.	Words, Words, Words: How the digital humanities are integrating diverse research fields to study people	Annual Review of Statistics and Its Application	2018
38	Stone K., et al.	Conducting community health needs assessments in the local public health department: A comparison of random digit dialling and the community assessment for public health emergency response	Journal of public health management and practice: JPHMP	2018
39	Smith A.M., et al.	Journal of open source software (JOSS): Design and first-year review	PeerJ Computer Science	2018
40	Shulin Z., Chienliang K.	How social media are changing nonprofit advocacy: Evidence from the crowdfunding platform in Taiwan	China Nonprofit Review	2018
41	Plana N.M., et al.	The first year of global cleft surgery education through digital simulation: A proof of concept	Cleft Palate-Craniofacial Journal	2018
42	Lattie E.G., et al.	A practical do-it-yourself recruitment framework for concurrent eHealth clinical trials: Identification of efficient and cost-effective methods for decision making (part 2)	Journal of Medical Internet Research	2018
43	Alam S.L., Campbell J.	Temporal motivations of volunteers to participate in cultural crowdsourcing work	Information Systems Research	2017

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ID	Authors	Title	Journal	Year
44	Olinski M., Szamrowski P.	Using dialogic principles on websites: How public benefit organisations are building relationships with their public	Nonprofit Management and Leadership	2017
45	Yamanoor S., Yamanoor S.H.	DIY digital decorations	IEEE Spectrum	2017
46	Huang Y.-H.C., Wu F., Huang Q.	Does research on digital public relations indicate a paradigm shift? An analysis and critique of recent trends	Telematics and Informatics	2017
47	Ferrucci P., Tandoc E.C., Jr.	Shift in influence: An argument for changes in studying gatekeeping	Journal of Media Practice	2017
48	Kamber T.	Gen X: The cro-magnon of digital natives	Generations	2017
49	Whitaker J.C., Chernock R., Dolan M.A.	Progress report of the advanced television systems committee	SMPTE Motion Imaging Journal	2017
50	Schreieck M., Wiesche M., Krcmar H.	Governing nonprofit platform ecosystems–an information platform for refugees	Information Technology for Development	2017
51	Mollura D.J., et al.	2016 RAD-AID Conference on international radiology for developing countries: gaps, growth, and united nations sustainable development goals	Journal of the American College of Radiology	2017
52	Dush L.	Nonprofit collections of digital personal experience narratives: An exploratory study	Journal of Business and Technical Communication	2017
53	Marshall C., Hobbs J.	Creating a web-based digital photographic archive: One hospital library's experience	Journal of the Medical Library Association	2017

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ID	Authors	Title	Journal	Year
54	Ferrucci P., et al.	Times Are a changing: How a merger affects the construction of news processes	Journalism Studies	2017
55	Ferrucci P.	Exploring public service journalism: Digitally native news nonprofits and engagement	Journalism and Mass Communication Quarterly	2017
56	Alberti F.G., Varon Garrido M.A.	Can profit and sustainability goals co-exist? New business models for hybrid firms	Journal of Business Strategy	2017
57	Sieber R.E., et al.	Doing public participation on the geospatial web	Annals of the American Association of Geographers	2016
58	Raman A.	How do social media, mobility, analytics and cloud computing impact Nonprofit organisations? A Pluralistic study of information and communication technologies in indian context	Information Technology for Development	2016
59	Arunachalam S., Madhan M.	Adopting ORCID as a unique identifier will benefit all involved in scholarly communication	National Medical Journal of India	2016
61	Kostelnick C.	The re-emergence of emotional appeals in interactive data visualization	Technical Communication	2016
62	Wojdynski B.W., Kalyanaraman S.	The three dimensions of website navigability: Explication and effects	Journal of the Association for Information Science and Technology	2016
63	Lowe G.F., Stavitsky A.G.	Ensuring public service news provision in the era of networked communications	International Communication Gazette	2016

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ID	Authors	Title	Journal	Year
64	Naraine M.L., Parent M.M.	Illuminating centralized users in the social media ego network of two national sport organisations	Journal of Sport Management	2016
65	Ilten C.	"Use your skills to solve this challenge!": The platform affordances and politics of digital microvolunteering	Social Media and Society	2015
66	Hofer C.	Records are not books – preservation, archiving and digitization of historic sound carriers	VOEB-Mitteilungen	2015
67	Martin E.J.	What's at stake for content creators in the net neutrality debate?	EContent	2015
69	Ferrucci P.	Public journalism no more: The digitally native news nonprofit and public service journalism	Journalism	2015
71	Bürger T.	Use of digital advocacy by German nonprofit foundations on Facebook	Public Relations Review	2015
72	Skinner K., Blackwell L.S.	Critical moments: Chance, choice, and change in scholarly publishing	Serials Librarian	2015
74	Goldkind L.	Social media and social service: Are nonprofits plugged in to the digital age?	Human Service Organisations Management, Leadership and Governance	2015
76	Yoo S.-C., Peña J.F., Drumwright M.E.	Virtual shopping and unconscious persuasion: The priming effects of avatar age and consumers' age discrimination on purchasing and prosocial behaviors	Computers in Human Behavior	2015

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ID	Authors	Title	Journal	Year
77	Wilson M.W.	Paying attention, digital media, and community-based critical GIS	Cultural Geographies	2015
78	Dush L.	Building the capacity of organisations for rhetorical action with new media: An approach to service learning	Computers and Composition	2014
79	Nee R.C.	Social responsibility theory and the digital nonprofits: Should the government aid online news startups?	Journalism	2014
83	Fuentes-Bautista M.	Rethinking localism in the broadband era: A participatory community development approach	Government Information Quarterly	2014
84	Cheong P.H., Hwang J.M., Brummans B.H.J.M.	Transnational immanence: The autopoietic co-constitution of a Chinese spiritual organisation through mediated communication	Information Communication and Society	2014
85	Pin C.	Cluster policies and digital entrepreneurship in Ile-de-France (France) and in Lombardy (Italy)	Innovations	2014
86	Eimhjellen I., Wollebæk D., Strømsnes K.	Associations online: Barriers for using web-based Communication in voluntary associations	Voluntas	2014
89	Lee R.L., Joseph R.C.	An examination of web disclosure and organisational transparency	Computers in Human Behavior	2013

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ID	Authors	Title	Journal	Year
90	Hamann D.J., Bezboruah K.C.	Utilization of technology by long-term care providers: Comparisons between for-profit and nonprofit institutions	Journal of Aging and Health	2013
91	Özdemir V., et al.	Crowd-funded micro-grants for genomics and big data: An actionable idea connecting small (Artisan) science, infrastructure science, and citizen philanthropy	OMICS A Journal of Integrative Biology	2013
92	Thompson C.	Read free or die: Harvard hosts a nonprofit alternative to google books	IEEE Spectrum	2013
93	Nee R.C.	Creative destruction: An exploratory study of how digitally native news nonprofits are innovating online journalism practices	JMM International Journal on Media Management	2013
94	Pritchard M., et al.	Open access to geophysical data sets requires community responsibility	Eos	2012
95	Mitchell K., Elwood S.	Engaging students through mapping local history	Journal of Geography	2012
96	Powers E., Yaros R.A.	Supporting online nonprofit news organisations: Do financial contributions influence stakeholder expectations and engagement?	Journal of Media Business Studies	2012
97	Shafrir S.M., Yuan Y.C.	Getting the feel: Email usage in a nonprofit community organisation in a low-income community	Communication Quarterly	2012

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ID	Authors	Title	Journal	Year
98	Manafy M.	Interaction is good business	EContent	2011
101	Bischoff C., et al.	In the flow of media, religion, and culture: A case study with TVbyGIRLS	Religious Education	2011
102	Wilson M.W.	'Training the eye': Formation of the geocoding subject	Social and Cultural Geography	2011
103	Alfasso A.	Information literacy instruction for community members: An academic partnership with a community nonprofit organisation	Journal of Consumer Health on the Internet	2011
104	Pirson M.	Social entrepreneurship: A model for sustainable value creation	Advances in Appreciative Inquiry	2010
105	Andrews S.S., et al.	The development of a personal learning environment in second life	International Journal of Virtual and Personal Learning Environments	2010
106	Freddolino P.P., et al.	To Help and to Learn: An exploratory study of peer tutors teaching older adults about technology	Journal of Technology in Human Services	2010
107	Gurstein P., O'Neill J., Petersen M.	Outsourcing to further human development: The case of a social enterprise in Cambodia and laos	Journal of Architectural and Planning Research	2009
108	Riley A	Not going with the proverbial flow	GEO: connexion	2009
109	Ashenfelder M., et al.	NDIIPP models for mass data transmission and storage	Library Trends	2009
110	Zucker A.A.	The role of nonprofits in educational technology innovation	Journal of Science Education and Technology	2009

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ID	Authors	Title	Journal	Year
111	Mano R.S.	Information technology, adaptation and innovation in nonprofit human service organisations	Journal of Technology in Human Services	2009
112	Alfred J.	Securing the supply chain	Electronic Engineering Times	2008
114	Goodsmith L.	Beyond where it started: a look at the "Healing Images" experience	Torture: quarterly journal on rehabilitation of torture victims and prevention of torture	2007
116	Avni R.	Mobilizing hope: Beyond the shame-based model in the Israeli-Palestinian conflict	American Anthropologist	2006
118	Knox A.	Why American business demands twenty-first century learning: A company perspective	New directions for youth development	2006
122	Riggs C.	Educase 2003: A conference summary	Library Hi Tech News	2004
123	Humphrey M., Kim D.W., Dudley L.	The use of computer technology in rural nonprofit organisations	International Review of Public Administration	2004
124	Tucker N.A., Holley R.P.	Digital infrastructure development within a nonprofit polymer science library: An analysis of the transition to digital serials at the michigan molecular institute	Serials Review	2004
126	Dresang E.T., Gross M., Holt L.E.	Project CATE: Using outcome measures to assess school-age children's use of technology in urban public libraries. A collaborative research process	Library and Information Science Research	2003

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ID	Authors	Title	Journal	Year
128	Means J.E., et al.	ARC parterships: industry and academia explore remote sensing applications	Journal of Forestry	2001
130	Fuhrmann S.	Designing a visualization system for hydrological data	Computers and Geosciences	2000
133	Murray C.L., et al.	Health care delivery reorganization innovative outcome: universal computerized patient identification	Medinfo. MEDINFO	1995
134	Landsbergen D., Shiang J., Byrnes P.	Fiber optic highways and network bridges: Planning for the telecommunications infrastructure needs of the city in the 21st century	Telematics and Informatics	1994
135	Chen Ching-chih	NIT Conference revisited the Latin American region: Moving toward digital, telecommunication, integrated applications	Microcomputers for Information Management	1993
136	Dvorzak M.	Geological societies and information transfer in the electronic age. Proceedings of the 25th meeting of the geoscience information society, October-November 1990	Geological societies and information transfer in the electronic age. Proceedings of the 25th meeting of the Geoscience Information Society, October-November 1990	1991
137	Allan Roger	Tactile sensing, 3-D vision, and more precise arm movements herald the hardware trends in industrial robots	Electronic Design	1983

Appendix B: Papers Analysis, Classification of the Articles

ID	Digital aim	Scope	NPOs	Technology	Business aim
1	DigInter	Ind	NPcentred	Platform	Edu
2	DigProc	InterOrg	NPcentred	Analytics	KnowMgt
3	DigProc	WholeBus	NPcentred	Platform	OrgDev
4	DigRes	WholeBus	NPcentred	Platform	KnowShar
5	DigRes	InterOrg	PA&NPtoB2C	Platform	CoProd
6	DigInter	WholeBus	NPcentred	Social Media	OrgDev
7	DigInter	WholeBus	NPcentred	Social Media	CommDev
8	DigInter	WholeBus	NPcentred	Social Media	CoProd
9	DigInter	WholeBus	NPcentred	Platform	KnowShar
12	DigRes	WholeBus	NPcentred	Platform	CrowFund
13	DigRes	WholeBus	B&NPvsPA&NP	SoftApp	SocValCreat
14	DigRes	WholeBus	PA&NPtoB2C	Platform	KnowShar
15	DigRes	WholeBus	PA&NPtoB2C	Platform	SocValCreat
16	DigRes	WholeBus	PA2NP	Platform	CrowFund
17	DigRes	BusUnit	PA&NPtoB2C	Mob	Edu
18	DigProc	WholeBus	PA&NPtoB2C	Platform	SocValCreat
19	DigRes	WholeBus	NPcentred	DigDevice	Edu
20	DigInter	WholeBus	NPcentred	Platform	CommDev
21	DigInter	BusUnit	NPcentred	Platform	CrowFund
22	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
23	DigOrgChange	WholeBus	PA&NPtoB2C	Platform	OrgDev
24	DigProc	WholeBus	NPcentred	DigDevice	CrowFund
25	DigInter	BusUnit	NPcentred	Mob	CommDev
26	DigProc	BusUnit	PA&NPtoB2C	DigDevice	OrgDev
27	DigInter	InterOrg	PA&NPtoB2C	Social Media	CrowSour
29	DigInter	Ind	NPcentred	Platform	Edu
30	DigInter	Ind	B&NPvsPA&NP	Social Media	CommDev
31	DigProc	WholeBus	NPcentred	DigDevice	CrowFund
32	DigInter	BusUnit	NPcentred	Social Media	CommDev
33	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
34	DigRes	InterOrg	NP2Partner	SoftApp	Edu
35	DigRes	InterOrg	NP2Partner	DigDevice	CrowSour
36	DigInter	Ind	NPcentred	Mob	CommDev

(*continued*)

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ID	Digital aim	Scope	NPOs	Technology	Business aim
37	DigProc	InterOrg	PA&NPtoB2C	Analytics	Edu
38	DigRes	BusUnit	PA&NPtoB2C	Analytics	KnowMgt
39	DigRes	WholeBus	NPcentred	Platform	CrowSour
40	DigProc	WholeBus	NPcentred	Platform	CrowFund
41	DigRes	InterOrg	NP2Partner	SoftApp	Edu
42	DigProc	BusUnit	PA&NPtoB2C	Social Media	OrgDev
43	DigProc	WholeBus	PA&NPtoB2C	DigDevice	CrowSour
44	DigInter	BusUnit	PA&NPtoB2C	Platform	CommDev
45	DigRes	WholeBus	NPcentred	DigDevice	SocValCreat
46	DigInter	BusUnit	B&NPvsPA&NP	Social Media	CommDev
47	DigInter	WholeBus	NPcentred	Platform	KnowShar
48	DigOrgChange	WholeBus	NPcentred	Mob	SocValCreat
49	DigProc	WholeBus	NPcentred	Platform	KnowMgt
50	DigInter	WholeBus	NPcentred	Platform	SocValCreat
51	DigRes	InterOrg	NPcentred	Platform	KnowMgt
52	DigInter	WholeBus	NPcentred	Platform	OrgDev
53	DigProc	BusUnit	NPcentred	Platform	KnowMgt
54	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
55	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
56	DigOrgChange	InterOrg	HybridOrg	Platform	OrgDev
57	DigInter	WholeBus	NP2Partner	Platform	CrowSour
58	DigOrgChange	WholeBus	NPcentred	Platform	OrgDev
59	DigRes	WholeBus	NPcentred	Platform	CrowSour
61	DigProc	BusUnit	PA&NPtoB2C	Analytics	OrgDev
62	DigRes	WholeBus	NPcentred	Platform	OrgDev
63	DigOrgChange	WholeBus	B&NPvsPA&NP	Platform	KnowShar
64	DigInter	BusUnit	PA&NPtoB2C	Social Media	CommDev
65	DigRes	Ind	HybridOrg	Platform	CrowSour
66	DigProc	WholeBus	NPcentred	Platform	OrgDev
67	DigInter	WholeBus	NPcentred	Social Media	SocValCreat
69	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
71	DigInter	WholeBus	NPcentred	Social Media	CommDev
72	DigProc	WholeBus	NPcentred	Platform	KnowMgt
74	DigOrgChange	InterOrg	NPcentred	Platform	KnowMgt
76	DigInter	WholeBus	NPcentred	Social Media	CommDev

