Unveiling the business opportunities arising from the Metaverse technological development process

Abstract

Metaverse is the protagonist of the current virtualization process offering to companies' advantages beyond any expectation. Its potential is confirmed by firms' investments in developing metaverse-related technologies and by the hot academic debate on the topic. However, given the rapid evolution, there is a lack of clear understanding of the current metaverse advancement and the consequent implications for business practices and research. Our study complements the extant studies on the metaverse by providing an integrated picture of the topic and proposing new food for thought about the business opportunities that can be generated from the development process of virtualization technologies. Following a systematic literature review and a bibliometric analysis, we identify the main characteristics of the metaverse research, the thematic areas currently addressed by scholars and their evolution overtime and, the advantages that companies can obtain from the development process of virtualization technologies according to the Rogers' innovation diffusion theory.

***Keywords**:* metaverse, virtual world, digitalization, virtualization technologies, business opportunities.

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1 Introduction

Digital transformation is guiding a change of business toward a virtualization process capable of creating a hyper-connected digital environment. In this process metaverse has the potential to change how consumers and businesses interact offering new opportunities to be used in virtual and interconnected spaces (Caputo et al., 2019; Giang Barrera & Shah, 2023; S. Li et al., 2023; Ooi et al., 2024).

The term "metaverse" was first introduced in a literary work called *Snow Crash* (Stephenson, 1992) and described as a black spherical planet where individuals had the ability to move, interact, and communicate through personalized avatars, extending the physical world (Messinger et al., 2019; Ramadan, 2023). Avatars and holograms are the "new humans" which seamlessly interact within real and simulated environments leveraging

on augmented and virtual reality technologies (Burova et al., 2022; Castellano et al., 2018; Dwivedi et al., 2022; Keeling et al., 2010).

From fiction to reality, metaverse technologies are seeing more and more investment from businesses in every sector. Facebook changed its name in Meta (Han et al., 2022) and is investing millions of dollars in building a metaverse-based universe (Giang Barrera & Shah, 2023). Coca Cola Company, in July 2021, launched the first inaugural collection of non-fungible token technologies (NFTs), created to celebrate core elements representative of the brand and reinterpreted for a virtual world in new and exciting ways[1]. Maison Gucci launched *Supergucci* collection with Janky, a made in Italy ceramic sculpture created by specialized artisans and sold on the metaverse through NFTs[2]. Hyundai coined the term meta-mobility by launching NFTs that open up a world of new mobility[3]. Crèdit Agricole is entering the metaverse with the launch of virtual offices and applications for operations, proposing holograms-based workstations for financial trading[4]. Ariva Wonderland aims to bring the dynamics of life and the pinnacle of entertainment around a unique travel experience on metaverse[5].

According to McKinsey forecasts, the development areas primarily linked to metaverse are marketing, customer engagement, next-generation commerce, brand loyalty, customer service, education, recruiting, digital twins, public services, and virtual tourism (McKinsey&Company, 2022). These developments impacted on several sectors, such as energy and materials, hi-tech industry, financial sector and insurance, healthcare, public sector, tourism, transport and logistics, media, and telecommunications (Kulkov et al., 2023; Marzi et al., 2021), underlining the high and global interest in metaverse technology and its potential of impacting global economy (Javornik et al., 2021). The overall metaverse market size was estimated at USD 128.98 billion in 2023 (Marcuta et al., 2023). The COVID-19 pandemic has speeded up the emergence of virtual communities as major sharing environments for locked-down users (Cui et al., 2023; Ren et al., 2024; Richards et al., 2023; Zhan et al., 2022). Since metaverse allows people to replicate physical activities in a virtual word, it is expected by 2026 that: i) 25% of people will spend at least one hour a day in metaverse for work, shopping, education, social media, and/or entertainment, and ii) 30% of companies in the world will have products and services ready for metaverse (Gartner, 2022).

[1] https://www.coca-colacompany.com/news/coca-cola-to-offer-first-ever-nft-collectibles. Last accessed: April 10, 2023.
[2] https://vault.gucci.com/it-IT/story/supergucci. Last accessed: April 10, 2023.
[3] https://www.hyundai.com/worldwide/en/brand-journal/mobility-solution/hyundai-metamobility-universe. Last accessed: April 10, 2023.
[4] https://www.credit-agricole.it/risparmio-e-investimenti/metaverso. Last accessed: April 10, 2023.
[5] https://ariva.game/home. Last accessed: April 10, 2023.

Several scientific studies also document the development of metaverse technologies in different industries: from the gaming world (Fang et al., 2009; Kari & Kosa, 2023; Rapp, 2020), passing through the big fashion brands (Herz & Rauschnabel, 2019), agri-food (Cha, 2022), transport (Pamucar et al., 2022), medicine, and healthcare (Jones, 1996; Zahedi et al., 2022), where companies are becoming familiar with strategies based on metaverse to increase competitive advantage. Fields of application widely discussed in the international scientific scenario encompass marketing (Arghashi, 2022; Bhardwaj et al., 2023; Van Kerrebroeck et al., 2017), advertising (Calderon-Monge & Ribeiro-Soriano, 2023; J. Kim, 2021; Q. Li et al., 2021), education (De Lorenzis et al., 2023; Kumar et al., 2008; Kye et al., 2021), social context (Callarisa-Fiol et al., 2023; Falchuk et al., 2018).

The above industrial and scientific evidence demonstrates the increasing global attention and the rapid adoption of metaverse technologies by businesses and governments for several purposes. However, metaverse research field is still in its infancy and there is still a lot of confusion about meanings, scopes, and business opportunities (Giang Barrera & Shah, 2023). To fill this gap, this study leverages on both quantitative and qualitative methods to provide an integrated picture of metaverse unveiling the business opportunities deriving from the technological development of metaverse.

Relying on a wide list of studies on metaverse retrieved from Scopus and Web of Science (WOS) databases, we synergistically adopted *performance analysis* and *science mapping* to explore the identified knowledge base (Bertoglio et al., 2021). By means of performance analysis, several bibliometric indicators are calculated to describe the current metaverse research field (e.g., the annual production, the country scientific production, research subject areas, document type and most relevant sources, productive authors and historical citation network, most relevant keywords provided by the authors and their timeline). By means of science mapping analysis (based on the keywords co-occurrence analysis), the main thematic areas addressed by the metaverse research, and their evolution overtime, are unraveled. These results were widely discussed to reflect on the opportunities deriving from the technological development process according the Rogers' innovation diffusion theory (Rogers, 1995) and the phases of the technology development process (Rogers et al., 2001) providing insights about the technological development process of metaverse.

