



Metaverse adoption in public sector: a bibliometric analysis

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Abstract

The objective of this study is to map the landscape and knowledge structure of the public sector metaverse through bibliometric analysis. Following this, a descriptive overview of the current state of public sector research related to the metaverse, including the leading ten authors and sources, most relevant keywords, and primary research topics, will be presented. The selection of the Scopus database was based on its status as the largest repository of its kind and its provision of an extensive compilation of abstracts and citations for peer-reviewed articles, proceedings, and journals. The initial search yielded 369 documents from Scopus; after eliminating duplicate and irrelevant articles, 354 documents remained. The results demonstrate the substantial development of the metaverse in the public sector, with an annual growth rate of 14.89%. This indicates that the adoption of virtual technology and the metaverse is gaining importance in the public sector. Castronova ranks first in terms of the quantity of studies published, with five articles, followed by De Kool and Zhang. "Metaverse," "virtual reality," and "virtual world" are the most pertinent keywords. Due to the extensive research that has been conducted on these phrases, they represent fundamental concepts in the field. Additional frequently occurring terms include "social networking (online)," "interactive computer graphics," "government data processing," and "internet." These terms underscore the significance of governance, human factors, technology, and data in shaping the trajectory of digital government services. They also exemplify the interdisciplinary character of metaverse applications within the public sector.

1. Introduction

Since the introduction of Horizon Worlds by Meta Platforms in 2021, the metaverse has transitioned from a speculative concept in science fiction into a significant and tangible element of modern society. This transformation has caught the attention of both academic and practical circles. The public sector, in particular, emerges as a promising area for metaverse applications. Governments, policymakers, and public institutions are keen to explore how metaverse technologies can fundamentally transform governance, public services, and citizen engagement. As these technologies progress, they open new avenues for interactive, immersive, and interconnected digital realms, significantly impacting various disciplines including computer science, public administration, digital ethics, and policy studies [1][2][3]. Despite the growing intrigue and potential impact of the metaverse in the public sector, there is a notable scarcity of systematic bibliometric studies that map out the scholarly landscape of this domain. This gap impedes the ability of stakeholders to fully understand and leverage the metaverse's capabilities for enhancing public sector operations. The absence of a comprehensive academic review or analysis means that the policy formulations and strategic decisions in integrating metaverse technologies are often not supported by a thorough understanding of the existing research, trends, and key contributions in this field. This research aims to fill the existing gap by conducting a comprehensive bibliometric analysis of metaverse adoption in the public sector. The study will systematically review and analyze scholarly works to map out growth trends, identify key contributors, and highlight seminal works and thematic domains that have emerged in this space. Through this analysis, the study seeks to offer valuable insights into the current state of research and emerging trends in metaverse-related public sector research. This will provide a robust foundation for scholars, practitioners, and policymakers to base their strategies and policies, contributing to the broader discourse on digital governance and its implications for society [4][5].

The research questions (RQ) that will be answered in this investigation are as follows:

RQ1 : What is the current state of Metaverse-related public sector research?

RQ2 : Which authors are the most significant based on the number of publications?

RQ3 : What are the most pertinent keywords and sources according to published literature?

RQ4 : What are main research topics in the area of metaverse in public sector based on cluster analysis?

RQ5 : How has study on the metaverse changed over time in the public sector field?

The remainder of this bibliometric article is organized as follows. In the subsequent sections, we delve into the methodology employed for data collection and analysis, elucidating the criteria for selecting relevant literature and the techniques used for bibliometric evaluation. Following this, we present the empirical findings, which encompass an overview of the growth patterns in metaverse research, the identification of influential scholars and sources, and the delineation of prominent thematic clusters within the public sector context. In the discussion section, we synthesize these findings, reflecting on their implications and suggesting future research directions. Ultimately, this bibliometric exploration seeks to provide a comprehensive portrait of the metaverse's evolution within the public sector, illuminating its transformative potential and the scholarly discourse that surrounds it.