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ID	Digital aim	Scope	NPOs	Technology	Business aim
77	DigInter	WholeBus	B&NPvsPA&NP	Social Media	CommDev
78	DigProc	Ind	PA&NPtoB2C	DigDevice	Edu
79	DigRes	WholeBus	NPcentred	Platform	OrgDev
83	DigOrgChange	WholeBus	PA&NPtoB2C	Platform	KnowShar
84	DigInter	InterOrg	PA&NPtoB2C	Platform	CoProd
85	DigOrgChange	InterOrg	NP2Partner	Platform	OrgDev
86	DigInter	WholeBus	NPcentred	Social Media	CommDev
89	DigInter	WholeBus	NPcentred	Platform	SocValCreat
90	DigInter	WholeBus	NPcentred	Platform	KnowShar
91	DigRes	InterOrg	B&NPvsPA&NP	Analytics	OrgDev
92	DigProc	WholeBus	B&NPvsPA&NP	Platform	KnowMgt
93	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
94	DigProc	WholeBus	NPcentred	Platform	KnowMgt
95	DigProc	InterOrg	NPcentred	Platform	KnowMgt
96	DigProc	InterOrg	PA&NPtoB2C	Platform	CoProd
97	DigInter	WholeBus	NPcentred	Mob	CommDev
98	DigInter	WholeBus	NPcentred	Social Media	OrgDev
101	DigOrgChange	WholeBus	NPcentred	Platform	KnowShar
102	DigProc	Ind	PA&NPtoB2C	Mob	CoProd
103	DigOrgChange	WholeBus	NPcentred	Platform	Edu
104	DigOrgChange	WholeBus	NP2Partner	Platform	SocValCreat
105	DigInter	Ind	NP2Partner	Platform	Edu
106	DigRes	Ind	NP2Partner	Platform	Edu
107	DigProc	WholeBus	NPcentred	Mob	Edu
108	DigProc	WholeBus	NPcentred	Platform	SocValCreat
109	DigRes	InterOrg	NPcentred	DigDevice	CoProd
110	DigProc	InterOrg	NP2Partner	Platform	KnowMgt
111	DigRes	InterOrg	HybridOrg	Platform	Edu
112	DigProc	InterOrg	NPcentred	Platform	KnowMgt
114	DigRes	WholeBus	NPcentred	Platform	SocValCreat
116	DigRes	Ind	NPcentred	Mob	SocValCreat
118	DigRes	InterOrg	NP2Partner	Platform	Edu
122	DigInter	WholeBus	NPcentred	Platform	KnowShar
123	DigOrgChange	WholeBus	NPcentred	Platform	OrgDev
124	DigOrgChange	WholeBus	NP2Partner	Platform	KnowMgt

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ID	Digital aim	Scope	NPOs	Technology	Business aim
126	DigRes	WholeBus	PA&NPtoB2C	Mob	SocValCreat
128	DigRes	InterOrg	NP2Partner	DigDevice	CoProd
130	DigRes	BusUnit	PA&NPtoB2C	SoftApp	KnowMgt
133	DigProc	InterOrg	NPcentred	Platform	KnowMgt
134	DigRes	InterOrg	PA2NP	Platform	OrgDev
135	DigRes	InterOrg	NPcentred	Platform	Edu
136	DigProc	InterOrg	NPcentred	Platform	KnowMgt
137	DigRes	BusUnit	B&NPvsPA&NP	DigDevice	OrgDev

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Benefits and Challenges

Retweeting in the Age of Fake News - A Cognitive Style Perspective

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Abstract. Twitter is not only used to stay connected to a specific group of people or friends, but emerges as a platform to spread news. Celebrities, institutions and news outlets increasingly tweet information which they deem as worthy. However, independent users are also able to share various information, which makes it increasingly hard to distinguish which information is credible. In this research we attempt to gather an overview about Twitter users' attitude towards news sharing on Twitter and how credible they find information provided on Twitter. Drawing on the elaboration likelihood model, we operationalized the elaboration likelihood with the default cognitive style of the users. Surprisingly, the results show that people with a more rational cognitive style prefer Twitter as a news source.

Keywords: Twitter · Cognitive style · Fake news

1 Introduction

Janze and Risius [11] describe "Fake News" as misinformation, fabricated to mislead its readers without providing objective facts. The increasing use and relevance of social media in nowadays society elevates the power of the intentional spreading of false information. Users of social media may not have the intention to spread misinformation but are used by the creators of fake news to spread their fabricated news across the Internet. Fake news builds on cues to lead people into believing, and sharing them [11]. Intentionally spreading false information is not a new phenomenon, but with more and more opportunities to access and reach towards social media users paired with the effortless further distribution via "liking" or "retweeting", false information flourishes.

The terminology of "fake news" first gained the attention of the public in the US election in 2016 [17]. Stories about election manipulation were shared among social media and were widely discussed in the web. The discussion was elevated because most discussed fake stories in the election tended to favor Donald Trump over Hillary Clinton [25]. Research showed that many people, in fact, believed fake news [25]. Furthermore, [30] among others [11,25] show that fake stories are shared among social media more frequently than on traditional mainstream media.

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Fake news in the sphere of social media is a relatively new phenomenon. Therefore, little is known about the users' attitude of acquiring and sharing information on social media platforms. It is important to identify how valuable social media as an information source is for the individual users. Building on our Research-in-Progress paper, we elaborate on the influences of news sharing attitude and the role of the personal preferred cognitive style. In line with [18], who investigated real and fake news based on the information presentation, we build on the elaboration-likelihood model (ELM) to understand under which circumstances Twitter news sharing attitude is influenced by the users' reliance on peripheral cues, or if they instead analytically try to verify given information.

In the past, research effects of cognitive abilities have been neglected. Studies focused heavily on anchoring effects, endowment, ambiguity aversion or probability weighting. Researched topics rarely reference the possible impact of cognitive ability/style [7].

Therefore, this research paper addresses the questions:

RQ 1a: How does source credibility influence the news sharing attitude on Twitter?
RQ 1b: How does quality influence the news sharing attitude on Twitter?
RQ 2a: How does the individuals' preferred cognitive style affect the relation of source credibility towards the news sharing attitude on Twitter?
RQ 2b: How does the individuals' preferred cognitive style affect the relation of information quality towards the news sharing attitude on Twitter?

In our study, we asked US Twitter account holders about their attitude to share news on Twitter, if they instead rely on source credibility (well-known personality or expert in the field), or if they try to verify information with external sources (i.e., relying more on the information quality). The participants were not introduced to the topic of fake news to avoid social-desirability-bias [4].

The rest of the paper is structured as follows: First, a review of the literature is presented, discussing relevant concepts like the ELM and its applicability as the theoretical foundation of this study. After that, the hypotheses are developed, the research model, and the research method described. The paper closes with presenting the results and the contribution to research.

2 Literature Review

2.1 Elaboration Likelihood Model

In line with [31], we draw on the Elaboration-Likelihood Model in the context of social media. The ELM is part of what is called dual-process theory. In the following, we will elaborate on the concept of the dual-process theory and the stance of the ELM.

The dual-process theory proposes that external information drives individuals' attitudes and behavioral change. In general, individuals rely on two cognitive

styles when confronted with information or decisions. There is a rational, analytical style, which takes facts into account and deductively reaches a certain conclusion. This style of thinking requires the individual's awareness and specific cognitive effort to reach a conclusion consciously. And there is an affective, processing of peripheral cues. The two routes of effortful and effortless processing - hence the name - are the core of dual-process theories [1].

Petty and Cacioppo [21] describe in the ELM the two routes which lead to an attitude or behavior as the central route and peripheral route. The two routes represent the two distinct processing styles in dual-process theory. Bhattacherjee and Sanford [1] elaborated on how the two routes differ and found three characteristics:

(1) The central route relies on information-related arguments, which are within the presented information, whereas the peripheral route relies on cues which do not necessarily have a link to the information. When confronted with an argument, the central route would depend on the consistency of the argument in combination with the information presented on which the argument is based on. For the peripheral route, the argument for itself is not as relevant. The author of the argument or a pre-existing frame of the person play a much more significant role.
(2) The central route, therefore, requires a higher cognitive effort than the peripheral route. Individuals need to have a certain motivation to engage in an analytical cognitive style to elaborate on a piece of information.
(3) Due to the higher cognitive effort and the assumption that individuals engage truthfully in the systematic elaboration, behavior or attitude changes induced by the central route are more stable in the long term according to Petty and Cacioppo [21]. Relying on peripheral cues induces the risk that individuals will easily change their attitude or behavior when confronted with the right cues. In the case of Twitter, users are confronted with masses of information daily. This mass of information requires to filter and evaluate presented information. Due to this vast amount of information, users may rely on peripheral cues to reach a conclusion which information is relevant and worth to engage with.

In IS research the two routes of the ELM were operationalized by using two constructs: information quality and source credibility [1]. In the ELM the central route is suggested as the effortful processing of information. On this route, individuals analyze the information based on the information quality (or argument quality as mentioned in (1)) [1,3,20,29].

The peripheral route which relies on cues has more weight, due to their easiness to process them. Examples for cues can be the source credibility or agreement with their own opinion [12]. In the context of social media, credibility could also be reached by a high amount of likes in terms of Facebook, or a high number of "retweets" in the case of Twitter. For the source credibility, it is possible that people assess the perceived trustworthiness of information based on well-known personalities (e.g., head of state, journalists, scientists) or institutions (e.g., universities, media houses). ELM suggests that people with

higher motivation (a higher elaboration likelihood) are likely to spend cognitive resources on the central route [20,21].

The question remains under which circumstances people tend to use the central or the peripheral route. In the ELM the elaboration likelihood of individuals moderates the influences of the two routes. This construct suggests that people add something on their own to presented information to reach a conclusion [22]. To verify that certain information is not fake, people have to invest time and cognitive effort. For the central route, this effort tends to be higher. Therefore, the peripheral route seems to be more 'attractive'. Based on individual traits, people prefer a certain cognitive style. In a high state of elaboration likelihood, people elaborate more carefully on the presented information. People who tend to use the central route, therefore a high elaboration likelihood, are more likely to be persuaded by argument quality than by cues. In a state of low elaboration likelihood, especially lacking motivation or lack of expertise to engage in analytical evaluation of information are the factors why individuals get persuaded by peripheral cues [1]. In past research, the ELM was used in the adoption of information from social media, as suggested in the paper of [3] and the trust of information on social media platforms [20].

2.2 Cognitive Style

We draw on the concept of the cognitive style to conceptualize elaboration likelihood, and therefore the cognitive motivation or demotivated individuals are. In the ELM processing cues for the peripheral route do not need much attention of the individual and thus induce an 'auto-piloted' behavior. Without elaborating, individuals evaluate presented information on given cues. Twitter users who rely on Tweets as news source may not consider the presented information carefully by reflecting on the topic or reaching out to different sources, but rather rely on the credibility of the source (the people they follow). However, research has shown that people show different styles in reaching a conclusion and therefore do invest time and effort to rethink their actions, based on the individual's cognitive style [7].

Past research repeatedly elaborated on the distinction between cognitive processes which are executed effortless with little conscious deliberation, and processes which show inherent cognitive effort, but more reflective, without considering social content [5,7,26]. Easy to operate processes involve everything which happens spontaneous and does not require or consume attention or motivation. A prominent example of this process is the recognition of faces [7].

The Cognitive Reflection Test (CRT) [7] presents problems which at first glance have an intuitive, but wrong answer. The right answer, however, can only be concluded if the problem is solved logically, which calls for a higher cognitive effort. This way, it is easy to identify people who have robust analytical processing. The test is reliable in that sense, that wrong answers are not random. Most of the time the incorrect answers are shared among a vast margin of participants.

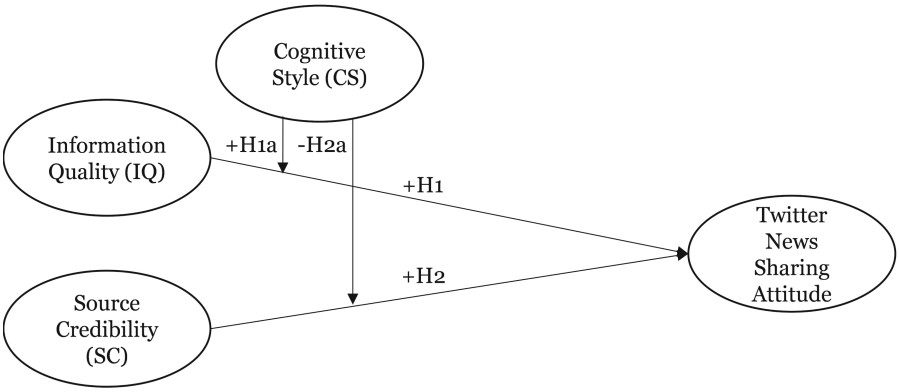

Fig. 1. Research model

3 Research Model and Method

As suggested by the literature, we base our research on the Elaboration Likelihood Model (ELM) which is depicted in Fig. 1. ELM presents a fitting framework to capture the information evaluation on social media as shown by [31], who show a similar approach in the context of information adoption for working purposes. This research aims to gain a better understanding of the dynamics in which fake news spread on Twitter. Intentionally spread fake news aim towards tricking their readers by cues and avoid verifiable facts. Source credibility on Twitter is special, since people choose who they follow and whose information they want to see. However, one could argue that the difference in reading newspapers is not that different since individuals also choose on what newspapers they want to read or buy. Due to the exposure of information, which individuals choose themselves, we could call this environment a self-made filter bubble.

The Twitter news sharing construct is derived from the attitude construct of [1]. We define Twitter news sharing attitude as the personal belief on how problematic or beneficial sharing news on Twitter is. Based on their attitudes we can make assumptions about whether individuals may share news in general. To fit the context of social media, items have been altered to specifically target the news sharing aspect, which can be seen in the appendix.

We define information quality by the judgment of Twitter users, whether they perceive information as valid or not. It describes how Twitter users engage with the presented information, whether it is incomplete or accurate. We can argue that it represents how Twitter users validate given information, e.g. by reaching out for external sources such as news magazines, or whether they check for the internal consistency of the given information. By judging on the accuracy of the information, the user has to have either expertise in the field or needs to validate information with external sources. The construct reflects the perceived quality of the argument which is constituted by the central route in the elaboration likelihood model [21]. Measurements for argument quality have been suggested

before [1,29]. According to the ELM, the judgment of information quality calls for a bigger cognitive effort and voluntary engagement, since users have to reach out for alternative sources for comparison or check the consistency of the arguments and facts based on their expertise. According to [29], information quality as the central route leads to information adoption by the individual. Under high elaboration likelihood, Twitter users should value the validation of information as the primary determinant for their sharing attitude. We assume that it is in the interest of all users (without a specific agenda) that only truthful information is shared among the social media for their information adoption behavior. We, therefore, postulate the following hypothesis:

H1: Higher information quality is positively associated with the news sharing attitude on Twitter.

Trust is the willingness to take a risk and be vulnerable to the actions of the trustee. Trust is tied to an entity, the trustee, which or who individuals perceive as trustworthy [13]. Trustworthiness is considered to have three dimensions: competency-based (the competence of the trustee to provide the ability the truster needs), benevolence-based (the trustee acts in the interest of the one who trusts) and integrity-based (the honesty of the trustee) trustworthiness [13,14]. We adopted the construct of source credibility directly from [1] and altered it towards the Twitter context. Zha et al. [31] followed the same approach. However, they focus on social media as a whole, while this research specifically targets Twitter as a platform. This construct marks the peripheral route, since Twitter users, while on low elaboration likelihood, will rely on peripheral cues to judge whether it is good to share news or not. [6] and [29] argue that according to ELM source credibility is the peripheral route of information processing. The operationalization of source credibility typically is based on how recipients perceive the person who shared the information in terms of trust and credibility [15]. Peripheral cues are meta information about the shared information and are not directly connected to the content of the information. The peripheral cues in the context of Twitter can be the follower base of a person who shared news or information. Another indicator of a credible source in the eyes of the users can be whether the tweeter is a famous personality. Based on the person who shared the information, people will elaborate on whether it is a good idea to share information or not.

H2: Higher source credibility is positively associated with the news sharing attitude on Twitter.