Overall, to the best of our knowledge, this is the first attempt to discuss the business opportunities deriving from the adoption of metaverse technologies for several industrial sectors and innovation stages. This aspect is the distinctive element of this study compared to previous literature reviews as it can encourage businesses toward the adoption of virtual technologies by clarifying the associated benefits (Abbate et al., 2022; Giang Barrera & Shah, 2023; Mancuso et al., 2024, 2024; Schmitt, 2022). Moreover, we designed our research protocol with aim

to overcome the limitations declared by the authors of previous literature reviews, e.g., investigation in a single database, temporal limits, document types filtering (Abbate et al., 2022; Giang Barrera & Shah, 2023; Schmitt, 2022), thus proposing a more inclusive overview on the topic: our research scheme is designed to encompass the most general and widely recognized terms representative of the topic and to consider all the contributions retrieved during data collection without stringent filtering. These choices allowed us to assure a broad selection process and avoid missing important works. The use of science mapping techniques allowed us to provide new knowledge about the main thematic areas addressed by the metaverse research and their evolution overtime, thus contributing to provide new insights about the future research routes to investigate.

The rest of this article is organized as follow. In Section 2 we discuss the background of the research on the metaverse, with a focus on existing literature reviews on the topic. In Section 3 we describe the methodology of the study. In Section 4 we discuss the main characteristics of the metaverse research field. In Section 5 we present the main thematic areas addressed by the metaverse research field and their evolution overtime. In Section 6 we offer a discussion on the business opportunities from the development process of metaverse technologies. In Section 7 we elaborate the practical and theoretical implications of the study. Finally, in Section 8, we conclude by summarizing insights and limitations of our study, and proposing the future research avenues.

2 Literature reviews on metaverse

The increasing global attention on metaverse has led to the rapid adoption of metaverse technologies by businesses and governments for several purposes, but, at the same time, it has also stimulated an astonishing growth of the scientific literature on this topic. However, as we have mentioned above, metaverse research field is still in its infancy and there is still a lot of confusion about meanings, scopes, and business opportunities (Giang Barrera & Shah, 2023). In such a scenario, literature reviews typically help to systematize knowledge in a research field, providing a picture of the current efforts made by the academia (Tranfield et al., 2003). To the best of our knowledge, only four studies propose a literature review of the metaverse research field with the aim of systematizing the related knowledge. These studies are discussed below.

Abbate *et al.* (2022) have conducted the first bibliometric literature review on metaverse research with the aim of defining the key elements of this topic. The findings of this study underline the presence of a conspicuous knowledge base on the subject and identify the relative network of authoritative authors. Game and education are indicated as the first fields of metaverse application, envisaging a gap in the application of the metaverse in other industrial sectors. Abbate *et al.* (2022) highlighted a limitation of their study, suggesting other researchers to

overcome it in future research. That is, only publications published in the Scopus database were considered in the search, leaving out documents from other databases, such as Web of Science and Google Scholar.

Schmitt (2022) has conducted a bibliometric literature review aimed at identifying guidelines to achieve value creation using metaverse-based strategies for several categories of stakeholders, as well as highlighting risks and challenges. The performance indices calculated include the distribution of publications in terms of years and country, and the network of keyword co-occurrences. Results indicate that metaverse research is largely taking place in Asia, US, and UK and is mainly investigated by engineers, computer scientists, and social scientists. Schmitt (2022) has also suggested that the metaverse concept is at an initial state of development and represents the next step to be taken in the digital transformation process, where, however, there are many challenges to be solved related to ethics, regulations, governance, security, and privacy.

Giang Barrera & Shah, (2023) have integrated the findings of a literature review and experts' viewpoints to propose a framework for the metaverse applications in marketing. Therefore, this study differs from the others two in that it focuses on a specific application field. By means of content analysis, the study clarifies the definition of metaverse, the technologies applied in the metaverse, the consumer experience in the metaverse, and the implications for future marketing research. Authors have also discussed some limitations of their study the search of articles was restricted to studies centered on marketing applications of metaverse; ii) stringent filtering criteria have been used (i.e., articles with impact factor > 3.00).

Ritterbusch & Teichmann, (2023, p. 6) conducted a literature review to analyze and investigate scientific definitions of metaverse and the related main characteristics. This analysis led the authors to develop an overall and inclusive definition of metaverse: "a (decentralized) three-dimensional online environment that is persistent and immersive, in which users represented by avatars can participate socially and economically with each other in a creative and collaborative manner in virtual spaces decoupled from the real physical world."

2.1 The novelty of the study

Despite the presence of the studies discussed above, the current relevance of metaverse requires more effort both in the organization of the extant knowledge and in the development of new knowledge. Being positioned in this research stream, our study provides an integrated picture of metaverse capable of complementing the existing studies. The main novelty of the present study is the discussion of the business opportunities deriving from the adoption of metaverse technologies for several industrial sectors and innovation stages. Leveraging on the combined use of quantitative and qualitative methods, the results of our study were discussed according the Rogers' model of diffusion of innovation (Rogers, 1995), and the phases of the technology development process (Rogers

et al., 2001), which provide insights about the technological development process of metaverse. Therefore, our study aims to encourage businesses toward the adoption of virtual technologies by clarifying the associated benefits (Abbate et al., 2022; Giang Barrera & Shah, 2023; Schmitt, 2022). For this purpose, we posed the following research questions:

a) *What are the main characteristics of the metaverse research field?*

b) What are the main thematic areas addressed by the metaverse research field and their evolution overtime?

c) What are the business opportunities deriving from the technological development of metaverse?

Moreover, we paid effort in designing our research and analysis protocol to overcome some of the limits emerged from the previous literature review studies with the aim of proposing a more inclusive overview on the topic capable of providing a new and interesting layer of knowledge. To better clarify the improvements made, Table 1 summarizes a comparison of the review and analysis protocols between our study and the extant literature reviews. Specifically, the studies were compared according the following requirements established according to the literature (Page et al., 2021; Paul and Criado, 2020; Šebalj et al., 2019; Ardito et al., 2019; Mustak et al., 2021; Leemann and Kanbach, 2022): i) the use of an inclusive query capable of collect a relevant number of studies without restricting the sample to a specific field; ii) the use of multiple and relevant databases to increase the relevance of the selected sample; iii) the use of sample size suitable for quantitative analyses; iv) the combined and synergistic use of quantitative analyses (e.g., performance analysis and science mapping); v) the use of qualitative analysis to enrich the results obtained from quantitative analyses. If a requirement is satisfied the cell is green.