2. Research Method

The bibliometric method was used to compile the data for this analysis. According to [6], a bibliometric technique is a suitable strategy utilized in tracking and reporting the statistical understanding of a particular term or concept published in a specific domain. A researcher can examine and document a knowledge diffusion and metadata source using bibliometric analysis. Faithorne first used the term "bibliometrics" in December 1969 to explain the statistics of articles published in a particular field, including but not limited to: concepts, studies, trends, methods, keywords and citation sources [7]. Since bibliometric analysis provides science mapping on the related publication database, it is widely used in literature reviews to help researchers gain a deeper understanding of the area. By doing a bibliometric review, the researcher can better integrate their findings into the existing body of knowledge [8].

2.1 Database Selection

We retrieved all publications pertaining to metaverse in public sector from the Scopus database. This academic database is a vast collection of abstracts and citations for peer-reviewed materials, such as journal articles and conference proceedings [9]. It is considered one of the largest archives in its field. Scopus offers various operational features that facilitate the implementation of bibliometric analyses, making it a widely utilized tool by academics seeking top-notch analyses. Scopus, being a property of Elsevier, is comparatively more thorough than PubMed or Web of Science (WoS). Garrido-Cardenas contend that Scopus encompasses 84% of the titles found in WoS, but only 54% of the papers in Scopus are included in the WoS index [10]. Scopus surpasses Google Scholar in precision due to its enhanced management of referenced publications and controlled indexing [11]. Scopus encompasses a comprehensive collection of more than 14,000 papers across several disciplines, encompassing fields such as social sciences and mathematics. Scopus offers an extensive and inclusive summary of worldwide research output across various disciplines, including science, technology, medicine, social science, and the arts and humanities [12]. Consequently, the Scopus database was the sole viable choice for performing the study due to its accessibility and comprehensive coverage of peer-reviewed scholarly literature. The collected data encompassed the names of the authors, titles of the publications, journals, types of publishing, abstracts, affiliations of the authors, and article numbers. In order to conduct a more in-depth examination, the data was extracted and exported in CSV format.

2.2 Search Strategy

In accordance with [13], the article employed the specified search string in the title, abstract, and keywords sections to retrieve data from Scopus. The search phrase consisted of the terms "metaverse," "second life," and "virtual world," along with the terms "public sector" or "government." By utilizing this search string, we were able to acquire a limited quantity of articles for manual evaluation and minimize inaccurate positive outcomes caused by the absence of certain terms unrelated to the area of investigation. Only papers written in English were chosen because English has evolved into a globally prevalent and universally comprehensible international language. Furthermore, we have insufficient resources to facilitate translation into several languages, such as Spanish, Russian, and others.

The search was conducted on September 5, 2023, resulting in the discovery of 369 items. Subsequently, the titles and abstracts of the publications were assessed to determine their relevance. As a consequence, 15 publications were excluded due to their lack of relevance to the research topic and not written in English. Consequently, a total of 354 articles were chosen for the ultimate examination.

Figure 1 depicts the precise steps involved in conducting the bibliometric analysis and the search technique employed in this study.