We use the cognitive style in this research as an indicator to what degree individuals are willing to engage information presented on Twitter. As mentioned beforehand, the cognitive style is the individual's preference on whether to rely on an intuitive evaluation of a problem or the analytical cognition [27]. Fake news showed to rely on peripheral cues heavily and tries to trigger intuitive thinking. People who more often prefer analytical cognition generally use more time and effort to reach a conclusion than people with a heuristic cognition [7]. This is in line with the theory of the ELM with the central and peripheral route. Individuals who take their time in problem-solving and do not easily

fall for wrong intuitive answers will have a higher elaboration likelihood of the information. Individuals with heuristic cognition, who will more naturally fall for wrong intuitive answers, will rely on cues since it is the effortless cognition strategy. Therefore, they are more likely to take the peripheral route (source credibility). We postulate the two hypotheses:

H1a: A high level of cognitive style positively moderates the effect of information quality on the news sharing attitude.
H2a: A high level of cognitive style negatively moderates the effect of credibility on the news sharing attitude.

We gathered data from actual Twitter users by utilizing Amazon's Mechanical Turk (mTurk) as a crowdsourcing platform. MTurk provides the opportunity to reach verified Twitter account holders to make sure the study is targeted at the right participants. With mTurk it is possible to filter the sample based on predefined characteristics.

To qualify for our study, the participants had to be US citizens and an active Twitter users. Data were analyzed with Structural Equation Modelling (SEM) using the partial least squares (PLS) approach, since this research mainly wants to predict the Twitter news sharing attitude. PLS-SEM shows good results in a prediction-oriented environment [23]. The overall data evaluation was done in SmartPLS version 3.2.7 [23].

Studies on mTurk showed that the platform represents the demographics of US citizens and is widely used in research [2,10,19,24,28]. A valid criticism, especially concerning the cognitive style, could be that individuals engaged these types of "tests" over the years. The measurement of Frederick [7] was developed in 2005 after all. However, a recent study on mTurk [16] showed that even though the measurement is old, no significant learning curves could be observed by the turkers (n = 14,053). Even individuals who engage the test multiple times did not show significant changes in their answering behavior.

The questionnaire contained previously validated measurement instruments. The cognitive style scale ranges from 0 to 3. The participants were introduced to three separate problems. Based on their conclusion of each problem, they were assigned with one point. Therefore, 3 points could be gathered in total, which indicates an analytical cognitive style, whereas 0 indicates a heuristic cognitive style.

In total we gathered data from 144 males (56.47%) and 109 females (42.75%) (2 of the participants did not identify with either) with age ranging between 19 and 71.

4 Results

The sample size of $n = 255$ exceeds the rule of ten [8] by which only 20 filled questionnaires were needed. Since the rule of ten is argued to give too rough estimates for the minimum sample size and also only provides the technical required sample size to run the algorithm, Hair Jr et al. [8] suggests a second method to

assess the sample size, by taking estimates for the minimum explanatory power of the model R^2 into account. Zha et al. [31] provided an R of around 29% in the context of social media, Bhattacherjee and Sanford [1] and Sussman and Siegal [29] showed R of above 30%. If we estimate a minimum R^2 of 0.25, which is lower than the presented research, the minimum R^2-method determines the minimum sample size at 41 participants. Furthermore, if a more challenging approach would be applied and a weak R^2 of only 0.1 was assumed, the method recommends a sample size of at least 113, which is also exceeded by this study.

Internal consistency reliability was assessed through Cronbach's Alpha and composite reliability (CR). Cronbach's Alpha is a conservative criterion, whereas composite reliability takes into account the different outer loadings. Therefore, both can be taken as boundaries for reliability. Cronbach's Alpha typically presents lower values, while CR overestimates the internal consistency reliability. Values above 0.70 are desirable, whereas values above 0.95 are not desired since it indicates that all indicators measure the same phenomenon [8]. Table 1 shows that neither the values of Cronbach's Alpha nor CR exceeds those boundaries.

Convergent validity was assessed by the average variance extracted (AVE) and by observing the factor loadings. For the AVE, values of above 0.5 indicate convergent validity [8], which is the case as can be seen in Table 1. In addition, the factor loadings, are all above the threshold of 0.708 [8] and significant at the 0.001 level. Based on these criteria convergent validity can be concluded for this research model.

Table 1. Cronbach's Alpha, Composite Reliability (CR), Average Variance Extracted (AVE) and Fornell-Larcker-Criterion

	Cronbach's alpha	CR	AVE	(1) Twitter news sharing attitude	(2) Information quality	Source credibility
(1) Twitter news sharing attitude	0.861	0.913	0.778	**0.882**		
(2) Information quality	0.829	0.899	0.748	0.502	0.865	
(3) Source credibility	0.911	0.944	0.849	0.505	0.749	0.922

Three criteria assessed discriminant validity. Even though simulations showed that cross-loadings do not reliable identify discriminant validity [9], we first observed the cross-loadings to show that the indicators correlate with their respective construct the most. Second, the Fornell-Larcker criterion was applied to assess discriminant validity. Table 1 shows that the squared AVE (0.882) at the top is higher than the correlation between the constructs. Therefore, the criterion indicates discriminant validity. Lastly, the heterotrait-monotrait ratio (HTMT) was observed. Values above 0.90 are considered to not show discriminant validity [8]. A more conservative threshold is the value of 0.85 [9].

In this case, we observed a value slightly above 0.85. To conclude that discriminant validity is not an issue, we performed a bootstrapping routine to evaluate

whether the HTMT is significantly different from 1. This is the case for the source credibility on information quality (3). Therefore, based on the presented three criteria, we can conclude discriminant validity for this model.

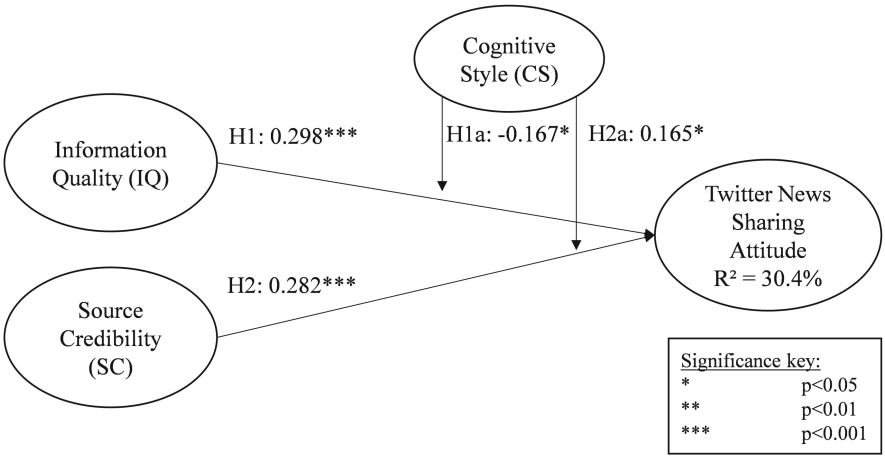

Fig. 2. Research results

Since all quality criteria were met, Fig. 2 shows the results of the structural equation modeling with its paths, significances and R^2, respectively. The moderation effects show some counter-intuitive results.

Information quality (IQ) shows a significant influence on the Twitter news sharing attitude ($\beta = 0.298$, $p < 0.001$), which supports H1. Furthermore, Source credibility also significantly influences the twitter news sharing attitude ($\beta = 0.282$, $p < 0.001$), which supports H2. According to theory, cognitive style should strengthen the influence of information quality and weaken the influence on source credibility. However, the results show that cognitive style negatively moderates the path of information quality on the dependent variable ($\beta = -0.167$, $p < 0.05$) and positively moderates the path of source credibility on the dependent variable ($\beta = 0.165$, $p < 0.05$). Therefore, H1a and H2a could not be supported. Overall, the presented model can explain 30.4% of the variance of the Twitter news sharing attitude. We also controlled for age, gender, as well as a different use of Twitter (Twitter as an information source, as a communication tool, etc.) which showed no significant differences between the groups.

5 Conclusions

The results of the structural equation modeling show counter-intuitive results. We assumed that the personal trait of the preferred cognitive style should

increase the behavior of verifying information based on the quality or argument consistency. However, the data shows influence in the opposite direction. A possible explanation for this phenomenon could be the inherent characteristics of Twitter as a platform. Given the results, we contribute to theory in three ways:

Routes in ELM Do Not Necessarily Predict Heuristic or Analytical Thinking Style. Based on our results, we can conclude that we cannot conclude if individuals invested cognitive effort in their evaluation of the presented information. The items aimed towards a general assessment whether the information on Twitter is perceived as true. However, it is not possible to identify if the information is generally verified. Since Twitter users choose who they follow, this can be a product of a self-defined echo-chamber. Following this logic, people who prefer a more controversial information environment would rather judge Twitter on the lower end of information quality, which can be seen when observing the moderating effect of the cognitive style. Therefore, the ELM does not provide a clear answer to the question, which thinking style was used first and foremost. In this case, the context has to be taken into account, which explains the counter-intuitive answer. Judging Twitter on the lower end of information quality is actually the more rational approach, which leads us to the second contribution of this research.

Cognitive Style as a Means for the Elaboration Likelihood. Researcher distinct between processes which are executed relatively fast (intuitive/affective) and processes which draw on a certain cognitive effort (reflective/rational) [27]. In the past, research rarely investigated the influence of a person's cognitive style [7]. We investigated an environment which heavily relies on the person's cognitive style on whether the information is shared. With the cognitive style, we operationalized the elaboration likelihood to investigate how the individual's cognitive style moderates and therefore changes the interaction of the peripheral and central route.

In contrast to the hypothesis, we found that high cognitive style strengthens the relationship between the source credibility and the twitter sharing attitude, which is counter-intuitive at first glance. The high cognitive style should promote a more rational, and therefore more information verification-driven behavior. The results, however, show that with high cognitive style, individuals tend to favor the peripheral route. The nature of the Twitter environment can explain this phenomenon. As already mentioned above, users can define their "information environment" beforehand. Individuals with high cognitive style may define this environment (the people they follow) more carefully and only select personalities on which they already invested cognitive effort in the evaluation on whether they provide trustful information. This circumstance might also indicate that people with high cognition might not be immune to echo chambers. An alternative interpretation could also be that due to the huge amount of information provided on social media, it is simply not practical to assess every piece of information without relying on cues. Therefore, one could argue that defining a "least biased" information environment beforehand is indeed the more

rational approach to consume information on social media. On a side note, we also controlled whether cognitive style has a direct significant influence on the Twitter news sharing attitude, which is not the case. Participants with high or low analytical cognition, both found sharing news on Twitter as equally good or bad. The significance of the moderation effect, however, shows that cognitive style alters the influences of the independent variables, and therefore should be investigated further to understand sharing behavior.

News Sharing Attitude as a Predictor for Fake News. Research in the sphere of the fake news phenomenon has shown that false information is shared more frequently than fact-based information [11,30]. The high frequency of sharing fake news indicates that research should focus on what triggers news sharing in the first place. For our research we investigated the role of the perceived trustworthiness of the information sender, and the overall evaluation of presented information. The finding of the strong correlation between sharing and the occurrence of fake news has substantial implications for the presented research model since we predict the news sharing attitude on Twitter. A high frequency of news sharing on Twitter can, therefore, predict the sharing and therefore high occurrence of fake news.

Social media with its convenient sharing mechanisms sets an ideal scenario in which we can understand social behavior on an intercontinental level. Especially concerning the misinformation of the broad public via social media, it is of importance to understand personal differences in information adoption and sharing behavior. This research showed that individuals who choose to take time on the internet are probably more in doubt about the information presented to them. This implicates that a more intuitive, affective online behavior leads to the emergence of echo-chambers in which false information can flourish. It would be possible to identify users with a one-sided information environment and then automatically engage them with further information which does not necessarily confirm the beliefs of the user.

We only investigated Twitter as a platform on which Fake News emerge. The Internet shows much more ways in which Fake News can spread, such as Instagram, Facebook or YouTube. Furthermore, for the current research, we drew solely on the US demographic. The sharing behavior may differ in other developed countries with a lesser polarized user basis when it comes to political views. The Left-Right scheme in the US naturally induces much clearer enemy stereotypes, in which Fake News can flourish.

For further research, we want to investigate how stable the cognitive style is according to the environment an individual participates in. This calls upon more research on echo-chambers and how they change the individuals' perceptions over time due to the exposure of one-sided information. We assume that there is a certain point on which individuals stop to check for information quality and start to copy any views which are presented in their echo chamber.

Appendix

Twitter news sharing attitude	Using Twitter to inform other people by retweeting news is a good idea	Adapted from [1]
	Using Twitter to share news is a foolish idea	
	I dislike the idea of using Twitter to share news	
Information quality	The news on Twitter are accurate	Adapted from [1]
	The news on Twitter are consistent	
	The news on Twitter are incomplete	
Source credibility	I believe that news on Twitter is provided by people who are trustworthy	Adapted from [1]
	I believe that news on Twitter is provided by people who are knowledgeable on the topic	
	I believe that news on Twitter is provided by people who appear to be credible	
Cognitive style	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? (Intuitive answer: 24; right answer: 47)	Adapted from [7]
	If it takes 5 machines 5 min to make 5 widgets, how long would it take 100 machines to make 100 widgets? (intuitive answer: 100; right answer: 5)	
	A bat and a ball cost 1.10$ in total. The bat costs 1.00$ more than the ball. How much does the ball cost? (intuitive answer: 10 Cents; right answer: 5 Cents)	

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The Use of Social Media for Electoral Purposes. The Case of the Italian Election in 2018

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Abstract. The aim of this paper is to study the role of social media in political communication and their possible influence on electoral results. For this purpose, we analyze the parties' Facebook Fan pages in the last general election in Italy (March 2018) over two periods: from 1st February to 4th March 2018 (Election Day); and, from 5th March to 31st March 2018. Our results show that there is a positive and significant relationship between the effort of the parties to inform citizens thorough the use of Facebook before the elections and their electoral outcomes in the congress. Specifically, we find that the higher the parties' engagement, the better their electoral results. Nevertheless, we do not find any evidence that a higher engagement of citizens on a party's Facebook Fan page before the election leads to this party having better electoral results. Finally, we explore if the parties change their political discourse before and after the election on their Facebook Fan pages, and find that there are, indeed, differences.

Keywords: Facebook · Political communication · Public engagement · Electoral outcomes · General election

1 Introduction

Scholars concentrate on implications for digital politics, considering that the penetration of digital technologies among the population can transform the relationship between politicians and the electorate [1–3]. In this regard, the development of social media such as MySpace, Facebook, or Twitter has attracted academic interest since they may change communication between citizens and politicians. Indeed, today we can talk of "communication 3.0".

Previous studies underline that media coverage of politics takes a variety of forms [2, 4, 5]. This variety of approaches has increased with the use of social media data. In this sense, the interest of academics and experts about the possibility of using social media to measure political communication and public engagement is on the rise. There are several studies on online forms of participation and political communication that

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use social media tools [e.g., 6–9]. In this regard, Facebook presents many advantages: it is direct, strong and has free access. Moreover, it has as important feature in that the messages conveyed can reach anyone anywhere. Facebook has the potential to connect the members of real-world communities (geographic, ideological, or otherwise) and it combines the local bulletin-boards, newspapers, and town hall meetings and places. Facebook offers many ways for users to interact directly (e.g., wall postings, instant messaging, messages) and indirectly (e.g., posting notes, status updates) [10]. Therefore, this communication tool can be used to foster political engagement. Indeed, although Facebook was not originally thought of as political tool, politicians have quickly adapted it to their purposes [11]. A key aspect of political communication on Facebook is that all members of the community can decide whether, when and how they contribute to the conversation. At the same time, politicians can use Facebook to communicate with community members and the community members can express their opinions to political actors and so increase their engagement. Westling [12, p. 4] argues that: "What Facebook does is bring members of a community together and provide a means to share information through a single network". Thus, Facebook is a good means of achieving a truer public sphere than anything that has come before it [12].

Our paper seeks to understand how politicians interact with citizens via social media and examines the role of social media in contemporary political communication and public engagement in political issues as well as their possible influence on electoral results. First, we built two indicators to measure the effort of the parties to inform citizens via Facebook and the level of citizens' engagement, before and after elections. Then, we studied whether there is a relationship between these parties and citizens' behaviors. Finally, we analyzed the effect of parties and citizens' engagement on electoral outcomes.

We used information from the last general elections in Italy (March 2018) focusing on parties' Facebook FanPage. In particular, we measure parties' Facebook FanPage activity over two periods: (a) from 1st February to 4th March 2018 (Election Day), (b) from 5th March to 31st March 2018.