Table 1 - Review and Analysis Protocol: comparison between our study and the extant literature reviews

Study	Inclusive query	Multiple and relevant data bases	Sample size suitable for quantitative analysis	Synergistic use of quantitative analysis	Qualitative analysis to enrich quantitative results
Abbate *et al.* (2022)	"metaverse"	Scopus	211 Selection criteria: Studies published in English language, in journals, conference proceedings, or books	Performance analysis: Documents distribution over time, top cited documents, and country distributions.	-
Schmitt (2022)	"metaverse" OR "metaverses"	Scopus	198 Selection criteria: Limitation to the last 8 years, article and conference proceedings, business and management thematic areas	Performance analysis: Distribution of publications in terms of years and country, and the network of keyword co-occurrences	-

Giang Barrera and Shah (2023)	"metaverse" AND "marketing"	Google Scholar, Business Source Complete, Academic Search Complete, Science Direct	164 Selection criteria: Removal of articles on education or published on low impact factor journals, restriction to 1992-2022 studies	-	Qualitative content analysis: Definition of metaverse, the technologies applied in metaverse, the possible consumer experience in the metaverse, and the implications for future marketing research
(Ritterbusch & Teichmann, 2023)	"metaverse"	Web of Science, JSTOR, Wiley. Definition of final hits. Information Systems eLibrary (AIS)	28 Selection criteria: Limitation to English, without duplicate, removed papers hot pics	Definition analysis: Words Frequency with a Python library spaCy.	-
Our study	"metavers*"	Scopus, Web of Science	3183 Selection criteria: Limit to English contributions	Performance analysis: Annual production, country scientific production, research subject areas, document type and most relevant sources, productive authors and historical citation network, most relevant keywords provided by the authors and their timeline. Science mapping: Main thematic areas addressed by the research on metaverse, and their evolution overtime	Qualitative analysis of the results: The conjectured strategic technology management path of the metaverse

3 Data and Methods

In this section we describe the review protocol and the research methods for data collection and analysis, in order to enhance the transparency, the rigor, and the replicability of the study.

3.1 Research Setting, Sample, and Data

The first step of the methodology is the definition of the search scheme to build a query fully representative of the topic under examination. The review protocol was established according to PRISMA flowchart (Behl et al., 2023; Page et al., 2021) illustrated in Figure 1. We chose to adopt a large query ("metavers*") with the desire to assure a broad selection process and avoid missing important studies. The search was performed on April 2024, extracting the corpus of contributions available until December 2023, using Scopus and WOS Core Collection databases (Šebalj et al., 2019). These two repositories collect various types of contributions in terms of sources (e.g., articles, reviews, conference proceedings, book chapters), in different exportable bibliographic format also favoring the export of selected references. These features ensure the scientific rigor, making all contents valuable

for bibliometric analysis (Ardito et al., 2019; Fabrizio et al., 2022; Mustak et al., 2021). Downline the launch of the identified query on Scopus (Title, Abstract and Keywords fields) and WOS (All fields, without any temporal restriction), an amount of 7,288 contributions were retrieved until December 2023. Only the contributions in English were considered eligible since more comprehensible and internationally recognized (Leemann & Kanbach, 2022), leading to a processed sample of 5,303 contributions. However, only the articles, reviews and conferences proceedings were selected in order to elevate the bibliometric analysis, thus deleting grey literature (Kraus et al., 2020). Relying on a semi-automated procedure of dataset filtering, performed through RStudio procedure (www.rstudio.com), 2,120 duplicates were eliminated. The final sample consists of 3,183 documents.

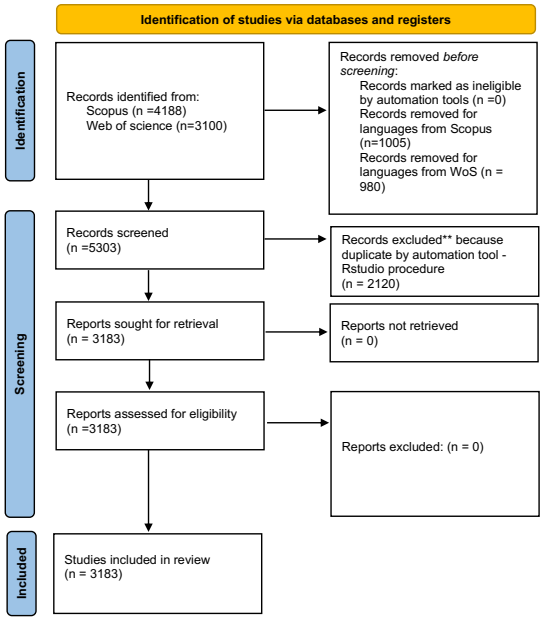


Figure 1. Prisma guideline flowchart for data collection

3.2 Data Analysis Procedure

We chose bibliometric analysis to analyze the retrieved knowledge base since it represents a strategic methodology for providing, in a systematic manner, meaningful insights over the research works published (Della Corte et al., 2018; Zhou & Song, 2021). According to Noyons *et al.*, (1999), bibliometric analysis combines two procedures: performance and mapping. The first one leverages on different kinds of bibliographic data and is able to perform several analyses, e.g., word frequency, citation, and country publications analyses (Thelwall, 2008; Veloutsou & Ruiz Mafe, 2020). The second one utilizes the recurrent words in a document to create a network of co-occurred keywords clustered in a non-overlapping way.

Performance analysis was applied to discover the features of the metaverse research field*:* the annual production, the country scientific production, the research subject areas, the most productive authors, cloud authors keywords. The choice of describing the research field according to these variables depends on the typology of data that was possible to extract from the selected databases. We applied statistical frequency analysis using Bibliometrix and a statistics software.

Science mapping was applied to discover the main research areas of the metaverse research field and their evolution overtime. To this scope we used VOSviewer software, which performs very well in the construction and visualization of the co-occurrence networks of the most important terms extracted from the metadata (da Silva Serapião Leal et al., 2019). The minimum term frequency was set equal to 10, following the full-counting method. To ensure the content validity and avoid duplicates, a quality-control procedure was conducted (Swanborn, 1996). Results of the bibliometric analysis were discussed in a focus group (Morgan, 1996), consisting of five experts who came from different training and work domains (two from digital technology innovation, one from marketing, one from computer science, and one from data science), with the aim to collectively recognize the thematic areas covered in the emerging clusters of terms and investigate experts' and practitioners' positions regarding the business opportunities from the technological development process. Therefore, during the focus group, we asked participants to read the science mapping findings according a double lens: i) the Rogers' diffusion of innovation (Rogers, 1995) to map the discovered application field in the Innovators and Early Adopters categories and hypothesize the future Early Majority, Late Majority and Laggards and, ii) the phases of the technology development process (Rogers et al., 2001) to map the current emerging metaverse-related technologies and conjecture on the developments in advanced and mature phases.

4 The main characteristics of the metaverse research field

Figure 2-a shows the trend of publications on metaverse from 1995 to 2023. We identified the first study on metaverse (i.e., Parr and Rohaly, 1995), which described the first avatar realization. The publication trend remains contained until the 2005, contributing for only the 4% to the total production. However, the peak in metaverse production is observed in 2023, with a jump from about 15 annual publications to 2,105 in the last year alone, with an increment of about +1,393%, which demonstrates the overwhelming interest in metaverse-related issues. Figure 2-b shows the countries with highest publications on metaverse. Our results confirm the strategic role in metaverse research of Asiatic countries (e.g., South Korea, Japan, China) confirming the results of Schmitt (2022), and enlarge this role to US and Europe, in light of the emerging involvement of Germany, Italy, and Spain. More generally, most academic contributions come from developed countries. Figure 2-c shows the ranking of the most

productive authors. Furthermore, the top five institutions (based on previous analysis, production of the authors affiliated to each institution) are: Sejong University (South Korea), Nanchang University (China), National University Singapore (Singapore), Sabanci University (Turkey), and University of Bologna (Italy).