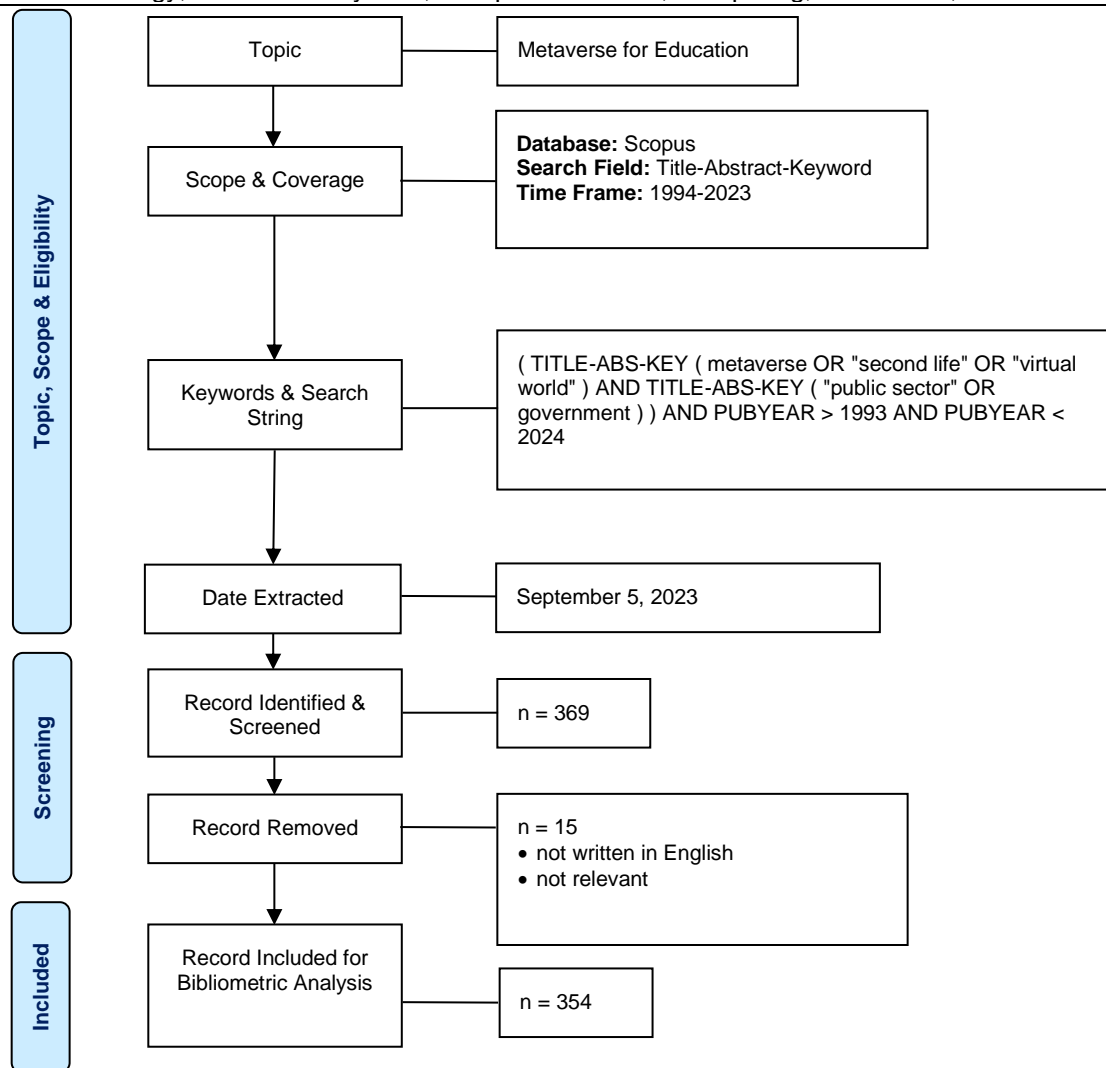


Figure 1. Flow Diagram of the Search Strategy [14]

2.3 Data Analysis

According to [15], there are two main approaches to conducting a thorough bibliometric analysis: performance analysis and science mapping. Science mapping examines the connections between different elements of research, while performance analysis evaluates the individual contributions of research elements within a certain topic. The key elements of research in this particular setting encompass authors, institutions, journals, countries, and affiliations. Publication serves as a substitute for measuring productivity, while citation quantifies the impact and influence of a work. Science mapping refers to the cognitive linkages and structural connections among different components of study. Citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis are methodologies employed in the field of science mapping. When used in conjunction with network analysis, these techniques play a crucial role in illustrating the bibliometric and conceptual framework of a research field. This study use co-occurrence analysis to identify the main research topic by examining thematic clusters and to forecast future research in the field. Co-occurrence analysis can also demonstrate the temporal progression of the field. The method is advantageous for pinpointing hotspots in several domains. The study employed bibliometric analysis with Vosviewer and Biblioshiny. VOSviewer, developed by Leiden University in the Netherlands, is a sophisticated software designed for organizing and displaying bibliometric networks [16]. Additionally, it has text mining capabilities that enable the creation and visualization of co-occurrence networks of important labels retrieved from a wide range of scientific articles. Biblioshiny was utilized due to its ability to allow users to do pertinent bibliometric and visual analysis on the performance of research constituents [17].