The paper is structured as follows: in the next section we present the literature on the use of social media for political communication and citizen engagement. In Sect. 3, we describe the Italian General Election process. Next, the methodology used is explained. Section 5 discusses the result and Sect. 6 describes an additional study about content analysis of the posts published. Finally, in the last section, the conclusion, limits and future research perspectives are given.

2 Existing Literature

The growth of digital technologies has attracted significant academic interest in terms of their impact on the public sphere and on politic communication. The position of the scholars is divided between those who emphasize the potential of the Internet for political communication and democracy [13, 14] and those who have several doubts, underlining the different threats to democracy that the Internet entails [15].

Several authors highlight the importance of social media as channels of political communication practices and electoral campaign tools, thanks to the great number of citizens that use them regularly [16–19]. Indeed, social media appear as an important source of

political information, contrary to Putnam's [20] suggestion that Internet consumption leads to social isolation and disengagement [21, 22].

In this sense, Wesling [12] examines the features of Facebook that can be used for political communication and their effectiveness for political actors and communities. This author focuses on the role of Facebook as a tool to help politicians have an active role in this medium, whether by questioning sources, responding to journalists or passing along relevant stories to their peers. Moreover, his study values the role and the weight of alternative political campaigns by using Facebook rather than traditional ones - mass media (newspapers and television) - or their own resources (official web sites and direct mail) to communicate with constituents. In this regard, Gibson et al. [23] show that it is not implicit that larger parties dominate Facebook political campaigning. Elsewhere, Larsson and Kalsnes [17] analyze the routine uses of Facebook by politicians and find that an individual politician's characteristics can influence the social media adoption and use. Focusing on Twitter, Vergeer and Hermans [24] find that the propensity of some candidates to use this tool during the electoral campaign was higher than other candidates show. In this sense, for example, Lilleker and Jackson [1] consider that right-wing parties are apparently more open to interaction, whereas Sudulich [25] argues that left-wing parties are more open to interact with Internet users.

Just as politicians use social media for political communication, so citizens use them to engage and give their opinion on political matters, in an attempt to influence the course of politics. In this sense, the literature has centered on the ability of politician to engage citizens through the social media during campaign cycles thanks to active conversation about political issues. Utz [26] shows that social media provide an opportunity to reach individuals less interested in politics. Moreover, some papers make a content analysis to study the public opinion on political matters through social media. In this regard, Anstead and O'Loughlin [7] explore how social media data were used by the public to discuss the Prime Ministerial debates on Twitter during the 2010 UK General Election campaign. Nulty et al. [19] survey the European landscape of Twitter using from and referring to political actors during the 2014 European Parliament election campaign. Applying sentiment analysis to the text of the Tweets, this study describes the language and national distribution of the messages, the relative volume of different types of communications, and the factors that determine the adoption and use of Twitter Anstead and O'Loughlin [19] analyze the use of Twitter during 2010 UK General Election and show how social media monitoring allows for analysis of the social dynamics through which public opinions are formed. In the same vein, Jungherr [9] analyzes which political events increased the volume of Twitter messages referring to politics during the 2013 German federal election. Through sentiment analysis, Burnap et al. [28] use Twitter data to forecast the outcome of the 2015 UK General Election and propose a 'baseline' model of prediction.

Furthermore, social media may represent an opportunity to develop civic engagement skills. Vitak et al. [10] find that the political activity of citizens on Facebook (e.g., considering posting a politically oriented status update, becoming a "fan" of a candidate) is a significant predictor of other forms of citizens political participation (e.g., volunteering for an organization, signing a paper or online petition). Moreover, these authors state that citizens can acquire greater political knowledge, increase political interest,

and improve political self-efficacy by using Facebook [28]. Valera-Ordaz [5] analyses the comments published by citizens on profiles of three Spanish candidates during the Spanish General Election campaign of 2011. She shows that Facebook has democratic functions, such as citizen self-expression, democratic socialization and reinforcement of social cohesion among party activists and sympathizers.

Given the above, the literature also studies how the use made by politicians of social media for political communication can influence the level of citizens' engagement in political activity, and, in turn, electoral results. In this sense, there are several authors whose interest in social media focuses primarily on their effects on political participation [e.g., 29, 30] or on their potential to predict electoral participation [e.g., 10, 31–35]. Thus, Utz [26] explores how interaction with potential voters through social media can influence the evaluation of the candidates. The author shows that politicians who react on the comments of users were perceived as more favorable. In the same vein, Jungherr [9] tests if the popularity of politicians on Twitter reflected their relative political importance as measured by their voteshare. Vergeer et al. [36] highlight that the use of social media is more effective to increase popularity of candidates if used near (up to one year) the election. In contrast, Yamamoto and Kushin [37] show how the use of social media during electoral campaign can have negative effect. They conducted an online survey of college students during the 2 weeks before the 2008 presidential election at a large state university in the northwestern United States. The results show that attention to social media for campaign information is linked to cynicism and apathy and negatively related to skepticism.

3 Research Context: Italian General Election Process

The Italian electoral system is the set of rules, based on the votes cast by Italian citizens during the elections, are allocated the seats in the local, national and European political-institutional bodies. The situation is articulated and differentiated according to the various categories of voting envisaged by the Italian political order:

- the political elections, in which the Chamber of Deputies (composed of 630 members) and Senate of the Republic (composed of 315 member) are elected.
- the European elections, in which the 73 members of the European Parliament due to Italy are elected;
- regional elections, in which the president of the regional council and the regional council are elected;
- local elections, in which the mayor and city council and council are elected.

Since 2017, a mixed electoral system with complete separation, renamed Rosatellum bis, has been in force [38]. In the light of this system, in each of the two branches of Parliament, 37% of the assembly seats are assigned with a single-member majority system (maggioritario uninominale a turno unico), and 61% of the seats are allocated among the competing lists by means of a proportional mechanism corrected with different dam clauses (proporzionale con sbarramento). The candidates for the latter component are presented within plurinominal colleges. There is no preference vote or separate vote.

Moreover, Italian citizens residing abroad, according to the Law, must choose twelve deputies and six senators.

4 Method

4.1 Sample

This article examines the role of social media in contemporary political communication and public engagement. We concentrate on the recent general election in Italy (4th March 2018), focusing on parties' Facebook FanPage. Specifically, we analyze the parties' official Facebook pages, measuring their activities over two periods: from 1st February to 4th March 2018 (before the election) and from 5th March to 31st March 2018 (after the election). Table 1 shows the coalitions and parties running in the majority of multi-member constituencies.

Table 1. Coalitions and parties running in the majority of multi-member constituencies

Coalition	Political parties
Centre-right coalition	Forza Italia
	Lega Nord
	Fratelli d'Italia
	Noi con l'Italia-UdC
Centre-left coalition	Partito Democratico
	+Europa
	Civica Popolare
	Italia Europa Insieme
	SVP-PATT
Movimento 5 Stelle	
Liberi e Uguali	
Potere al Popolo	
Casa Pound Italia	
Il Popolo della Famiglia	

In our analysis we only consider the parties that have an official Facebook FanPage. In the case of the two coalitions (centre-right and centre-left) we take into account the information of all the Facebook pages of all the parties that compose these coalitions. Specifically, we include in our sample the information on the following coalitions or parties (before and after the general election): centre-right coalition, centre-left coalition, Movimento 5 Stelle, Liberi e Uguali, Potere al Popolo and Casa Pound Italia[1]. Therefore,

[1] The Popolo della Famiglia party is not included in our sample since it has no official Facebook FanPage.

we have 12 observations for our variables described below (6 before the election and 6 after).

4.2 Variables

The aim of our empirical analysis is to assess the role of social media in contemporary political communication and public engagement. First, we built an indicator to measure the effort of the parties to inform citizens thorough the use of Facebook (*Party_engagement*). It is composed of two items and data are collected from parties' official Facebook pages. The items chosen are: (i) number of posts published by parties on their official Facebook page during the period; (ii) number of posts shared by parties on their official Facebook page during the period[2]. We build this indicator by adding the scores obtained in these two items ((i) and (ii)) following Guillamón et al. [39] and Metallo et al. [40]. Second, we built an indication to measure the level of citizens' engagement (*Cit_engagement*). In accordance with the literature, we measure the citizens' engagement level through three dimensions based on Bonsón and Ratkai [41] and Metallo et al. [40]: popularity, commitment and virality (as explained in Table 2).

Table 2. Measurement of the three dimensions of citizens' engagement

Dimensions	Measurement
$Popularity_i$	(Popularity1_i/number of fans$_i$) * 100 where: Popularity1_i = Total likes$_i$/total number of posts$_i$
$Commitment_i$	(Commitment1_i/number of fans$_i$) * 100 where: Commitment1_i = Total comments/total number of posts$_i$
$Virality_i$	(Virality1_i/number of fans$_i$) * 100 where: Virality1_i = Total shares/total number of posts$_i$

Popularity is the Facebook page fame ($Popularity_i$) and can be measured as the median number of "*likes*" on Facebook page by users. Commitment is the ability to catch attention through the Facebook page in order to promote the comments by users ($Commitment_i$) and can be measured as the median number of "comments". Virality is the message's ability to go viral ($Virality_i$) and can be measured as the number of "shares" on Facebook. Thus, we build our *Cit_engagement* by adding together these three dimensions:

$$Cit\_engagement_i = \Sigma\ (Popularity_i + Commitment_i + Virality_i) \quad (1)$$

[2] To build the variable Party_Engagement in the case of the two coalitions (centre-right and centre-left) we sum the posts published and shared by the parties of the coalition.

Table 3. Definition of variables and descriptive statistics

				1st February - 4th March 2018 (before election)				5th March - 31st March 2018 (after election)			
Engagement	Variable	Description	Source	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
	Party_engagement	Effort of the parties to inform citizens thorough the use of Facebook Sum of (i) number of posts published by parties; and (ii) number of posts shared by parties	Own elaboration from the parties' Facebook page	371.83	314.66	150.00	977.00	118.00	85.04	8.00	262.00
	Cit_engagement	Level of citizens' engagement via Facebook Σ ($Popularity_i$ + $Commitment_i$ + $Virality_i$)	Own elaboration from the parties' Facebook page	2.53	2.60	.52	7.70	2.45	2.61	.67	7.66
Electoral outcomes	Variable	Description	Source	Mean		Std. Dev.		Min		Max	
	Votes_Congress	Percentage of votes obtained by the party/coalition in the congress	Italian Home Office	16.26		16.51		.95		36.93	
	Votes_Senate	Percentage of votes obtained by the party/coalition in the senate	Italian Home Office	19.31		16.54		1.06		37.42	

We have calculated the variables *Party_engagement* and *Cit_engagement* for both periods: from 1st February to 4th March 2018 (before the election) and from 5th March to 31st March 2018 (after the election).

Finally, to analyze the effect of parties and citizens engagement on electoral outcomes, we also include in our analysis the variables *Votes_Congress* and *Votes_Senate.* These variables represent the percentage of votes received by the party/coalition in the congress and senate, respectively, in the 5th March 2018 general election.

Table 3 shows the definition of our variables and their descriptive statistics.

5 Results

In order to analyze if the use of social media for political communication (parties and citizens engagement) differs before and after the general election, we apply a test for differences of means. Specifically, we compare the means between two related groups, given that we compare the engagement before and after the election. Furthermore, to perform this analysis, it is important to know the statistical distribution of data, so that we can determine which statistical tools are the most appropriate. Thus, if the data follow a normal distribution we will use parametric tests for differences of means (dependent T-test). However, if the data are not distributed as normal we will use nonparametric tests (Wilcoxon signed-rank test). In this respect, we applied the Shapiro-Wilk test to check the normality of the dependent variables (*Party_engagement* and *Cit_engagement*), since this test is applied when the sample has less than 30 observations. The null hypothesis of this test states that the data follow a normal distribution. Table 4 shows that both variables, *Party_engagement* and *Cit_engagement,* do not follow a normal distribution.

Table 4. Shaphiro-Wilk test

	Party_engagement	*Cit_engagement*
Degrees of freedom	12	12
Shaphiro-Wilk W	.720	.676
Significance	.001	.000

Therefore, given that both variables are not distributed as normal, we use the Wilcoxon signed-rank test (see Table 5).

Table 5. Differences in the parties and citizens' engagement before and after elections

Wilcoxon signed-rank test	*Party_engagement*		*Cit_engagement*	
	Before election	After election	Before election	After election
N	6	6	6	6
Mean	371.83	118.00	2.53	2.45
Wilcoxon signed-rank test – Z (sig)	−2.201 (.028)		−.524 (.60)	

According to the Wilcoxon signed-rank test –Z, the behavior of parties before and after the election is different. In fact, the parties publish and share more information before the election. However, in the case of citizens, there are no significant differences in their behavior before and after the election.

Once we have analyzed the behavior of parties and citizens before and after the election, we aim to study if there is a relationship between parties' and citizens' behaviors. Table 6 shows the correlations between the parties' and citizens' engagement. As we can see, the correlations are positive but not significant in any period, and are higher before the election.

Table 6. Correlations between the parties and citizens' engagement

Correlation before election		
	Party_engagement	*Cit_engagement*
Party_engagement	1.000	
Cit_engagement	.250	1.000
Correlation after election		
	Party_engagement	*Cit_engagement*
Party_engagement	1.000	
Cit_engagement	.153	1.000

Significance: *** .01, **.05, *.1

Finally, we analyze the relationship between the parties' engagement before the election and the percentage of votes obtained in the election. We also explore the relationship between the engagement of citizens in the Facebook of the parties before the election, and the votes received by these parties (see Table 7).

Table 7. Correlations between parties and citizens' engagement before the election and electoral outcomes

Correlation between parties' engagement and electoral outcomes			
	Party_engagement	*Votes_Congress*	*Votes_Senate*
Party_engagement	1.000		
Votes_Congress	*.741	1.000	
Votes_Senate	.740	***1.000	1.000
Correlations between citizens' engagement and electoral outcomes			
	Cit_engagement	*Votes_Congress*	*Votes_Senate*
Cit_engagement	1.000		
Votes_Congress	.168	1.000	
Votes_Senate	.070	***1.000	1.000

Significance: *** .01, **.05, *.1

Our findings show that there is a positive and significant relationship between the level of engagement of parties and their electoral outcomes in the congress. Specifically, we find that the higher the parties' engagement the better their electoral results (in terms of percentage of votes obtained). We do not find any evidence that a higher engagement of citizens on a party's Facebook FanPage before the election led to this party having better electoral results.

6 Additional Study: Content Analysis of the Posts Published

In this section, as additional study, we consider it interesting to analyze if the parties/coalitions change their political discourse before and after the election on social media. We selected some relevant words in a political discourse. Table 8 shows the number of times that these words appear in the posts published by the different parties/coalitions before and after the election, according Valera-Ordaz [5] and Valera-Ordaz et al. [2].

Given that parties publish and share more information before the election, as we find above, it stands to reason that the number of quotes that has each relevant word be higher before the election than after. Regarding the pre-electoral period, our analysis shows that the most repeated words in the political discourse are public services, taxes, pension and equality while the least used are health, environment, research and immigration. However, after the elections, the political discourse changes. Some topics, such as public services, continue to be red-hot issues, while others drop into the background (e. g., pension or equality).