Figure 2-d shows the top five subject areas of the documents in the sample: Computer Science (72%) exhibits the first position and, whereas Business (8%) exhibits the sixth one, confirming the results of Schmitt (2022), albeit with slightly different percentages.

In Figure 2-e the words cloud is observed. The term "metaverse" appears for a total of 1,818 occurrences while in the plural form "metaverse" with a total of 33 occurrences. The term "virtual reality" appears with 487 occurrences and can be considered as a possible evolution of "virtual worlds", with a total of 78 occurrences. Also, "augmented reality" was relevant keyword with 222 occurrences.

Overall, by means of the performance analysis, we were able to unravel the main characteristics of the metaverse research field, thus answering our first research question. Metaverse research shows the presence of a wide, young, widespread, international, and of high quality body of knowledge, thus confirming the results of Abbate et al. (2022). The astonishing growth in the last two years also documents the interest in this approach, which will likely soon turn into an increasing use of metaverse-based strategies by firms.

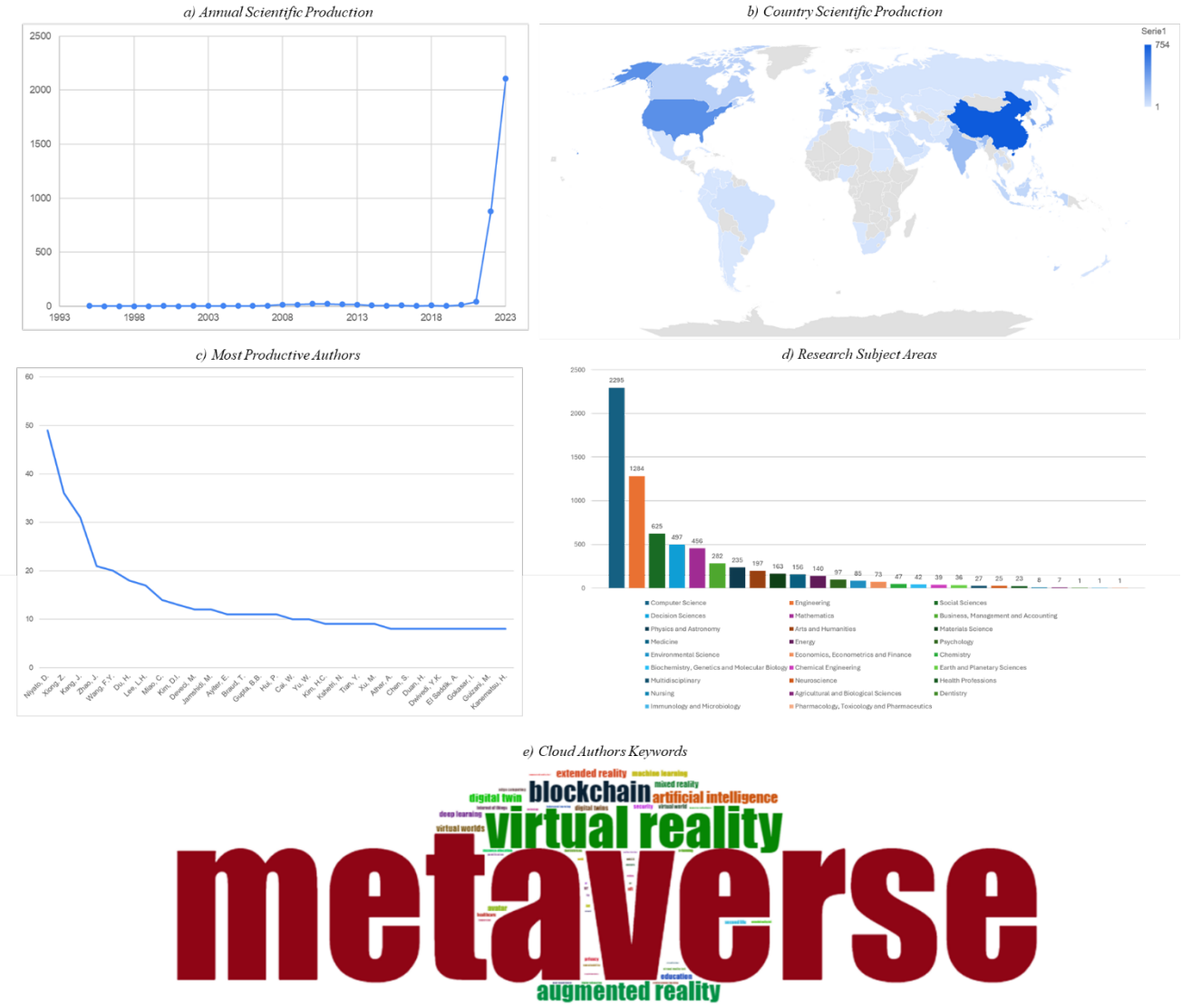


Figure 2. Infographic about bibliometric, performance analysis

5 Areas of metaverse research and their evolution over time

According to the settings described in the "Data and Methods" section, only 1,737 out of the 54,736 recurring terms retrieved from "title" and "abstract" fields meet (or exceed) the threshold set for the occurrences of terms (i.e., 10). After a qualitative screening of the terms by the research team no duplicates were found. Therefore, all 1,737 terms were considered for the clustering process.

Figure 3-a shows the co-word (keyword co-occurrence) network highlighting ten clusters of terms (indicated by the colors: red, green, blue, yellow, purple, and azure, respectively). The term "metaverse" (terms_freq=7,573) is

the largest node in the network of co-occurrences, followed by: “technology” (terms_freq=1,832), “study” (terms_freq=1,876), “paper” (terms_freq=1,636), “system” (terms_freq=1,432), “user” (terms_freq=1,399), “model” (terms_freq=1,318), “application” (terms_freq=1,202), “research” (terms_freq=1,196), “data” (terms_freq=1,130), “experience” (terms_freq=951), “education” (terms freq=804), “environment” (terms_freq=768), “student” (terms_freq=702), “virtual reality” (terms freq=676), “virtual world” (terms_freq=657), “article” (terms freq=623), “service” (term freq=592), and “problem” (terms_freq=547). Leveraging on the expertise of the focus group involved in the research, the terms characterizing each cluster were analyzed and clear distinctive themes emerged from the discussion, as explained below.

Cluster 1 (red) consists of 429 items, resulting the largest in the network. The main node of this cluster is the term “study” followed by “education” “student”, “activity”, “learning”. Therefore, the studies belonging to *Cluster 1* focus on the adoption of metaverse technology in the training context as a learning tool based on virtual environment It is observed that in this stream students often use a personal avatar during the training activities. Moreover, in this context, virtual word and second life with educational purposes aim at developing knowledge through social interaction that can take place in a virtual reality environment. Teaching art, culture, and languages in spaces where students are identified by avatars reveals the opportunity of observing behaviors in virtual spaces and the effectiveness of teaching/training methods. Indeed, the presence of the “effectiveness” term denotes studies focusing on the assessment of the effectiveness of teaching/training methods based on the metaverse. Finally, it is interesting to highlight the presence of “survey” and “review” terms, suggesting that these are currently two of the most popular research approaches utilized in the study of metaverse.