3. Results and Discussion

3.1 RQ1: What is the current state of Metaverse-related public sector research?

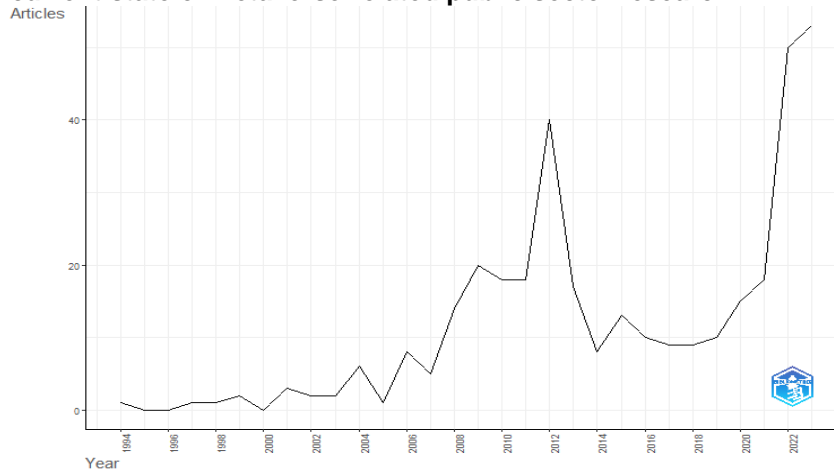


Figure 2. Publishing Tren in the area of Metaverse in Public Sector

Figure 2 displays the specific years when the relevant publications were retrieved. It also indicates the trend in the quantity of articles published over time.

Initial Years (1994): The first study that investigate the metaverse adoption in public sector began in 1994. The study addresses the network requirements for a federal government initiative called Distributed Interactive Simulation (DIS). They resulted a map of DIS network requirements for the capabilities inherent to these broadband technologies, and specified the access of those capabilities from DIS application through the broadband network and services [18].

However, since 1994 until 2007 the quantity of studies remained relatively low and showed a little fluctuation. But after 2007, there is significant growth of research with 40 documents published in 2012. This suggests that the interest and research in this area significantly accelerated around 2007-2013. In this period various existing studies provide insight into how these concepts are used in the public sector context. One interesting research focus is the use of Metaverse in public services, namely how metaverse can be used to improve public services or provide better access to citizens.

Furthermore, in the 2020-2023 period in the Covid-19 pandemic era, there was an exponential growth in the number of studies. This is because the use of metaverse and virtual technology is becoming increasingly important in helping the public sector adapt to changing situations [4]. Research in this period can provide valuable insight into the potential and limitations of metaverse use in the public sector. Total of annual growth rate of this research area is 14.89%.

3.2 RQ2: Which authors are the most significant based on the number of publications?

It is critical to identify the leading authors in the field of metaverse in public sector, and this may be done by comparing the number of documents created by each. By following this procedure, scientists will be led more efficiently in the right direction. The researchers used Biblioshiny to produce an exhaustive list of the 10 most influential authors in the subject. To accomplish the aforementioned goal, bibliographic data files were used to conduct a co-authorship analysis. Figure 2 displays the results of this investigation. The analysis found that several authors and sources have attained extremely high document rates, which indicate their substantial contributions to the subject. This finding highlights a rapidly expanding field of study.

There are currently 828 writers conducting research in the public sector relating to the metaverse. Over the past three decades, these authors have compiled 354 separate research studies. A breakdown of authors who have written extensively on this subject is shown in Figure 2. Given their prolific output, these authors must have made important contributions to the discipline. Castronova is the most prolific of these writers. Castronova has established himself as a leading figure in the public sector metaverse with five publications. After him, with 4 articles each, come De Kool and Zhang.

publication of materials in this field of study. With a total of 12 articles, "Lecture Notes in Computer Science" stands out as the most fruitful publication venue. After that, "First Monday" and "Americas Conference on Information Systems" tie with 6 articles each. With only four papers, "Sustainability" is the only publication to make a substantial contribution to the growing field of public sector metaverse. With so many articles published, "Lecture Notes in Computer Science" appears to have considerable sway in the public sphere's metaverse research community. Their articles have been influential because of their high quality and importance.