Table 8. Content analysis of the posts published before and after election

Terms	Public services	Taxes	Pension	Equality	Investment	Energy	Justice	Participation	Debt	Education	Corruption	Rights	Crisis	Deficit	Unemployment	Transparency	Health	Environment	Research	Immigration
Before election																				
Centre-right coalition	2	25	1	1	1	9	6	11	3	10	7	0	0	2	0	0	0	1	0	0
Centre-left coalition	19	17	9	17	4	7	7	4	6	3	2	4	0	1	4	4	1	1	3	1
Movimento 5 Stelle	4	2	13	1	2	2	3	0	0	0	0	1	5	1	0	1	0	0	0	0
Liberi e Uguali	10	6	5	6	10	1	2	0	5	0	5	1	3	2	0	0	1	1	0	0
Potere al Popolo	16	0	4	4	12	7	5	5	3	2	1	4	1	1	2	0	1	0	0	0
Casa Pound Italia	2	1	1	1	0	0	0	1	0	2	1	1	0	0	0	0	0	0	0	0
Total	**53**	**51**	**33**	**30**	**29**	**26**	**23**	**21**	**17**	**17**	**16**	**11**	**9**	**7**	**6**	**5**	**3**	**3**	**3**	**1**
After election																				
Centre-right coalition	2	6	1	0	0	2	0	0	0	0	5	0	0	1	0	0	0	1	0	0
Centre-left coalition	7	1	2	0	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0
Movimento 5 Stelle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Liberi e Uguali	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potere al Popolo	16	1	1	2	1	5	4	0	0	0	3	5	0	0	0	0	1	0	0	0
Casa Pound Italia	2	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Total	**28**	**8**	**4**	**3**	**2**	**8**	**6**	**0**	**0**	**0**	**10**	**6**	**0**	**1**	**1**	**1**	**1**	**1**	**0**	**0**

7 Conclusions

The paper analyzed how politicians interact with citizens using social media, examining the role of social media in contemporary political communication and public engagement in political issues as well as their possible influence on electoral results. We analyze information from the last general elections in Italy (March 2018) focusing on political parties' Facebook FanPage. We measure parties' Facebook FanPage activity over two periods: (a) from 1st February to 4th March 2018 (Election Day), (b) from 5th March to 31st March 2018.

First, we built two indicators to measure the effort of the parties to inform citizens thorough the use of Facebook and the level of citizens' engagement, before and after the elections. We find that the behavior of parties before and after the election was different, with parties publishing and sharing more information before the election. However, in the case of citizens, there are no significant differences in behavior before and after the election.

After analyzing the behavior of parties and citizens before and after the election, we study if there is a relationship between parties and citizens behaviors. Our results show that the relationship between the effort of the parties to inform citizens thorough the use of Facebook and the level of citizens' engagement is positive but not significant in any period, being higher before election.

Later, we analyze the effect of parties and citizens' behavior on electoral outcomes. Our findings show that there is a positive and significant relationship between the effort of the parties to inform citizens thorough the use of Facebook before the elections and their electoral outcomes in the congress. Specifically, we find that the higher the parties' engagement, the better their electoral results. However, we do not find any evidence that a higher engagement of citizens on a party's Facebook FanPage before the election led to this party obtaining better electoral results.

Finally, as an additional analysis, we explore if the parties change their political discourse on their Facebook FanPages before and after the election. Our analysis shows that the most repeated words in the political discourse in the pre-electoral period were public services, taxes, pension and equality, whereas after elections the political discourse changes and, although some topics, such as public services, continue to be red-hot issues, others, such as pension or equality, drop into the background.

Given the above, we think that the politicians should pay attention to their political communication through social media (the number of messages, the discourse, when they publish, etc.) since, although the citizens appear not to change their behavior on social media regardless of what politicians publish, the political communication that they do in social networks does seem to influence the electoral outcomes. Anyhow, this is however an interesting result, as it seems that in the political communication the role of social media is not that different compared the other media, that means one direction communication media.

Furthermore, we believe that politicians should inform citizens more throughout the electoral cycle and not focus only on the election campaign period. We consider that citizens can take more advantage of this means to inform themselves and participate in political campaigns without having to attend the meetings in person. Finally, we believe that there should be more control over publications on social media by political

parties and their environment (affiliated, interest groups, etc.), to prevent fake news, fake profiles, etc. to avoid social media banning their use for political issues. In fact, Twitter has banned, since November 22, 2019 the promotion of political content and ads of any type from political figures like candidates, political parties and government officials. However, we believe that political communication through social media can be really effective in electoral terms and useful for citizens as long as they are used diligently. Finally, future research could analyze the use of social networks by politicians in larger samples, considering other countries or other political and social contexts beyond the Italian case.

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Mobile Application for Healthcare

The Case of COVID-19 in MobileApp

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Abstract. The Covid-19 era asks for a reduction in face to face relationships. For this reason, the Information and Communication Technologies (ICT) are becoming the main tool able to substitute the direct relationship among people. So, one tool able to support health authorities in monitoring and mitigating the ongoing COVID-19 was Mobile Applications (mApps), by facilitating follow-up among patients and practitioners and providing direct guidance to citizens in order to play their part in the control of the disease. The main purpose of this paper, is to know and analyze features and functionalities of the mApps for COVID-19, currently available in the widely used smartphones applications stores, like Play Store and iTunes. The first results obtained at this stage of the research have permit to give a preliminary taxonomy of the mApps specifically oriented to COVID health management in Italy. The research found n°71 mApps operating on principle stores, by underlining features and aspects useful to make users more responsible and self management regarding own health. MApps in COVID period could represent one organizational support for maintaining a useful relationship among patients and health operators regarding health care assistance. In order to do this it's necessary to determine optimal capabilities and evaluate utility and clinical benefit of these tools. This work permits to recognize and obtain first informations to this regard.

Keywords: Health knowledge management · ICT · Mobile Application (mApp) · COVID-19

JEL: D80 · D83 · I10

1 Introduction

The World Health Organisation (WHO) [14, 22, 23] has declared the COVID-19 one pandemic outbreak. The Coronavirus pandemic has showed the importance of Information and Communication Technologies (ICT) in a context in which "moving information" is much better than "moving people". In the pandemic context, where it's impossible to

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communicate among people in face to face mode, the ICT are becoming therefore the only tool able to substitute the direct and personal relationship.

The COVID context has imposed, especially on elderly people, the need to develop ICT-related skills. At the same time, organizations face the need for using various mechanisms that facilitate and support interaction between individuals through ICT tools.

ICT showed to be a powerful tool in promoting the fields of healthcare by allowing patient empowerment and disease management. In this way the same mobile application can be useful to transmit information among health organizations, experts, families and people worldwide. Mobile Applications (mApps) can support health authorities - at national and EU level [6] in monitoring and mitigating the ongoing COVID-19 pandemic, by facilitating follow-up among patients and practitioners and providing direct guidance to citizens in order to play their part in the control of the disease. With these premises, the spread of mobile applications represents a way by health knowledge can be shared, so that, the Apps are increasingly being used like innovative tools for knowledge sharing in health sector, more and more able to improve the interactions between health operators and patients and probably to improve general efficiency on processes. MHealth has great potential in addressing disruptive issues in healthcare, given the ubiquity of mobile devices around the world and the unique aspects of mobile technology including its high reach, cost-effectiveness and relative easy to use [18]. Among the different tools, mHealth has the possibility to link and interact directly patients with operating interfaces inside the App, frequently without the same involvement of health-care operators.

In this way, this possibility could bring new awareness regarding health and indirectly it will impact on the same costs related to the health system. So, mHealth represents a rapidly developing field which has the potential to play a critical role in the re-organization of healthcare system. This study focus on implementation and use of mobile devices in order to carry out or support health care activities remotely during pandemic era. In fact the situation of COVID-19 has pushed for the development of new mApps able to substain patients and communities in this complex period; so the main purpose of this work is to review and analyze features and functionalities of the apps specifically dedicated to COVID-19 currently available in the widely used smartphones applications stores, like Play Store and iTunes. The research questions are:

RQ1 Which are the principle characteristics of mApps used for Covid-19?
RQ2 Could mApps be functional to the objective?
RQ3 Are users' ratings proportionally linked to the functional content of mApps?

The study starts from a systematic examination of mApps for smartphones in the most popular mobile app stores in Google Play (for Android system) and Itunes store (for macOS system). The analysis of available mApps was conducted from February to April 2020, by selecting a total number of n°7 Play Store and n°64 iTunes. The present work is structured as follows: 1. Introduction, 2. Theoretical Background, 3. Methodology and Data Selection, 4. Results and Discussion, 5. Conclusions.

2 Theoretical Background

Several scholars' state that the application of Knowledge Management (KM) practices in healthcare sector are a growing research area. In effect, Van Beveren [21] observed the Australian public health system's needs of KM practices and he concluded that specific models and techniques of KM are necessary in the health sector. Under this theoretical approach health organizations are an institutional and social model that represent a complex organizational environment. The traditional practices of KM in health organizations appeared no coherent in the institutional aims of them; in fact, the adoption, transfer and sharing of new knowledge in health organizations needs different methods and techniques. Within the KM area one particular consideration deserves the ICT in healthcare, even if, its role in KM has been the source of much controversy in academic literature. Information and Communication Technologies have proven to be a powerful prospect in promoting the fields of healthcare by allowing patient empowerment and disease management and becoming a key factor in development [8]. It is possible to reconcile the different positions in the literature, privileging the organizational perspective of new institutional theory. For this reason, the first phase of the study had the goal of understanding the main theories in this research area. This phase is necessary for the exploratory nature of the study. In particular, the keywords were inserted through the consultation of databases. A search string was built to identify all the scientific documents in English, published in double-blind review journal and belonging to management area. After this selection, a focus on systematic review of the phenomenon was carried out by VOS viewer like a software tool for constructing and visualizing bibliometric networks. Figure 1 shows the relationship among the keywords that the authors for their scientific contributions. Each circle represents a keyword. The size of a circle reflects the number of publications of the corresponding word. The distance between two circles approximately indicates the strength of link. In general, the closer two circles are located to each other, the stronger is the link between the keyword. Colors represents clusters of keywords with strong links. Lines are used to indicate the links between keyword.

From Fig. 2, it is clear that a new phenomenon of mApps in health has a solid framework in the KM field of study. The selection of the keywords sub-area highlights how the mApps phenomenon studied under the KM perspective is linked to: Knowledge Management, Knowledge Transfer, Innovation, Open Learning, Health Care Management, Higher education and Culture. So, it is possible to identify within the graph one research area that links the topics covered in this study (Fig. 3).

With these theoretical bases and in order to understand how knowledge sharing is manifested in ICT contexts we first obtained a framework of what knowledge sharing is, why it's important, and how it can be achieved. As recognized by [4], knowledge sharing is not simple, as knowledge is abstract and therefore difficult to grasp. Knowledge has been described as a mixture of experience, values, contextual information, and expert insight that supports one person to evaluate and incorporate new experience and information [4]. So, the most innovative technologies (e.g. mobile applications, cloud computing, etc.…) allow the emergence of knowledge creation, facilitating new ways in which the relationships among actors (patient, doctors, nurse etc…) of health system happen. For the medical field, the World Health Organization (WHO) [21] defines mHealth like "medical and public health practice supported by mobile devices, such as

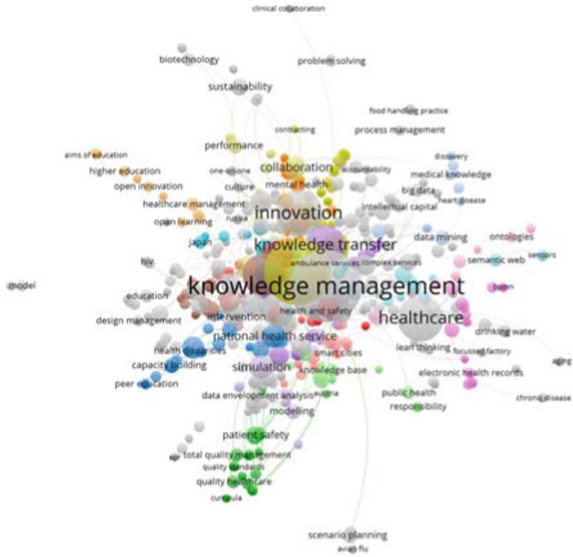

Fig. 1. Relationship between keywords – VOS viewer Software

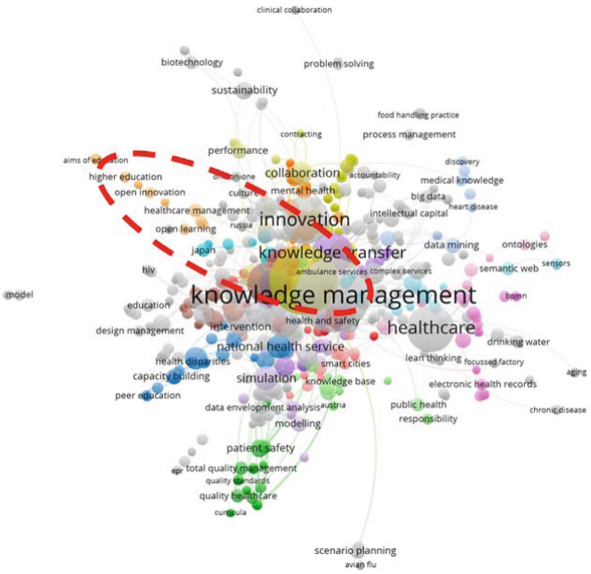

Fig. 2. Sub area keywords – Our Elaboration on VOS viewer Software

mobile phones, patient monitoring devices, personal digital assistants and other wireless devices (p. 6)". The changes largely depend on the possibility given by the new role of knowledge in the organizations and by ICT like new tool able to improve new performance in Health System.

In this new changing context, a particular role plays the Apps (on mobile devices), like a new technological system able to transmit, create and share knowledge and improve an open innovation model [3]. M-Apps is an interactive tool among patients and doctors, able to facilitate the monitoring and highlighting of alerts by developing combinations of know-how among the nodes of healthcare networks. In digital age, virtual communities develop themselves outside of the traditional definitions of geography and physical constraints [12] and in health system knowledge flow among actors is subject to several reciprocal interdependence. Under these conditions ICT experts and doctors can combine their knowledge with the aim to produce innovative and easy-to-use m-Apps; patients as users – on the other side - can learn new information on how prevent and cure their disease, even if the m-App isn't connected with healthcare operators [11]. According to the Institute for Healthcare Informatics [9], consumer-related mHealth apps focus on overall wellness, diagnosis, finding a healthcare provider, prescription filling, and compliance. Dennison, Morrison, Conway, and Yardley [5] conducted a qualitative study in young adults with the objective to explore their experiences and positions regarding Apps related to health behavior change, including their perceiving of various features and their willingness to use these apps. They identified several valuable features that have important influences on the app usability such as: accuracy, legitimacy, security, effort required and immediate effects. It is interesting that context-sensing capabilities and social media features were considered unnecessary. Nevertheless, they have also noted that some participants in their study were not motivated enough to regularly and precisely use the apps in making healthy lifestyle changes. This phenomenon is particularly salient in immersive online virtual worlds, which offer new territories that can be often customized by users and where rules and canons get more labile [20].

3 Methodology and Data Selection

The work presents the results of the exploratory and descriptive study in order to understand and define the frame of the general dynamics of the phenomenon [7, 17, 24]. This study is based on two-steps method (Fig. 3).

The first step - Theoretical Background - explores the literature and underlines the characteristics of the mApps as new mechanism of sharing health knowledge. In this on the desk analysis scientific documents were identified and filtered by using key words, language and abstract. This allowed us to frame theoretically the phenomenon in according to our research questions.

The second step – Empirical Observation - firstly explores the different mApps officially identified as COVID-19 tools and present in the most popular operating platform (Play store and iTunes); then we classify mApps in according with their Type, Technical functionality, Description, Download and Users comment. In this way it was possible to comprehend the knowledge aspects related to and the possibility to act for their sharing and diffusion (see Table 1 and 2).

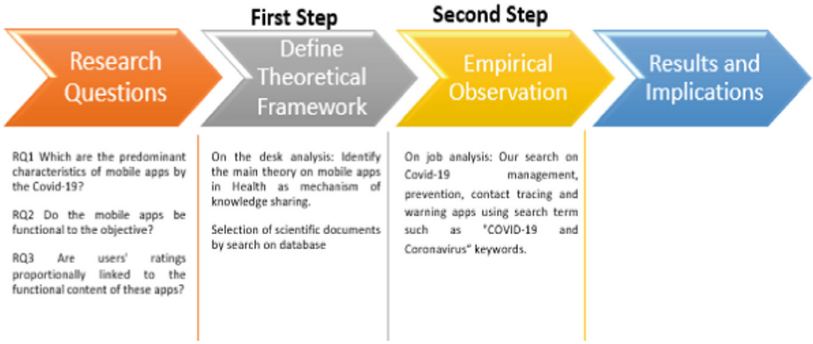

Fig. 3. Methodology. Source: our elaboration

In this phase, we have to consider mApps both payment and free searched in the Play Store and iTunes app stores (Fig. 2). Up to the date of 28 April 2020, Android and macOS users could choose among n°71 mApps. Our search focused on Covid-19 management, prevention, contact tracing mApps using search term such as: "COVID-19 and Coronavirus". In the following scheme is presented the research process (Fig. 4).