Cluster 2 (green) consists of 425 items. The term “metaverse” is the main node of this cluster, followed by “paper”, “platform”, “problem”, “user”, “virtual world”, “space” and “blockchain technology”. The studies characterizing *Cluster 2* emphasizes the role of technology in the metaverse, focusing on virtual reality applications, systems, platforms, capable of involving users and solving problems and challenges. Moreover, “trend” and “risk” were evaluated in these studies. It is interesting to note the presence of “blockchain” technology and “NFTs” terms proposed, respectively, as tools for data security management and tokens to identify specific digital elements in the metaverse. While the “metaverse” term falls into this cluster, we note that this node has naturally many connections also to all other clusters (as can be seen from Figure 3-b).

Cluster 3 (blue) consists of 387 items. The term “model” is main node of this cluster followed by “data”, “service”, “application”, “framework”, “communication”, “approach” and “artificial intelligence”, “digital twin”, “scheme”. *Cluster 3* highlights the essential role of data-driven models and framework for supporting not only the

development sophisticated virtual environments but also communication schemes and network. Interestingly, "artificial intelligence" and "digital twin" are the technologies that emerged prominently within this cluster.

Cluster 4 (yellow) consists of 295 items. The main node of this cluster is "user" associated with the terms "environment", "virtual reality", "avatar", "interaction", "information", and "time". Starting from this evidence, this cluster emphasizes the "user experience" viewpoint, focusing on the dynamics in the interactions among users (virtualized thanks to avatar) and with the environment, may be evaluated in terms of time.

Cluster 5 (purple) consists of only 117 items. The term "technology" is the main node of this cluster, associated with the terms "research", "data", "tool", "article", "literature", "finding", and "algorithm". Starting from this evidence, this cluster systematizes the research in the management of metaverse data focusing on "data", "data visualization tools", and "algorithm". It is also interesting to underline the presence of "engagement" and "consumer" terms, which emphasize the ultimate goal of the metaverse strategy at least from a marketing perspective: *consumer engagement*. Moreover, the presence of different terms representative of literature review methodologies, such as "bibliometric mapping", "eligibility criterium", "prisma", "quantitative literature review", are also considerably documented.

Cluster 6 (azure) consists of 56 items, with "field" as main node. The main node is associated to "evaluation" "improvement", "indicator" terms, all of which deal with the measurement and assessment of the some performance in specific field. Investigating toward the cluster terms, it is interesting to note that *Cluster 6* is the only one focused on environmental sustainability performance measurement and evaluation through quantitative analysis in hospitality and construction sectors. Specifically, this cluster highlights the possibility to conceive new idea and path for collecting and analyzing quantitative evidences (such as carbon emission) in virtual landscape, supporting the sustainability development of industries.

Cluster 7 (orange) consists of 13 items, with "integration" as main node. Although the cluster is not nourished by a big mole of terms, the encompassed ones are more significance. The association to "integration" of "chatbot", "gpt", "user interaction", "means", "language", terms give to the cluster the thematic focus on the integration of emergent tools, as chatbot one (i.e. chatgpt), in metaverse experience, for natural language processing practices able to assisting user interaction during the surfing in the virtual environment.

Cluster 8 (orange) consists of 9 items. The main term is "inclusion", followed by "diversity". As it was for *Cluster 7,* also this cluster reveals a clear connotation: the experimentation of technological advance, like metaverse one, for supporting social sustainability initiatives such as those related to inclusion and diversity. It is interesting to

note that *Cluster 8* complements the sustainability vision of *Cluster 6* about the dimensions of sustainability (*Cluster 6* environmental one, *Cluster 8* social one).

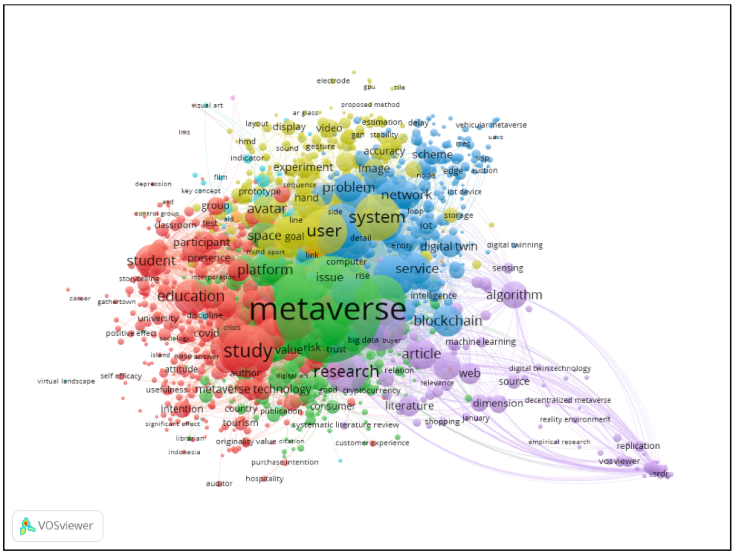
Cluster 9 (pink) consists of only 3 items, identifying in "contrast" the main node. Among the three terms, "contrast" is the only strictly linked to "metaverse" node, the other two, "mobile internet" and "lms" (acronym of learning management system) resulted more linked to *Cluster 1*.

Finally, *Cluster 10* (*fuchsia*) consists also of only 3 items, leaded by "interactive experience". The combination of "interactive experience", "human emotions" and "potential benefit" attribute to *Cluster 10* the analysis perspective about the emotional response of an interactive experience, also in terms of perceived benefit for human.

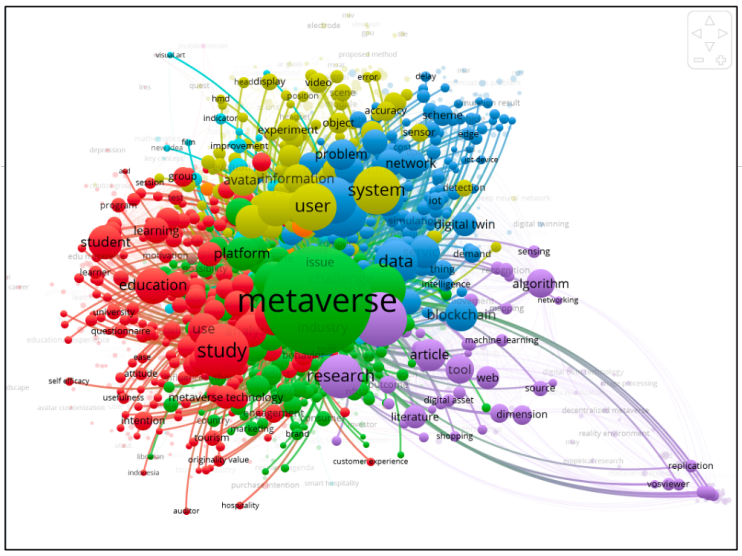
Figure 3-c shows the evolution of the terms overtime. The overlay visualization map reveals that some terms are more recent than others. For instance, the presence of three macro-groups of terms is evident, going from the oldest in dark blue (from the half of 2021 to the beginning of 2022) such as "virtual word", "second life" and "avatar", passing through the intermediate ones in light green (from 2022 to 2022.5) as "metaverse", "technology", and "education", up to the most recent ones in yellow (from 2022.5 to the end of 2023) such as "risk", "blockchain", "NFTs", "data visualization tool", "algorithms", "artificial intelligence", "digital twin", "chatbot", "gpt" and "metaverse technologies".