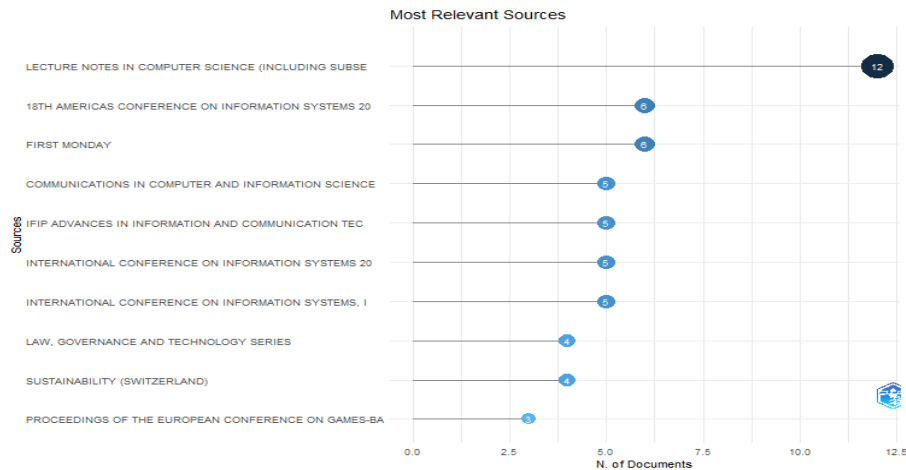


Figure 4. The Most Relevant Sources Based on Publications

To summarise, the information emphasises the function of various publications in distributing research on the metaverse within the public sector field. This analysis identifies the leading journals based on their number of publications and highlights the significant impact that specific journals have in this particular field of research. These publications have a vital role in influencing and progressing the discussion on the implementation of the metaverse in public sector.

3.4 RQ4: What are main research topics in the area of metaverse in public sector based on cluster analysis?

In this section, we conducted co-occurrence analysis with Vosviewer to map the main research topic based on cluster analysis. The methodology employed for the co-occurrence analysis was derived from the examination of author keywords. The threshold of three occurrences was set, which means the minimum number of occurrences of keywords that will be visualized is three. Out of the initial pool of 966 keywords, a total of 44 keywords were successfully acquired and selected for further analysis.

Figure 5 presents a visual representation of the co-occurrence of keywords in the analysis. Based on the analysis of the mapping data, it can be inferred that there exist six primary clusters that are relevant to the adoption of the metaverse in public sector. The subsequent paragraphs provide a comprehensive account of the six clusters observed in the analysis of keyword co-occurrence.

- Cluster 1 (red) consists of 9 items. This cluster is labelled with "Circular Economy and Second Life Business Models". The main keywords are second life, circular economy, electric vehicles, lithium-ion batteries and business model. This theme highlights the importance of sustainability and innovation in managing electric vehicle batteries, contributing to a more sustainable and environmentally friendly transportation sector while also exploring viable business opportunities [19].
- Cluster 2 (green) presents 8 items. It is labelled as "Immersive Technologies and Blockchain Integration for Enhanced Realities". Representative keywords include virtual reality, blockchain, augmented reality, mixed reality. This theme underscores the transformative potential of combining blockchain and immersive technologies to create more secure, transparent, and interconnected virtual, augmented, and mixed realities, opening up new opportunities for both technology developers and users [20].
- Cluster 3 (blue) comprises 8 items. The main keywords virtual world, covid-19, internet and cyberspace. This cluster is labelled as "Navigating the Pandemic: Exploring Virtual Worlds in Cyberspace during COVID-19". This theme reflects the dynamic intersection of virtual worlds, the internet, and cyberspace in the context of the COVID-19 pandemic, highlighting both the challenges and opportunities presented by the digital transformation of various aspects of life and society [21].

- Cluster 4 (yellow) is labelled as "Metaverse Impact: Education, Governance, and Privacy", consist of 7 items. The main keywords include metaverse, education, government and privacy. This theme emphasize the dynamic and multifaceted interactions between the metaverse, education, government, and privacy, emphasizing the need for thoughtful consideration, ethical frameworks, and innovative solutions to address the challenges and opportunities in this evolving digital landscape [22].
- Cluster 5 (purple) with 6 items is labelled as "Transforming E-Government with Web 2.0 and Cloud Computing ". The main keywords are e-government, web 2.0 and cloud computing. This theme focus on the dynamic intersection of e-government, web 2.0, cloud computing, and the metaverse, highlighting the potential for more interactive, citizen-centric, and efficient government services and engagement models [23].
- Cluster 6 (light blue) comprises 6 items. The main keywords are virtual worlds, artificial intelligence, intelligence user interface and interoperability. This cluster is labelled as "Creating Intelligent and Interoperable Virtual Worlds". This theme explores the evolving landscape of virtual worlds, where artificial intelligence and intelligent user interfaces play a pivotal role in enhancing user experiences and fostering interoperability across virtual environments [24].