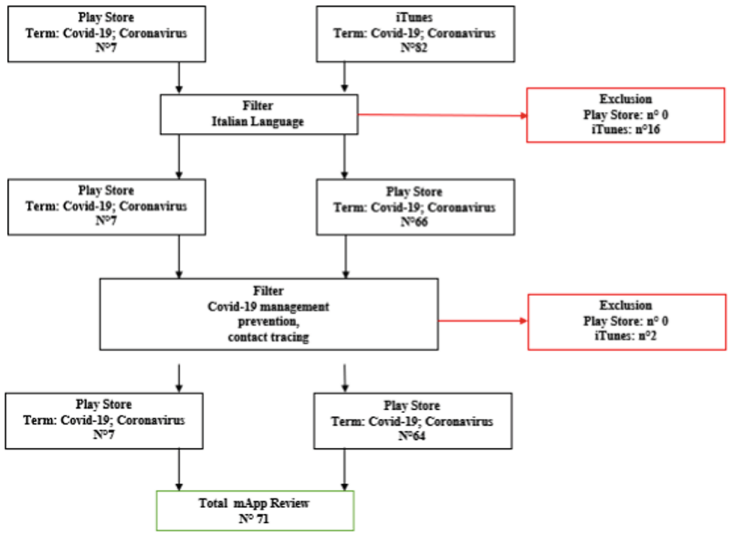

Fig. 4. Examination scheme of mApps; Source: our elaboration [15]

Then mApps was evaluated on a review based on product description, technical functionality and the screen shots provided with the reviews by current users. All data was collected in an Excel sheets, that associates the name, the functionality, and features of each mApps.

4 Results and Discussion

Since the beginning of the COVID-19 pandemic, numerous mApps have been developed, some of them by public authorities World Health Organization (WHO, newsletter march, 2020), Italian Ministery of Health; Ministery of Social Affairs; Ministery of Comunication; Governements and Departments and so one that have worked on the development of applications able to provide medically-approved information and advice to users based on their symptoms (see Table 1 and 2 section Actor Relevant). On 10Th April 2020, Google and Apple jointly announced an initiative related to the use of the Bluetooth protocol to support contact tracing mApps [16].

The protocol would support the use of Bluetooth LE (Low Energy) for detection of nearby mobile phones, and for the data exchange mechanism. In this way mApp users can receive one alert of possible CORONAvirus contagion, by showing people with positive diagnosed to the virus that have recently been in contact each other. The Apps included in the present study are those pertaining to Covid-19 and available in Google Play and iTunes Stores. Our research started with keywords like "Covid-19 and Coronavirus" by detecting n°71 mApps (Google play store and iTunes store); once identified, manual inspection followed on the app's by using the filters: management, prevention contact tracing and so n°7 mApps in Google Play Store and n°64 in iTunes Store was found.

The research led to map - according to the previous criteria - n°71 mApps overall. The differences among Google Store and Apple Store are remarkable for different reasons and the research on the Play Store showed only n°7 mApp unlike the initial n°82 in iTunes, all this in order to ensure the credibility of health and safety information related to mApps. Apple has chosen to manage applications related to the COVID-19 pandemic with a very critical review, by reviewing the publishing policies aimed at developers for apps. Google, in order to avoid problems, blocked mApps in March and subsequently publishes only n°7 of them.

The overall characteristics of the mApps selected are presented in Tables 1 and 2 (see Appendix); the analysis was developed by the authors directly through device phone. In fact, mApps are designed to interact directly with users with the acquisition of personal informations in order to manage own health, with or without the presence of a health worker. In this research, n°71 mApps were found able to support with pro-active approach patients by improving their participation and the self-management capacity with self-monitoring programs associated (see Table 1 and Table 2 section Type).

In this research, the n°71 mApps identified are mostly related to the detection and alarms of contacts, self-diagnosis or the transfer of information and knowledge and symptom control (see Table 1 and 2 section Type).

Our main purposes of this work in progress research are to give answers regarding the three Research Questions proposed (RQ1-RQ2-RQ3). At this point of analysis the contribution presents the survey produced during this COVID period with the full list of existing mApps and their principle characteristics, as reported in attach in the Tables (see Table 1 and 2). Every mApps have their own specific goals and technical characteristics such as the minimum number of clicks, taps or other user gestures in order to activate themselves by responding in a fast and rapid way to the interactions requested.

One of the principle caracteristic is its simple design, able to ensure good contents, high value and acceptance among users. A lot of mApps are responsive when running long operations such as database access, network access (users comment). Another feature regards App's personalization with the creation of individual contents and roles based on context or their specific usage. In fact the users desire that the mApp should fit their needs and perform the way they want. This specific attribute not only covers custom-made content but also controls over data that is stored, shared or used for different actions. The mApps handle sensors that respond to device movement, numerous gestures, global positioning system, cameras and multiple networking protocols. About the 30% of the selected mApps show localized information and the possibility to provide position-based informations are crucial features that render mobility impressive, convenient, valuable by providing good user experience. So, their reachability permit that they can be used anywhere at any time (100% mapping). The m-Apps can send and receive and record Bluetooth signals even in the background mode (even when the phone is locked) and can estimate with sufficient accuracy the proximity among mobile phones via Bluetooth signals. They should advertise continuously their presence using a temporary anonymous ID that permits established contact with other App users in proximity. App should record and store IDs observed from other mobile phones in epidemiologically relevant proximity on the device and then App communicates to Public Health Authority. Another important feature is security; around 20% of the comments found by users ask for a secure mobile app. They believe that these problem should be rectified since they think that mobile apps are vulnerable. In fact with the interactive knowledge-transfer platform can be acquisitioned and monitored vital parameters and subsequently sent them to the reference health organizations. In this way, the users can record major information on the virus; it is important and practical to record routine activities, the medical cares received and keep track of the progress of the disease. In this way it's possible to indicate accelerated or delayed growth of virus. The users can make use of diary and recording features. Likewise, keeping the mApp on own hand is important in order to evaluate and detect and diagnosis eventual discomforts.

Beyond, the healthcare workforce can be more efficiently and virtually close to patients, supported by real-time communication with them (e.g. via the exchange of app user's data); in addition the possibility to share experiences with others can be of great assistance in addressing certain issues about manage and social relationship. Social support can reduce levels of stress as well as can improve the overall health and quality of life. Secure and easy-to-use mHealth apps have the potential to increase adherence and engagement with the health system as a whole. The last characteristic is the usability; it relates to the ease with which users can complete their tasks in a specified context of use (comments by the users).

Task structure and interaction style should be optimal to minimize usability flaws. The purpose of the development of the mApp with focus on Covid-19 is to limit the infection, to manage monitoring, self management of the virus, etc. In this study it was considered whether mApps were functional to the objective. The 70% of mApp has the function in order to reliably determine the epidemiologically targeted, so that the information on App should be able to estimate with sufficient accuracy the proximity to the "contagion risk map". In 30% of mApps has the function of acquiring and monitoring vital parameters and subsequently sent them to the reference health organizations (see Table 1 and 2 section Technical Functionality).

5 Conclusions

The results of this study show that mApps' have high ability to engage users (patients) in healthcare process. This is mainly due to the accessibility of apps and the spread of the mobile phone [13]. MHealth apps can be used as a powerful tool for health prevention and self-management; infact the charaterist and the technical functionality of mAps - ubiquitous, portable and capable of advanced computational capacity - permit to explore new opportunities to change patients' health behavior [1, 2]. The diffusion of mobile application in health sector is a particular event that in a short period of time has completely modified not only the relationship between medical professional and patients, but also habits and patients' lifestyles, so that it is very difficult to imagine living without it [10]. This digital technology in COVID era, if deployed correctly, could contribute substantively to containing and reversing virus spread. The sharing knowledge and the community created among patients, medical doctors and public authority through mobile technology can play a prominent role in order to improve the quality of life (support social and personal interactions) and modify the contact tracing and symptom checking; so, the mobile technology can have a prominent role during this pandemic period. In this COVID-time, n°71 mApps was specifically developed (on different platforms and stores) in order to support self-management, contact tracing, symptom checking, differently for quality, content, and functionality.

Research is needed to determine optimal capabilities and evaluate utility by determining clinical benefit, and the mHealth can offer a wide range of smart modalities that allows patients to interact directly with health professionals and systems in order to obtain helpful in real time and feedback along the continuum care from prevention to diagnosis, treatment and monitoring. Specifically, the apps offer a particular value for health treatment in those situations where continuous interaction is important. App developers get deeper insight on critical determinants that govern the adoption of mApps. It is

initially important to consider antecedents like perceived usefulness, ease to use, enjoyment, and cues to action when designing the user interface and application features in order to establish a solid foundation for one health app. The developed research allowed to underline the easy and practical use of the mApps in supporting Health System. But the sensitivity of the subject requires greater attention to their practical use. Hundreds of mobile applications are available to user\patient and they are rapidly changing on a daily basis. Our results indicate, however, that the quality and content of these applications varies greatly. This suggests that while users consider that certain applications have high quality, many others are sub optimal and in need for improvement. Technical malfunctions may be one of the primary reasons for negative reviews (comments users). Despite these limitations, users find the applications to be tremendously beneficial.

Some limitations appear about this research paper. Firstly, applications born and fail on a daily basis and their dynamic nature gives to this work a contingent value; in the future the situation could modify itself. Secondly, authors used for their analysis the available informations presented in the full descriptions of each application regarding functions and capabilities. It is possible that applications had features that were not listed in the description or, conversely, that advertised features were not present or functional in the actual product. The analysis used comments and ratings on technical functionality; users who provide reviews may differ systematically from users who do not so; in addition the language could be an obstacle to the real diffusion of the mApp and understanding the phenomenon at international level. In any case, the results can providing information on currently available features of mobile applications. Similarly, findings can provide valuable guidance to clinicians, patients and public health authority by considering the use of mobile applications. On these premises, it is essential to ensure that patients use well-functioning applications that fulfill their unique needs for health self-management. Another important problem regards privacy and security of users of mApps.

So, the existence of a privacy policy is an important baseline standard to know why, where, and how personal details will be collected, used, shared and protected [19]. Health-related apps, in particular, are dedicated for tracking, recording and managing Personal Health Information (PHI) of users. PHI is extremely sensitive and needs to be highly protected through robust security and confidentiality mechanisms such as encryption and authentication methods. Differently without appropriate safeguards, the use of mApps could have a significant negative effect on privacy and individual rights.

Appendix I

Table 1. Play Store mApps

	App name	Type	Technical functionality	Description	Actor Relevant	Territorial area of reference	Download	N° Comments by users
1	AllertaLOM	Symptom checking and contact tracing	Proximity technology In order to reliably determine the epidemiologically targeted. The information on App should be able to estimate with sufficient accuracy the proximity the " contagion risk map".	App (in conjunction with Regional Crisis Unit) should be able to record symptom day by day through the self-diagnostic	Public Authority (protezione civile Lombardia Region)	Local Territory (Region Lombardia)	500.000+ 3,1*	3.104
2	Sicilia Si Cura	Contact tracing and self-diagnostic	Proximity technology In order to reliably determine the epidemiologically targeted.	App should be able to record symptom day by day through the self-diagnostic	Public Authority Sicilia Region	Local Territory	1000+ 3,5*	30
3	LaziodrCovid	Contact tracing and self-diagnostic	Proximity technology In order to reliably determine the epidemiologically targeted.	Control of the level of risk. Consultation of statistics. Sending a contagion report.	Team Project	Local Territory	50.000+ 3,2*	557
4	WHOinfo	Contact Tracing and warning	Proximity technology Information on the state of the virus and better health for everyone everywhere	Control of the level of risk.	Public Health Authority	Total Territory	50.000+ 3,8*	162

(*continued*)

Table 1. (*continued*)

5	SM_Covid 19	Contact tracing and self-diagnostic	Proximity technology App should be able to send and receive and record Bluetooth signals even in the background mode (even when the phone is locked). App should be able to estimate with sufficient accuracy the proximity between mobile phones via Bluetooth signals. App should advertises continuously its presence using a temporary anonymous ID that permits establishing contact with other app users in proximity. App should record and store IDs observed from other mobile phones in epidemiologically relevant proximity on the device. App should be able to indicate the Public health Authority.	Control of the level of risk. Consultation of statistics. Sending a contagion report. The code (QR codes) created ensures that it cannot be used by other individuals to pollute the data collected on the server.	Team Project	Local Territory	10.000+ 4.0*	280
6	OpenWho knowledge for Health Emergencies	Knowledge transfer	Interactive knowledge-transfer platform	Offering online courses to improve the response to health emergencies	Public Health Authority and Team Project	Total Territory	500.000 4,2*	2173
7	Covid-19	Contact Tracing, warning and self-diagnostic	Acquisition and monitoring of vital parameters. Subsequently sent to the reference health organizations	Control of the symptom level (Application for those in self-isolation)	Team Project	Italy Territory	10.000+ 2,8*	119

Source: Play Store (Android)

Table 2. iTunes Store mApps

	App name	Type	Technical functionality	Description	Actor Relevant	Territorial area of reference	Download	N° Comments by users
1	COVID-19!	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone everywhere	App provides expert information about the infection on how to identify it and how to defend yourself	Team project	Total territory	54 4,1*	16
2	Healthlynked Covid-19 Trancker	Self diagnostic	Proximity technology in order to reliably determine the epidemiologically targeted.	App should be able to record symptom day by day through the self-diagnostic	Public Authority	Total territory	1097 4,4*	37
3	Covid-19 Gov Pk	Contact Tracing and Knowledge transfer	Proximity technology. Information on the state of the virus and better health for everyone everywhere and Interactive knowledge	The app provides expert information about the infection and Offering online courses to improve the response to health emergencies	Public Authority (National Information Tecnology board)	Local Territory (Pakistan)	5 1,0*	0
4	Stop Codi19 CAT	Contact Tracing and Self diagnostic	Proximity technology n order to reliably determine the epidemiologically targeted.	App provides expert information about the infection on how to identify it and how to defend yourself	Public Authority (Generalitat de Catalunya)	Local Territory (Catalunya)	21 2,5*	5
5	Trecovid19	Contact Tracing	Infention management in the region	The app indicates the measures for the containment of the virus and the numbers to contact in case of need	Public Authority (Heath Company)	Local Territory (Trentino)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	

(*continued*)

Table 2. (*continued*)

6	Covid19Regione Sardegna	Contact Tracing and Self diagnostic	Proximity technology in order to reliably determine the epidemiologically targeted.	App for self-declaration of arrivals and departures in Sardinia and authorization for transport	Public Authority (Sardinia Region)	Local Territory (Sardinia)	2 4,5*	0
7	Coronavirus-Covid19	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone everywhere	App provides expert information about the infection on how to identify it and how to defend yourself	Public Authority (Heath Company)	Total Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
8	Coronavirus- SUS	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	Control of the level of risk. Consultation of statistics. Sending a contagion report	Public Authority (Government of Brazil)	Local Territory (Brazil)	16 3,0*	4
9	patientMpower for COD-19	Contact tracing and self-diagnostic	Proximity technology in order to reliably determine the epidemiologically targeted.	The app will allow you to monitor the symptoms and health information in self-isolation.	Tem Project	Local Territory (Ireland)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
10	Coronavirus Covid Trancker	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone everywhere	The app fight the covid 19 by tracking global evolution and stayung up to date with latest official information on protection measures and treatments	Team project	Total Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	

(*continued*)

Table 2. (*continued*)

11	TraceCovid	Contact Tracing	Proximity technology. Information on the state of the device	The app helps Government whit contact tracing for the benefit of the whole community	Public Authority Depatment of health Abu Dhabi	Local Territory (Abu Dhabil)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
12	Relief Central Covid-19	Gudelines	Proximity technology to give Gudia lines in the management of the epidemic	The app help the health community stay up-to-date with this rapidly changing infectious	Team project	Total territory	22 4,3*	0
13	Disinfection Checklist	Prevent infections	Proximity technology to give Gudia lines for disifection	The app is a great tool for ensuring properdisinfection for commercial and residential facilites	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
14	Covid-19 News	Contact Tracing	Proximity technology. Information on the state of the device	All the news related to Pandemic	Team project	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
15	Covid -19 AR	Contact tracing and prevention	Proximity technology in order to reliably determine the epidemiologically targeted.	The app will allow health information for prevention	Public Authority (Governament Argentina)	Local Territory (Argentina)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
16	Castor Covid-19	Contact tracing and self-diagnostic	Proximity technology in order to reliably determine the epidemiologically targeted.	The app will allow you to monitor the symptoms, can be monitored by trained healthcare professionals through real-time dashboards	Public Authority (Healthy Ageing)	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	