The above discussion helps us unveilling the main thematic areas addressed by the metaverse research field. Indeed, the map in Figure 3-c confirms the youth of the metaverse research, since the variability of terms maturity is significant in a short temporal range (from 2021.5 to the end of 2023). Leveraging on this timespan classification, since only a small group of terms belong to the oldest dark blue cluster (from the half of 2021 to the beginning of 2022). This result is in line with Schmitt (2022). On the other hand, the terms related to technology are placed in the most recent time frame (from 2022.5 to the end of 2023), suggesting the key role that technology, and the integration of it, is currently playing in this context. Moreover, by analyzing the overlay visualization map, we note that the concepts of "virtual world", "second life" and "avatar" appears in the literature before 2021, proving more mature than the metaverse concept, which has instead been mostly recognized by academics and scholars during the 2022. In particular, this suggests that the metaverse can inherit the experience, best practices and use cases gained overtime in the virtual reality and second life environments, evolving them in a well-defined manner.

a) Co-words (keywords co-occurrence) network



b) Metaverse links



c) Overlay visualization map

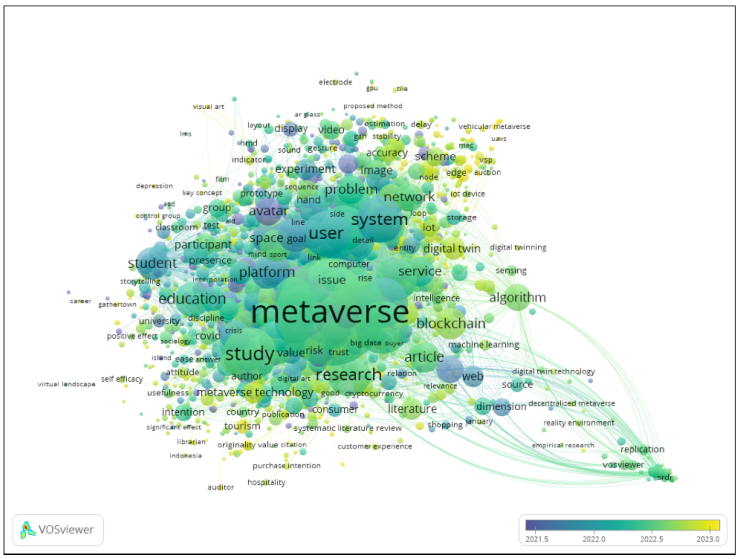


Figure 3. Infographic about bibliometric, mapping

6 Business opportunities from the technological development process of metaverse

By leveraging on the focus group discussion, we elaborated the findings obtained from science mapping to discover metaverse application fields, sustainability purposes and technologies. This activity was preliminary to the discussion on the development process of metaverse technologies and on the business metaverse-based opportunities.

6.1 Emerging application fields

Most of Cluster 1 (red) is built around the "virtual environment" node, exhibits a large number of linkages with the metaverse node, and focuses on the adoption of metaverse in the training context as a learning tool based on virtual world and simulation. Therefore, training can be considered one of the most mature application fields of metaverse. This application field has taken advantage of the development of knowledge related to the use of avatars and second life to foster training activities and social integration. Metaverse-based learning technologies have been shown particularly beneficial in increasing the effectiveness of learning for students and artists, and thus could be used to replicate these benefits in other fields. Interestingly, the presence of new application fields emerges from clusters 2 (green), 3 (blue), 5 (purple) and 6 (azure): tourism, fashion, digital marketing, construction gaming and healthcare (which are linked to industry categorization), digital marketing and consumer engagement (which are linked to business strategies at different organizational levels). This result partially confirms the application fields identified by Abbate et al. (2022). Indeed, in addition to education and game application fields, our study reveals new fields of application, such as tourism, fashion, healthcare, digital marketing and consumer engagement. The marketing field, though not categorizable among industries, is represented by digital marketing, namely the marketing branch linked to the usage of digital technologies for advertising and sales strategies (R. Y. Kim, 2020). Moreover, in representation also of marketing domain, we found consumer engagement, which is a specific business strategy applicable in other industrial landscapes (Dessart et al., 2016). The presence of "digital" element near the "marketing" domain, highlighted by our results, are consistent with the position of Giang Barrera & Shah, (2023), who chose to focus on this new application field.

6.2 Metaverse sustainability purposes

Thanks to the studies involved in *Cluster 6* and *Cluster 8*, for the first time comparing with the extant four literature reviews, metaverse arose as helpful in achieving sustainability purposes. Specifically, the environmental dimension of sustainability is the main focus of the studies encompassed in *Cluster 6*, within which metaverse technology is used for the environmental sustainability performance measurement and evaluation, for example through quantitative analysis in virtual landscape (such as carbon emission). Complementarily, ethics and

inclusions are the principles on which the studies encompassed in *Cluster 8* are based, highlighting the key role of the "self-virtualization" in the breaking down of social barriers. Economic sustainability dimension in metaverse implementation seems to be not explored yet. However, metaverse could lead to several economic sustainability opportunities, enabling the creation of job opportunities and new business models, promoting economic inclusion by allowing people to work and conduct business from anywhere, as well as enabling small businesses and startups to reach global audiences through virtual marketplaces (Boutenko et al., 2022).

6.3 Metaverse technologies

The technological nature of metaverse emerges from *Cluster 2* (green), where the extant research discusses applications, systems, platforms, and methods to involve users in a virtual environment to take actions, face challenges, or solve problems. Our study also confirms the role of NFTs in the metaverse, which have been already adopted in several business settings, as well as identifies blockchain, data visualization tools, artificial intelligence, and augmented reality, as frontier technologies. Indeed, these technologies appear among the most recent ones in the network of terms (2022-2023), and will probably require more investigation and testing in the future. This finding complements the knowledge base of metaverse technologies envisaged by Schmitt (2022) and Giang Barrera & Shah, (2023) confirming blockchain, artificial intelligence, and extended reality as technological pillars for the metaverse evolution. It was surprising to find "digital twin" technology, which is clearly and strictly related to the metaverse technologies as stated by Jagatheesaperumal et al. (2023), in a separate cluster. Thanks to the evidences of *Cluster 3,* our results highlighted that digital twin and artificial intelligence can jointly operate for building of models or frameworks able to develop virtual experience driven by data, as in depth analyzed by Aloqaily et al. (2023). The technological nature of metaverse also emerges from *Cluster 4* (yellow), where studies focusing on the user experience highlighted the role of avatar and virtual reality in facilitating the interaction among users. Moreover, *Cluster 7* allows to understand the possibility to integrate different technologies for virtual environment, such as the ones assigned to the natural language processing among users or users and machine (i.e., chatbots). This technological aspect of the metaverse is on the frontier of investigation, no reviews before allowed to highlight it. Finally, consistent with Schmitt (2022), our study pointed out the presence of many, yet to be solved, challenges related to ethics, regulation, governance, security, and privacy.