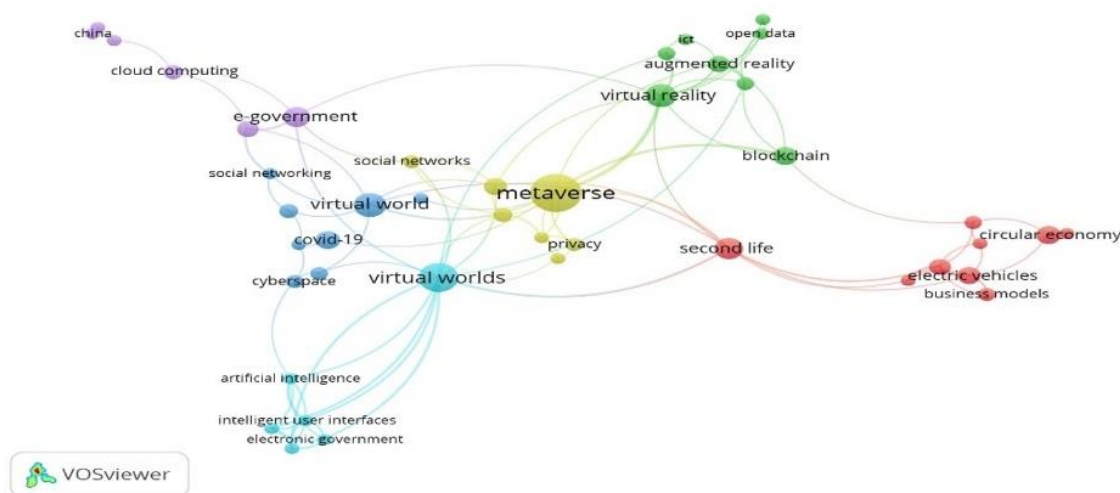


Figure 5. Author Keyword Co-Occurrence Network

3.5 RQ5: How has study on the metaverse changed over time in the public sector field?

The concept of the metaverse, as it is currently understood, has evolved significantly over the years. While the metaverse concept itself was not as well-defined or developed in the early 2010s as it is today, there were still developments in the public sector that can be associated with the early stages of virtual worlds and immersive technologies. Figure 6 illustrates the changes in research topics over different years. The colors represent specific time periods, with blue representing the years around 2010, yellow representing the years around 2020, and potentially other colors representing subsequent years. Each time period reflect the primary focus of research during that period. Here's a breakdown of research focus areas of metaverse in the public sector during these time periods:

From 2010 to 2012: During this period, research in the public sector may have focused on exploring virtual worlds and early immersive technologies, such as Second Life. Researchers might have investigated how government agencies and educational institutions could use virtual worlds for public engagement, training, and simulation [25];

From 2012 to 2014: This period could have seen an expansion of virtual world applications in the public sector. Researcher might have focused on specific case studies or pilot projects where government agencies or educational institutions used virtual worlds for public outreach, disaster preparedness, or collaborative workspaces [26];

From 2014 to 2016: During this period, virtual worlds and immersive technologies may have matured, laying the groundwork for early metaverse concepts. Researcher may have explored the integration of virtual worlds with emerging technologies like augmented reality (AR) and virtual reality (VR) [27];

From 2016 to 2018: This period, the concept of the metaverse might have gained more traction in this period, with research beginning to explore its implications for the public sector. Researchers may have examined the integration of blockchain technology for identity management and security in metaverse-like environments [28]; From 2018 to 2020: During this period, we could have seen early metaverse implementations in the public sector, such as virtual government meetings or metaverse-driven public services. Research may have assessed the scalability, cost-effectiveness, and impact of metaverse implementations in government [29]