(*continued*)

Table 2. (*continued*)

17	Cova Punjab	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app provide citizens with preventive care information and other governmentt advisories.	Public Authority (Governament Punjab)	Local Territory (India)	3 5*	0
18	Covive: your Covid-19 app	Symptom checking and contact tracing	Proximity technology in order to reliably determine the epidemiologically targeted.	The app guides you in evaluating you probability of having contracted Covid and help you monitor symptoms	Team project	Total territory	6 5*	0
19	SOS Coronavirus	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app inform raise awareness of the damage from Covid-19 and manage suspected cases	Public Authority (Ministry of Health and Social Affairs)	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
20	Covid-19 UAE	Contact Tracing	Proximity technology in order to reliably determine the epidemiologically targeted.	The app provides you with real-time Coronavirus cases information	Public Authority (Ministry of Health UAE)	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
21	Covid -19 Armenia	Contact Tracing and warning	Proximity technology Information on the state of the virus and better health for everyone everywhere	The app will app you stay up to date with the latest official news about Covid 19	Public Authority (Governament Armenia)	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	

(*continued*)

Table 2. (*continued*)

22	Covid-19 learning Platform	Knowledge transfer	Interactive knowledge-transfer platform	learning platform a is an online web and mobile based large-scale training solution developed by combining empower's digital, products and service, includin learning platform, impact measuement tolls and e-learning content	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
23	Covid-19 Cuernavaca	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app provide citizens with preventive care information	Team project	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
24	CDC	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app ensures that you're getting the most up to date health information	Team project	Local Territory	4 2*	1
25	MyAus Covid-19	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	A resource for information about covid-19 and how impacts you	Team project	Local Territory (Australia)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
26	Coronavirus Australia	Contact Tracing and information	Proximity technology in order to relia-	The app provide citizens with preventive care information	Team project	Local Territory (Australia)	The app did not receive a sufficient number of ratings	

(*continued*)

Table 2. (*continued*)

			bly determine the epidemiologically targeted.				or reviews and an average is not visible	
27	BMC Combat Covid	Contact Tracing	Proximity technology Information on the state of the virus and better health for everyone everywhere	The app mark you sition fr sel quarantine, this will help us track your helath progress and contain the spread of this virus	Team project	Local Territory (Mumbai)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
28	Patientsphere for COVID 19	Contact Tracing, warning and self-diagnostic	Acquisition and monitoring of vital parameters.	The app tarck the symptoms and help you to comunicate with your doctor and help them to accurately diagnose the disease	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
29	HowweFeel	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app is the global community to fight the covid	Team project	Total territory	2 5*	0
30	Bolivia Segura	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app gives official information of the covid	Team project	Local Territory (Bolivia)	1 5*	0
31	CoronaFacts	Contact Tracing and information	"Proximity technology Information on the state of the virus and better health for everyone everywhere"	Created by physician, the app provide a trusted source of information on the spead of covid globally	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	

(*continued*)

Table 2. (*continued*)

32	Nuahealth Video Consultation	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app is a Video Consultation service whit physician	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
33	Sentinel Monitor	Symptom checking and contact tracing	Acquisition and monitoring of vital parameters. Subsequently sent to the reference health organizations	Control of the symptom level	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
34	Tarassud	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app get updates about the virus disease in the contry	Public Authority (Ministry of health Oman)	Local Territory (Oman)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
35	StopCovid	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app supports to prevent the spread of Covid19 throught contatc tracing.	Public Authority (Ministry of health and Social Affairs)	Local Territory (Georgia)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
36	Covid-19 Tam	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app gives official information of the covid	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible

(*continued*)

Table 2. (*continued*)

37	CoronApp-Colombia	Contact Tracing and warning	"Proximity technology. Information on the state of the virus and better health for everyone everywhere"	Control of the level of risk.	Public Authority (Istitute national health)	Local Territory (Colombia)	3 2 4,3*
38	Covidom Patient	Contact Tracing and warning	Acquisition and monitoring of vital parameters	The app is only useful for patients who need to use hospital services	Public Authority	Local Territory (Paris)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
39	Assistencia Covid-19	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	App should be able to record symptom day by day through the self-diagnostic	Team project	Local Territory (Guatemala)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
40	Apollo Covid19	Contact Tracing and warning	Acquisition and monitoring of vital parameters	The app enables contactless screening for covid at the medical frontlines	Team project		"The app did not receive a sufficient number of ratings or reviews and an average is not visible"
41	GVA Coronavirus	Contact Tracing and warning	Acquisition and monitoring of vital parameters	App should be able to record symptom	Team project	Local Territory (Valencia)	1 0 5*
42	NHS24:Covid-19	Contact Tracing and warning	Acquisition and monitoring of vital parameters	The app assess symptoms	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
43	Corona care	Contact Tracing and warning	Proximity technology. In order to reliable	The app help healthcare providers in their	Team project	Total territory	The app did not receive a sufficient number of ratings

(*continued*)

Table 2. (*continued*)

			bly determine the epidemiologically targeted.	research the symptoms of infection			or reviews and an average is not visible
44	Canada Covid-19	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	Control of the level of risk.	Public Authority (Canada)	Local Territory (Canada)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
45	Assistencia Covid-19	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	App should be able to record symptom day by day through the self-diagnostic	Public Authority (Espana)	Local Territory (Espana)	The app did not receive a sufficient number of ratings or reviews and an average is not visible
46	Coronavirus UY	Contact tracing and self-diagnostic	"Proximity technology. In order to reliably determine the epidemiologically targeted."	App should be able to record symptom day by day through the self-diagnostic	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
47	bewellxcel	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone everywhere	The app help you be more informed about the developing pandemic	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible

(*continued*)

Table 2. (*continued*)

48	Cachoeirinha ContraCoronavirus	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone everywhere	The app help you be more informed about the developing pandemic	Team project	Total Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
49	GH Covid-19 tracker	Contact Tracing and warning	Proximity technology. In order to reliably determine the epidemiologically targeted.	The app help healthcare providers in their research the symptoms of infection	Public Authority (Ministry of Comunication)	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
50	Pubblic Access Control System	Contact Tracing and warning	Proximity technology. Information on the state of the virus and better health for everyone	This app is used for public access control purpose in Community any suspicious person can be blacklisted in communities and public areas so ensure safety for everybody	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
51	Musc Covid-19 Vital Link	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	App should be able to record symptom day by day through the self-diagnostic	Public Authority (Sud Carolina)	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
52	BC COVID 19 SUPPORT	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted.	The app gives official information of the covid	Public Authority (COLUMBIA)	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible

(*continued*)

Table 2. (*continued*)

53	OBVIO-19	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted	App should be able to record symptom day by day through the self-diagnostic	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
54	Tali Symptom tracker	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted	App should be able to record symptom day by day through the self-diagnostic	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
55	cov_cl	Contact Tracing and warning	Proximity technology. In order to reliably determine the epidemiologically targeted.	Control of the level of risk. Consultation of statistics.	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
56	PreMedicus ER	Contact tracing and self-diagnostic	"Proximity technology. In order to reliably determine the epidemiologically targeted"	App should be able to record symptom day by day through the self-diagnostic	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible
57	JamCovid19	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	Control of the level of risk. Consultation of statistics. Sending a contagion report.	Public Authority (Jamaica)	Local Territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible

(*continued*)

Table 2. (*continued*)

58	AarogyaSetu	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	the app is aimed at augmenting the initiatives of the Government of India for prevention covid	Team project	Local Territory (India)	3 5*	0
59	Spectrum-Clinicaldecisions	Contact tracing and self-diagnostic	Proximity technology. In order to reliably determine the epidemiologically targeted.	The app is a customizable clinical deicsions tool for infectious diseases	Team project	Total territory	2 5*	0
60	Kencor covid 19	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app is a Video Consultation service whit physician	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
61	Managing your stress& anxiety	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app provide information and evidence based coping strategies to help you manage stress and anxietyduring covid	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
62	Covid-19 Virginia Resources	Contact Tracing and information	Proximity technology in order to reliably determine the epidemiologically targeted	The app supports to prevent the spread of Covid19 throught contatc tracing.	Public Authority (Departiment of Social Services)	Local Territory (virginia)	The app did not receive a sufficient number of ratings or reviews and an average is not visible	
63	patientMpower for Covid-19 USA	Contact tracing and self-diagnostic	Proximity technology. In order to reliably	Control of the level of risk.	Team project	Total territory	The app did not receive a sufficient number of ratings	

(*continued*)

Table 2. (*continued*)

			bly determine the epidemiologically targeted.	Consultation of statistics. Sending a contagion report.			or reviews and an average is not visible
64	CNESST- Covid19	Job security	Proximity technology	Support the enterprise	Team project	Total territory	The app did not receive a sufficient number of ratings or reviews and an average is not visible

Source: iTunes Store (macOS)

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Social Media Use and Organizational Identity: A Case Study

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Abstract. The organizational identity (OI) concept has been used only sporadically in information systems (IS) research despite the fact that technology in general and social media (SM) in particular are transforming the way individuals, groups and organizations think about and define themselves. This study examines the relationship between the extent of employees' SM use for professional purposes and the nature of OI that employees hold about their employer. This relationship is examined in a medium-sized Italian HR Consulting Company. Data were collected by interviewing 22 employees and from examining their LinkedIn accounts. Our analysis unearths both strategic and cultural aspects of employees OI, with the former prevailing, and finds that that neither of these sides of OI vary depending on the extent of employees' SM use. Considering that LinkedIn is the world's largest professional SM, this study also has important practical implications highlighting the need to better explain SM use to employees.

Keywords: Organizational identity · Social media · Employees · Case study

1 Introduction

Is "who we are as an organization" [1] related to how much we as individuals in this organisation use social media (SM) for professional purposes? This question becomes increasingly eminent as both organizations and employees are engaging with SM on a massive scale [2]. For example, LinkedIn is widely used across the world for people to channel their professional identity and to interact with others for professional purposes [3].

The use of SM by employees for work is claimed to improve employees' commitment level [4], and to facilitate innovative ways of interaction and collaboration that can increase organizational performance [5]. Research tends to link the use of SM by organisational actors for work purposes with the characteristics of their organizational culture [4]. For example, the use of social technologies to facilitate the assimilation of new young employees was found to create high morale and increase employees' feelings of cultural belonging [6]. Studies have also found that SM use can facilitate relationship

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building, open communication and information sharing, leading to more engaged and productive employees [5–8].

Previous SM use research focused predominantly on organizations' motivations for using SM [9] or their SM adoption rates [10]. Though this research enriches our understanding of SM use, despite some exceptions, it mostly overlooks employees' SM use for professional purposes [8] or how by sharing their work-related experiences on SM employees can represent their employer (e.g. [11]). Indeed, in the era of SM not only organizations but every single member of an organization has an equal opportunity to project their perception of the organization – the organizational identity (OI) - externally via their SM accounts.

According to Albert and Whetten [1], OI concerns "Who we are as an organization?". Thus OI constitutes employees' mental representations of what is central, distinctive and continuous over time about their organization ([1, 12] as cited in [13]). OI concerns how organizational members define themselves as a social group in terms of practices, norms, and values and understand themselves to be different from members of other organizations [14]. Understanding OI is important because it influences the core competencies of an organization [15], and it contributes to the loyalty and commitment of employees [16]. Despite the broad applicability and extensive use of the OI concept in general management and organizational studies, OI has only been sporadically used in IS research [17]. Nevertheless, technology is important in understanding OI, as technology in general and SM in particular is transforming the way individuals, groups and organizations think about and define who they are both as individuals and as a professional group [17]. At the same time, OI also influences the use of these technologies. For example, previous research conducted with 679 communication and marketing managers from over 30 countries claims that there is a positive and strong significant effect between how individuals identify with the attributes recognized as "prototypical" for the members of the organization [18] and confidence in their professional SM use [19]. In particular, individuals who perceived a stronger bond with their organization were found to be more confident in using SM professionally [19]. Building on this previous research on SM and OI, we aim to understand the relationship between the extent of employees' SM use for professional purposes and the nature (dimensions) of the OI that an employee holds about their employer (RQ).

Understanding employees' OI in the SM environment is critical for the success of any organizational strategy [20], as the OI each employee projects externally can be observed by other employees, company management, and partners, as well as company customers and competitors. As such the OI they project can have an impact on the company reputation, employer branding or even its competitive advantage. Employees with high OI and high SM use often, for example, become Company Ambassadors [21], while the concerns and dissatisfactions of those with low OI can be fulfilled by knowing exactly which dimensions these are referred to.

In summary, this study will contribute to the research on SM use and OI in several ways: (1) by examining empirically the relationship between SM use and OI, and (2) by providing theoretical and practical implications for OI in SM environment.

The paper is organized as follows. The next section provides a brief literature review on SM use and OI, explaining also the theoretical framework adopted in this study; then

we explain our research methodology, which we follow by discussing our results and their significance. In the final section we offer the conclusions of the study, discuss its limitations, and the directions for future research.

2 Literature Review

Within IS research, OI has been studied in relation to its influence on the implementation of new Information Technology [22]. In SM research, identity has been examined in the context in which users' profile reflects, at least partially, their identity ([23, 24], as cited by [9]). Through work-related SM use, employees can emphasize their role as organizational members [9] and engage with their colleagues rapidly [25]. However, the use of SM in the workplace has been mostly studied along specific, isolated organizational dimensions [26] including the effect of SM use on social capital [27], on careers [7], and on the rate of innovation [28] among others, rather than through the lens of OI. Forsgren and Bystrom [29] have called for research beyond the occurrences of SM including an understanding of how SM incorporates into work.

Gioia and colleagues [30] stated that the rapid expansion of SM have re-invigorated the discussion about OI, changing the way the "identity" is conceptualized, operationalized and measured. However, now as before, the majority of the empirical research is not explicit on how OI is to be operationalized and assessed [31, 32]. Indeed, as mentioned by Margolis and Hansen [33] and then confirmed by Hsu and Elsbach [34] there is limited research on the shared aspects (or categorization) of OI, because OI is the discovery of an organization's distinctiveness and a methodology measure based on predetermined categories established by the researchers will most likely not solve the question of OI [35]. The challenges in operationalizing OI is also often attributed to the "fluidity" of the OI concept caused by its constant interrelationships with an organizational image [36], which makes it a constantly changing phenomenon. In a comprehensive work seeking to clarify the different components of OI, Corley [37] identifies four aggregate dimensions of OI including Nature of OI, Identity Discrepancies, Basis of Identity Change, and Identity Change Implementation. His approach examines OI in the context of change. As we are interested primarily in the nature of OI (regardless of whether the context changes or not), we focus here only on the first dimension proposed by Corley [37] (i.e. the nature of OI). The nature of OI covers the cultural and structural (strategic) aspects of the OI. The cultural aspect of OI includes the values and beliefs exposed by the organization, while the strategic aspect comprises organizational purpose, mission, and philosophy. According to Corley's [37] study, identity differentiation can occur at different levels of an organization's hierarchy. For example, employees at the top of the hierarchy (i.e. managers) are more likely to see OI in relation to the organization's strategy and purpose, while the perception of OI by employees on the lower levels focuses on the cultural dimensions. This multilevel notion of OI was also recognized by Puusa [38] who studied OI at the individual, group, organization or industry levels [38, 39]. At the individual level, identity has been argued to address the psychological motives of employees (self-knowledge, self-expression, self-coherence, self-continuity, self-distinctiveness, self-enhancement). At the organizational level, identity has been

argued to differentiate amongst organizations within an industry context. Acknowledging the multilevel nature of OI, our study will draw from these categories, aiming to explore whether they are also emerging in our context.