6.4 Technological development process of the metaverse

Leveraging on the above considerations, Figure 4 summarizes the contribution of our study regarding the development process of metaverse technologies. As explained earlier, we analyze this path from two viewpoints: i) the Rogers' model of diffusion of innovation (Kwangsawad & Jattamart, 2022; Rogers, 1995), ii) the phases of

the technology development process (Rogers et al., 2001). Accordingly, we provide the discussion of the business opportunities coming from the technological development process of metaverse.

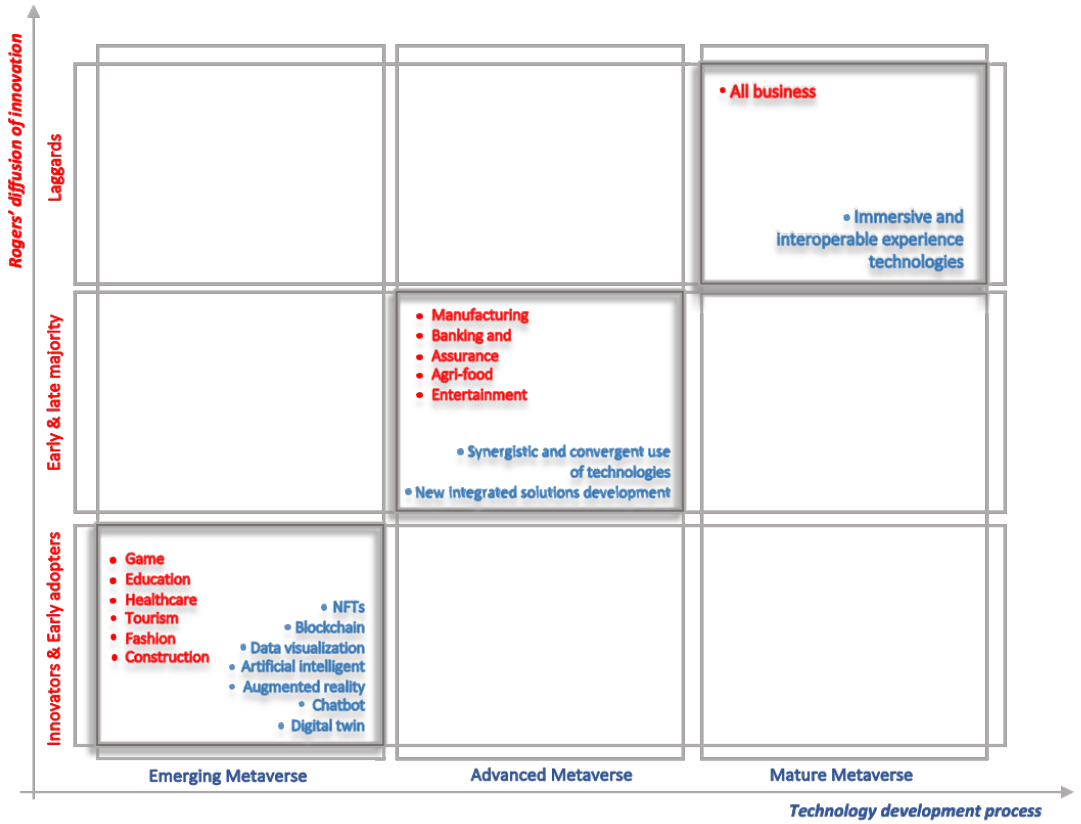


Figure 4 The conjectured strategic technology management path of metaverse

By looking at Figure 4, our study suggests that metaverse is currently in the emerging phase of the development process and, as such, attracts only *Innovators* and *Early Adopters* from few fields (e.g., game, education, healthcare, tourism, fashion, construction), who experiment with the current technologies available on the market (e.g., NFTs, blockchain, data visualization tools, chatbot, digital twin). These companies benefit from several opportunities that the adoption of the metaverse technologies offer, such as the increasing efficacy in learning and training activities not only for students but also for employees and professionals. Moreover, the game industry adopts these technologies to realize more immersive and evocative game environments, which enhance the users experience and interaction and therefore drastically raise the odds of market success of their products.

However, at the same time, the infancy stage of the metaverse highlights the need to adopt strategies capable of fostering and enabling the metaverse development process toward the advanced and mature phases, through which boosting the percentage of metaverse adopters (see the intermediate levels in Figure 4). To this purpose, managers and technology developers could reflect on the opportunity to adopt a combinative approach in technology development focusing on synergistic and convergent use of the current technologies and the development of new

integrated solutions for the metaverse. This combinative approach in technological development is expected to lead to an increase in the number of adopters also in other industries, primarily manufacturing, banking and assurance, agri-food, entertainment, given that these industries have a high socio-economic impact and, more importantly, have innovated toward more digital services in the last years, especially since the pandemic. Therefore, it is necessary to implement strategies of technology transfer toward new applicative fields and clearly communicate the relative benefits to companies. For example, manufacturing industry could benefit from the training function of metaverse applications, by reducing the cost of specialized maintenance personnel training as well as the operational risks associated with complex physical products (e.g., aircrafts). However, benefits are not exclusively related to learning and training, but also embrace the marketing field, for example the digital one, where, by nature, metaverse can have the biggest impact. Therefore, the development of metaverse applications according to marketing and consumer engagement lenses can create key business opportunities for industries addressing their product to mass consumption markets (e.g., agri-food, bank and assurance, entertainment). Finally, as the top-right part of Figure 4 suggests, in an estimated timespan of ten years, it is reasonable to expect that metaverse will reach a high level of maturity, where it will offer virtual, immersive, and interoperable experience to a wide range of businesses.

6.5 Metaverse-based business opportunities

From the above considerations we propose a list of business opportunities for companies intending to adopt metaverse technologies:

- Metaverse offers a new way to promote products and services giving to consumers and companies the opportunities to overcome physical barriers. Leveraging on experiential metaverse technologies (e.g., Decentraland, Sommium Space) and organizing virtual experiences (e.g., fairs, fashion shows, concerts, art exhibitions), companies can directly involve consumers worldwide opening up the way to a new communication form where entertainment and business merge.
- Metaverse offers a new way to establish marketing strategies based on gamification. Leveraging on gaming metaverse technologies (e.g., Sandbox, Roblox, Fortnite), a company can improve the ability to attract new consumers and retain them overtime, for example adopting revenue models able to stimulate selling and consumers' interaction (e.g., badge, discount). Therefore, metaverse technologies represent a way to improve and/or better characterize the business models of companies opening up the way toward new channels and customer relationship mechanisms.