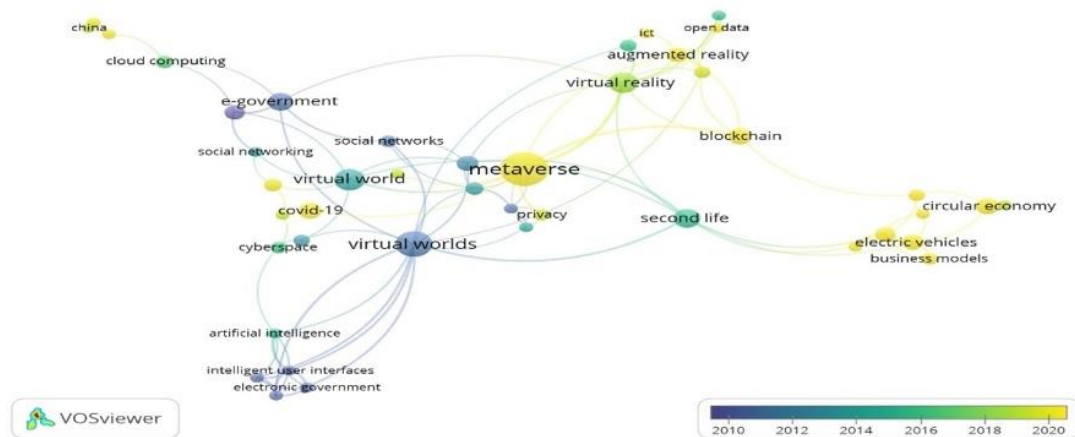


Figure 6. Author Keyword Overlay Network

The findings presented above can be the useful references for scholars and practitioners interested in investigating the use of the metaverse in the public sector through their trends. In conclusion, Figure 6 demonstrates the dynamic character of research in the metaverse in the public sector, as new themes and topics arise over time.

3.6 Current State of Metaverse-Related Public Sector Research

The bibliometric analysis reveals a marked growth in the volume of research on the metaverse in the public sector, particularly notable from 2007 onwards with a significant spike in publications around 2012 and another during the COVID-19 pandemic period of 2020-2023. This growth, quantified at an annual rate of 14.89%, signifies an increasing scholarly and practical interest in how virtual technologies can be adapted to enhance public administration and services.

3.7 Comparative Analysis of Author Contributions

The analysis identified several key authors contributing to the field, with Castronova leading with five publications. This figure compares favorably with other seminal contributors such as De Kool and Zhang, each with four publications, underscoring a concentrated yet growing interest among a core group of researchers. This pattern of contribution suggests a developing but still nascent academic community focused on this intersection of technology and public administration.

3.8 Integration and Novelty in Research

In comparing our approach to others, this study uniquely synthesizes across a broad array of journals and articles, utilizing tools like Vosviewer and Biblioshiny for comprehensive science mapping and co-occurrence analysis. Unlike prior reviews that may focus on narrower aspects of metaverse application, this study provides a macroscopic view of the field, identifying six primary clusters of research themes ranging from "Circular Economy and Second Life Business Models" to "Creating Intelligent and Interoperable Virtual Worlds."

3.9 Significance and Impact

The keywords "virtual reality," "virtual world," and "metaverse" recur with high frequency across studies, emphasizing their centrality to current and future research directions. These terms anchor the study's relevance, as they connect directly to contemporary issues in technology application in governance. The detailed keyword analysis and the identification of leading journals and articles within this niche area offer a roadmap for future research and implementation strategies.

3.10 Key Findings

1. The metaverse research within the public sector is expanding, as evidenced by a consistent increase in scholarly output and the diversification of topics over time.
2. The pivotal role of leading authors and their contributions helps shape the research agenda, providing a foundational corpus for new scholars entering the field.
3. Our bibliometric approach offers a novel integration of quantitative and qualitative analysis tools, enhancing the ability to trace thematic and conceptual developments over time.

4. Conclusion

The aim of this study is to create a bibliographic map of existing research on the evolution of the metaverse in the public sector. To the best of our knowledge, there have been no bibliometric studies on metaverse adoption in the public sector. Thus, this research intends to fill that gap by providing a comprehensive bibliometric analysis of metaverse adoption in public sector field. Scopus database was effectively used as primary sources of bibliometric data in this study. Biblioshiny and vosviewer were used to analyse the dataset on the use of the metaverse in the public sector. The investigation identified the most authored content, as well as the most frequently used keywords and sources. The examination also looked into the research timeline and the six main research concerns.

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