3 Methodology

3.1 Research Design

Taking into consideration the growing attention of contemporary research on the OI of consulting firms [40, 41] for our case study we selected a medium-sized Italian HR Consulting company with circa 10 international branches. The Company was founded more than 70 years ago and is now an European leader in developing and selling scientific assessment tools, which build the base for their HR consulting activities. The Company belongs to a larger family business, a Group Company which is the second largest in Italy in their specific sector. It recently (January 2017) changed its name to re-position itself in an international competitive context, and to reemphasize to their customers, suppliers, and employees who they are and what they do. Thus, the self-reflective question "Who are we as an organization" considered relevant in situations of organizational change [41] is pertinent to this organization.

22 semi-structured interviews were conducted with 22 Company employees chosen to represent employees with different employment tenure, hierarchical roles, and contract types to ensure the variety of the sample.

The questions were guided by the questionnaire based on Margolis and Hansen's interview protocol [33] that ensured that the interviews were focused on our research question [42].

The interviews lasted between 30–60 min, were recorded and transcribed verbatim. The text of interviews conducted in Italian was translated by one author and checked by another author. Only employees with LinkedIn accounts were interviewed.

The data on employees' OI were collected from the employees (individual) public LinkedIn profiles in a recent relevant study [45]. It's important to underline that at that time the Company did not have any guidelines for SM use.

The description of how data were collected is presented in Table 1.

Table 1. Approach to data collection

Type of data	Approach to data collection
The extent of SM use	Interviews
OI score	SM data from LinkedIn accounts
Nature of OI	Interviews

3.2 Research Design

Extend of SM Use

Following Heinrichs and colleagues [43] the data on employees' SM use were manually classified into three categories including employees with low, moderate, and high SM use.

To classify the data into these categories we considered employees' relation with SM, and the frequency of their SM use for both professional and personal purposes. To cross-check and triangulate the results of this analysis additional data obtained from employees on the type of SM content the company publishes was analyzed to verify their effective use and knowledge of SM platforms.

OI Score

There are several approaches to measure OI [42]. However, Van Rekom and van Rie [44] stated that existing studies on measuring OI are mainly based on primary input from organizational members. Therefore, in this study we used data collected not directly from organizational members, but from secondary sources such as employees' publicity available LinkedIn profiles. Specifically, the data on employees' OI were collected and analyzed in a previous recent study [45] aiming to measure how internal individual organizational members project OI via an external SM channel – LinkedIn.

Moreover, contrary to most of the existing case studies focused on measuring organizational identity qualitatively [42], the empirical case study where OI data were collected [45] used quantitative descriptive statistics and regression analysis.

The OI score was assigned based on a bespoke measure created on a scale of 0–10. This figure aggregates five variables that capture the extent to which employees project their OI on their personal LinkedIn profiles, based on whether:

1. they have a LinkedIn profile;
2. their LinkedIn profile is linked to their employer profile;
3. they specify the name of the Company in the job title/headline;
4. they state the name of the Company in their LinkedIn profile summary;
5. they describe their main work responsibilities or provide a brief introduction to the Company.

Each of these five variables weighted 0 when this information was not present and 2 when it was available. Finally, the data were also grouped into three relevant categories including employees with a low (OI = 2–3), moderate (OI = 4–6), and high (OI = 7–8) OI score. The aim here was to register how strongly employees felt a sense of belonging to the Company and projected their OI through their personal LinkedIn accounts.

Nature of OI

Instead of analyzing phrases as was done by Corley [37] in his original study, similarly to Lux [46], we analyzed adjectives used by the interviewees to describe the Company together with the adjectives they used when responding to broader questions about the Company to understand the nature of their OI: strategic or cultural [37] (see literature

review section for details). The goal here was to identify the types of attributes that may constitute participants' perceived OI which can be considered possible indicators of the content of participant's perceived OI [47]. Crosscheck of the adjectives each interviewee mentioned and the ones they used in their responses to broader questions about the Company revealed that interviewees utilize similar adjectives for the former and the latter.

To ensure qualitative rigor of our research and not to miss any key aspects of member's sensemaking by imposing preordained understanding of member's experience, following the Gioia and colleagues' [42] grounded theory articulation approach we did not cluster the adjectives in some existing terminology or categorization framework. The adjectives were manually classified by one author into the emerging categories. This classification was then re-checked by another author. If agreements about some codings/classifications were low, we revisited and discussed the data until arriving at consensual interpretations [42].

It is worthwhile to specify that most of the employees used the same adjectives; few synonyms were identified and classified under the same relevant adjective (e.g. fluid, and in movement). The number of times each adjective was used by interviewees is indicated in Table 2.

Then, the adjectives were clustered according to the two levels - individual, organizational - that emerged from our analysis. With the individual level, we associated the human's behavior and the organizational climate (i.e. needs of employees) as well as their individual aspects/characteristics (e.g. young age). To the organizational level, we linked all the issues and characteristics related to the Company itself (i.e. the distinctive competencies of the Case Company, its attitude, and goal orientation).

4 Findings

4.1 SM Use and OI

Our findings reveal that among the 22 employees interviewed, there was a homogenous distribution among the three categories of employees' use of SM - low, moderate, and high - and that the majority of employees had moderate OI score (see Fig. 1). These results suggest that OI might not depend on employee's use of SM (in particular LinkedIn).

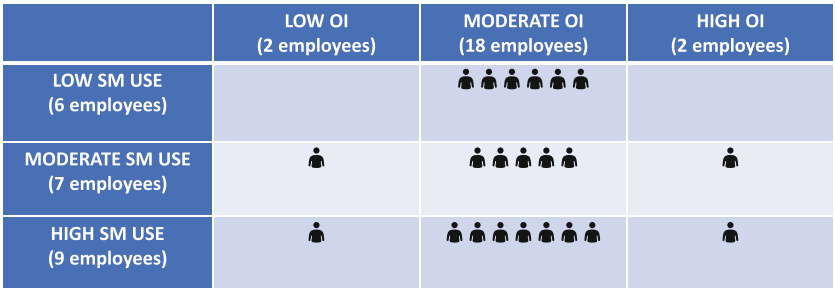

Fig. 1. Employees' level of OI and SM use

To understand what other factors could explain variance in employees' perceived OI, we also looked at the four extreme cases of employees' low and high OI. Both employees who demonstrated high OI identity, despite describing the Company as fluid or in constant movement, had a clear idea of their role in the Company. Moreover, both employees believed the Company to have a stronger market position compared to its competitors.

One of these employees also had a perception that the Company has strong values (e.g.: "it is a company with many values… and our mission is wellness" [Respondent 5]), though this employee also noted that these values might not coincide with the values other employees perceived about the Company (e.g. "these are the company values for me. I'm not sure that they necessarily coincide with the rest of the company, because we can have different values with [CEO]" [Respondent 5]). The other employee with strong OI also had a perception that he was important for the company only because he had "historic memories of organizational changes that "younger" employees in the company did not have" [Respondent 9]. He also mentioned that he now feels more identified with the Company, due to his past experience when he risked losing his job with the Company due to the economic crisis.

The other two employees with low OI both described the Company as unstructured (in a negative sense), and were unhappy about the vagueness of their role in the Company (e.g.: "(Laughs) you tell me what my role is !?" [Respondent 16] or "so even my role and my duties were not clear right away, not even with whom I should interface" [Respondent 10]). They were also unclear about where and how to find the information useful for their work (e.g.: "onboarding process was absent at my entrance, thus I had to find all information myself" [Respondent 10]).

4.2 SM Use and OI

Both strategic and cultural aspects of the employees' OI emerged from our analysis, although the former prevailed (see Table 2).

The Strategic Aspect of OI

Most of the adjectives used by employees related to the strategic nature of OI (see Table 3). Moreover, the majority of adjectives from this category belonged to the organizational level of analysis regardless of the extent of employees' SM use. Exception to this was the "scientific" adjective, which refers to the scientific approach continuously adopted by employees/individuals to develop products or to deliver customer services.

> *"This company stands out for making, proposing, selling products and services that are based exclusively on scientific methods and approaches. I give you an example [...] When we build a psychodiagnostic instrument we try it, as if it were a new molecule, like a drug. We try it, we experience it on very large samples. Then we do all the statistical work to make sure that it works…or that its evaluation is reliable" [Respondent 1]"*

Table 2. Classification of the adjectives used by employees

Strategic aspect	Number of times mentioned	Cultural aspect	Number of times mentioned
Fluid/in movement	11	Good organizational climate	5
Unstructured	8	Young	5
Scientific	8	Historical	5
Innovative	7	Collaborative	4
International	6	Sympathetic	2
High-quality products and services	6	Ethical	2
Leader	6	Trustworthy	2
Belongs to a family business	3	Motivated	1
Structured	3		

Table 3. Adjectives related to the strategic aspect of OI

Level of analysis	Adjective	Low SM use	Medium SM use	High SM use
Organizational	Fluid	27,3%	45,4%	27,3%
Organizational	Unstructured	25%	37,5%	37,5%
Organizational	International	0%	16,7%	83,3%
Organizational	High-quality products and services	16,7%	33,3%	50%
Organizational	Leader	16,7%	50%	33,3%
Organizational	Innovative	14,3%	28,6%	57,1%
Organizational	Belong to a family business	66,7%	0%	33,3%
Organizational	Structured	33,3%	33,3%	33,3%
Individual	Scientific	25%	0%	75%

The nature of OI of employees with high SM use was mostly associated with the international presence of the Company, and the scientific, and innovative approaches it adopted to develop products and to deliver services. Employees with high SM use overall were neutral to the Company organizational structure referring to it as neither fluid, unstructured nor structured.

Employees with medium SM use mostly perceived their Company as having fluid organizational structure and being a leader on their market. Meanwhile, employees with low SM use mostly perceived the Company as being part of a larger family traditional business, and exhibited less perceptions of the Company being innovative.

"[…] a company that still has a strong family root, in the sense that belonging to [name of the company group] in my opinion is felt and is important" [Respondent 3]

The Cultural Aspect of OI

Most of the adjectives referring to the cultural aspect of OI belonged to the individual level of analysis (see Table 4).

Table 4. Adjectives related to the cultural aspect of OI

Level of analysis	Adjective	Low SM use	Medium SM use	High SM use
Organizational	Good organizational climate	0%	60%	40%
Individual	Sympathetic	50%	0%	50%
Organizational	Historical	20%	60%	20%
Individual	Young	40%	60%	0%
Individual	Collaborative	25%	25%	50%
Individual	Ethical	50%	0%	50%
Individual	Trustworthy	0%	0%	100%
Individual	Motivated	0%	0%	100%

Organizational level of analysis emerged from the adjectives used primarily by employees with medium SM use who underlined a good organizational climate and a rich historical background of their Company. Employees who describe the Company as formed by young employees were middle-of-the-road users of SM. The nature of OI of employees with equally low and high SM use was both sympathetic and ethical.

"It is a correct company [...] as such everything is done very correctly here [Respondent 12]"

Meanwhile, employees with high SM use stressed the collaborative nature of the company, which they linked also to its trustworthiness, and their motivation at work.

"We are positioned as a trusted, reliable company" [Respondent 17]

5 Discussion

Building on previous SM and OI research, we explored the relationship between the extent of employees' SM use for professional purposes and the nature of the OI employees hold about their employer. We identified a number of patterns: OI perceptions related to innovativeness, large scale and internationalization, and collaboratives and trustworthiness are associated with higher SM use, while perceptions of smaller scale, family business and localization, as well as a differential in age, are associated with lower SM use.

Overall, the analysis revealed that the majority of employees, regardless of their level of SM use or OI levels, viewed their organization as unstructured and in constant movement (fluid). This might be associated with the current goal of the Company – a leader in the local market in its specific sector and part of the traditional family business - to innovate and to increase its international presence, as was highlighted by some interviewees.

At the organizational level, indeed, employees with high use of SM saw their organization mostly as international and innovative. This can be explained by the fact that this type of employees uses LinkedIn to keep up to speed with worldwide work-related news, which they find useful for their professional work as a source of new ideas:

> *"LinkedIn I think is also very useful for professional development because you can see what is new" [Respondent 2]*

They also use LinkedIn to keep in touch with colleagues from international branches, and with other people they need to interact with for work, overall seeing SM as a cost-effective tool to achieve this goal:

> *"LinkedIn serves me to maintain contacts with the people with whom I have professional relationships" [Respondent 18]*

In contrast, employees with low SM use see their organization mostly as belonging to a larger company group (which is an Italian family business without a Company LinkedIn page), not recognizing the international aspect of the Company. Though some of these employees with low/moderate OI describe the company as international, they also refer to it as being unstructured. The latter has a mostly negative meaning for them:

> *"And there are also people who have many roles and this clearly makes the workload bigger [...] it is not that [the Company] is very hierarchical [...] it is more difficult to organize and therefore also internal communication is often left to a goodwill rather than to a structured process. So you always risk losing information, you risk introducing errors". [Respondent 11]*

These employees with low SM use, who see their employer as a leading local company make less use of SM and utilize different means to portray their OI, when they choose to do so, including face-to-face communication and communication via personal networks rather than SM.

Employees with moderate OI describe the Company as fluid, similarly also to some employees with a high OI. Contrary to the unstructured aspect of the Company, which employees view negatively, fluidity is seen as a positive attribute:

> *"[…] a company is always in turmoil. Uneasy if we want. I find it a great strength - as an imprint to change. Yes, absolutely yes. [...] because I also believe that it is a salt that gives innovation, ideas and avoids sitting down". [Respondent 25]*

At the individual level, employees with high use of SM recognize collaboration and trustworthiness as the main aspects of their colleagues, while employees with low use of SM stress the young age of their colleagues. Good organizational climate is a component that is recognized by employees with both moderate and high use of SM. Trustworthiness, in particular, is an aspect of the Company which emerged only from employees with high SM use. Previous research on OI already recognized that the interactive qualities of SM (e.g. to facilitate the quality of organization–public conversations and generate positive outcomes) affect key relational values of trust [48], fostering brand loyalty and communities [49].

The fact that employees with high intensity of SM use utilize frequently the adjective *innovative* might mean that they see also SM as an innovative technology, and as such aligned with the OI of the organization they identify with. Therefore, the intensity of their SM use might also change when SM becomes taken for granted. A longitudinal follow-up study could help to confirm or reject this hypothesis. Moreover, our findings also do not fully support the findings of Hall and colleagues [50] who found a relationship between employee perceptions regarding the quality of a firm's offerings and perceived organizational identification. We did not observe in our study a relationship between the quality of the products and services the employees developed or delivered and their OI.

6 Conclusion

We set out to examine the relationship between the nature of OI and the extent of SM use. Our study contributes both to OI and SM use research.

To OI research, we bring two contributions. First, we identify a number of OI characteristics, both at the organizational and individual levels, which even though are not strictly dependent on the SM use, could be associated with varying extent of SM use. At the organizational level, these relate to the local versus international dimension, family versus corporate, and the innovative nature of the organization. At the individual level, they relate to the nature of collaboration and degree of trust, and the age differential between employees. Second, this study also draws on a bespoke framework developed for measuring OI via LinkedIn, which is explicit on the criteria employed to measure OI, compared to other existing frameworks that do not do so [42] or that are not specific/applicable for this specific SM platform [51]. Third, in this study instead of applying a pre-existing framework to analyze OI, we looked for emergent themes (adjectives), as we acknowledge that OI is socially situated and thus difficult to generalize. Moreover, this approach offers a guide for future scholars on how to identify and possibly measure OI in contexts where existing OI frameworks are not suitable.

This study also brings three main contributions to SM research. First, we explored the role that OI plays in explaining SM use, which is the concept mostly overlooked in this area. In particular, we found that OI does not solely depend on employees' SM use. Thus, we encourage future research focused on discovering other factors that could explain the extend of employees' SM use for professional purposes. Second, while research related to SM use has begun to consider the motivations of employees in using SM [52], our analysis takes a step further and shows that certain aspects of how employees perceive their OI (e.g. cultural and strategic aspects of OI) can still be important in explaining their engagement with SM for professional purposes. This finding also suggests that OI could be an antecedent to SM use, which future research should verify. Finally, we examine a type of SM which is mostly overlooked by existing studies which focus on internal SM channel. Taking into consideration that LinkedIn, with its 645 million users, is the world's largest professional social network on the Internet [53], this study can have important practical implications by revealing to the company management the emerging need for explaining SM use or management practices to employees. In fact, it has already been highlighted that it is important for organizations to consider the OI which employees can project externally via their SM profiles and whether and how these can affect them.

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