- Metaverse offers a new way to break down social barriers giving to disadvantaged classes (e.g., disabled, poor) the opportunities to access otherwise prohibitive experiences. For example, disabled people can access a paragliding service living a unique and unrepeatable experience in reality.
- Metaverse offers companies the opportunity to easily reach niche markets reducing the costs typically incurred when a company moves its offer from a broad to a specific market.
- Metaverse offers a new way to build pilot environment for testing new products and services, observing and assessing consumers' behavior, but also monitoring the efficacy of the product (or service) during its usage phase. This virtual environment allows to the company to realize an early testing phase reducing the product/service development and production costs.
- Metaverse offers a new way to build education and training environment where consumers, employees or more generally people can be involved for several purposes. According to design thinking principles, consumers can be involved in product/service co-creation and development experiences, with increased probability of product/service success in the market. Employees can be involved in training paths on complex products (e.g., aircraft) decreasing the training cost and increasing the employees' safety. People can be involved in virtual experiences to increase the social awareness regarding relevant issues (e.g., health, wellness, environmental safety). This virtual environment helps people to reduce anxiety and stress levels during training activities, thus increasing the learning performance.

7 Managerial and policy implications

This study offers important implications for researchers as, to the best of our knowledge, it is the first study providing a bibliometric literature review on metaverse, which uses performance analysis and science mapping synergistically (as shown in table 1). Therefore, this study represents an overall, updated, and integrated picture of the metaverse research, as well as enriches the extant literature with a reflection on the technological development process of the metaverse, the business opportunities each lifecycle phase can offer and the sustainability purposes achievement for which metaverse may be useful.

Our literature review maps the current body of knowledge on the topic from a multidisciplinary perspective covering a timespan of more than 25 years (1995-2023), thus expanding the time horizon of previous works. In particular, our study has leveraged on the adoption of validated tools, such as Bibliometrix and VOSViewer, to provide the literature with an example of their synergistic application. The first tool allows to maximize the flexibility of the procedure and the rapid integration with other R-based statistical packages (Aria & Cuccurullo,

2017; Campra et al., 2020). The second tool is capable of handling, elaborating and graphing large datasets to create more comprehensible maps of very large scientific domains (da Silva Serapião Leal et al., 2019).

Moreover, the position of the retrieved topics on the timeline facilitates the identification of the research streams that are younger and those that are more mature, with the aim to guide the future researchers' effort. The analysis of the research methodologies more commonly adopted in metaverse studies offers interesting points of reflection about the opportunity to enlarge the research field through the adoption of other methods. For example, future research could conduct case studies on metaverse adoption to identify the inherent benefits and costs that such adoption could bring to companies, thus shedding light on the market potential of metaverse. Finally, the comparison with the previous four literature reviews on metaverse paves the way for building the nomological construct validity in the analyzed field (Straub & Gefen, 2004).

This study also offers several practical implications for companies (both developers and users of technology) and policy makers, interested in metaverse applications. The analysis of the current body of knowledge suggests a diffuse perception of overlap between the concepts of metaverse, virtual reality, virtual environment and second life. This could limit the awareness of companies about the opportunity to fully exploit the benefits deriving from the adoption of metaverse-based strategies. Our systematization can instead increase the level of firms' confidence in the use of metaverse. Moreover, as identified in this paper, the technologies and approaches used in the metaverse can support companies involved in the implementation of metaverse-based strategies. Metaverse can also favor sustainability development, since it is able, among the others things, to i) contribute in carbon footprint reduction, transitioning to virtual meetings, conferences, and events (Cao et al., 2023); ii) stimulate virtual shopping, reducing the need for physical samples and minimizing product returns by allowing consumers to try products virtually (Shen et al., 2021); iii) support eco-education, providing immersive educational experiences about sustainability, encouraging eco-friendly behaviors and informed consumer choices (Claros-Perdomo et al., 2022); iv) allow virtual tourism, offering virtual experiences of natural sites; v) perform environmental monitoring, enhancing monitoring and management of natural resources and wildlife habitats through virtual simulations (Monaco & Sacchi, 2023); vi) ensure inclusivity and accessibility, providing access to services and experiences regardless of location, reducing geographic disparities, creating accessible virtual environments that accommodate various disabilities (Othman et al., 2024).

For practitioners interested in the metaverse development, this study is also food for thought with regard to both the current level of metaverse technological development, its potential application in new fields and the possibility to achieve sustainability goals through it. Therefore, working together with researchers (e.g., adopting concurrent

engineering approach), practitioners can focus the efforts to extend the metaverse paradigm to other potential application fields, thus contributing to evolve the maturity level of the technology, according to the conjectured strategic technology paths of the metaverse.

8 Conclusion

The metaverse is a frontline topic, as shown by the astonishing +1,393% increase in the production only in the last two years. Academics and businesses are investing time and money to enhance knowledge on the metaverse and propose innovative applications for the market. By leveraging on a systematic literature review and bibliometric analysis, our study complements and updates the body of research on the metaverse. Through bibliometric analysis, first the characteristics of the metaverse research field were defined. Then, thanks to mapping analysis, the main thematic areas addressed by the metaverse research field and their evolution over time emerged. Finally, through a verticalization of these results, it was possible to trace the business opportunities arising from the technological development of the metaverse. Specifically, we provide an integrated picture of metaverse and propose a discussion on the business opportunities achievable through the technological development process of metaverse.

Although the research methodology and the review protocols have been well-defined in our study, there are some limitations, which however offer opportunities for future research. The first one comes from the choice of the scientific databases: the integration of other databases (such as ProQuest or Google Scholar) could lead to differences in the data sample definition. The second one comes from the filtering process: an additional qualitative evaluation of the dataset could validate the semi-automated procedure of dataset screening. The third one comes from the methods chosen for the data analysis: performing a qualitative review on the selected sample through, for example, content analysis could allow mapping aims and insights of each contribution. The fourth one comes from the interpretation of the software output: perhaps a different team with a different background could interpret differently the output of the analysis, leaving room to possible qualitative bias (such as confirmation bias). By leveraging on the results of our study, researchers or practitioners could also: i) orient the research on metaverse towards the applications in emergent fields (i.e., marketing, customer engagement, and advertising); ii) perform an in-depth analysis mixing qualitative and quantitative methods for data analysis, in order to compare and/or validate results; iii) conduct empirical analyses, such as case studies or action research, in order to expand the type of knowledge existing in the literature; iv) replicate the as-is research in the future, and perform longitudinal analyses, in order to disentangle any differences about the performance of the production on metaverse topics and the evolution of the thematic map.

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