Bibliometric analysis: Adoption of big data analytics in financial auditing

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Abstract

Bibliometric analysis is a widely used technique for investigating and studying scientific information. There is no previous research that explains bibliometric analysis related to the adoption of big data analytics in auditing. Thus, this research will fill the gap in previous research to examine bibliometric analysis related to the adoption of big data analytics in auditing. This paper employs bibliometric analysis on Scopus-indexed journals to examine the topic of big data analytics in audits, utilizing the VOSviewer tool. The objective of utilizing bibliometric analysis in this research is to ascertain the progression of articles concerning the application of big data analytics in the field of auditing. This article discusses the development of the number of publications and citations, the trend of publication researchers, the country of publication articles, the relationship between researchers, and the relationship between words with the topic of big data analytics in the period 2010—2022. This research reveals areas of application of big data analysis adoption in auditing. Qualitative research, especially library research, is the best method widely used among writers. This study provides several useful insights into the meaning of big data and data analysis, the benefits of using big data analysis in the audit process, and how the audit process can be made easier with big data analysis. Among the most interesting insights, the results suggest that big data implies vast amounts of data that exceed

the limits of what can be stored and processed. Thus, the use of data analytics helps auditors reduce cognitive errors arising from large and diverse data sets. This bibliometric research presents the number of articles and citations of research publications, which authors and countries have the most research on this topic, and the keywords/terminologies that appear most frequently as well as the meaning of these keywords/terminologies.

Introduction

Increasing the growth of technology and information in business will increase company interest in following technological developments in achieving goals [1]. Big data technology has become very popular in various sectors ranging from business and government to scientific and research fields [1]. As stated by [2], big data analytics involves gathering and analyzing substantial volumes of data to draw conclusions and facilitate the process of decision-making. Big data analytics consists of techniques and technologies for capturing, storing, transferring, analyzing and visualizing large amounts of structured and unstructured data [3].

In the era of information technology, audit companies are urged to transition from conventional audits to data-oriented audits for enhanced audit excellence. This necessitates the continuous integration of technology into audit processes by the audit firm [4]. Within the auditing context, big data analytics is typically characterized as the scientific approach of discovering and studying patterns, detecting anomalies and extracting pertinent information from data relevant to an audit's subject matter. This is achieved through analysis, modeling and visualization aimed at audit planning or execution [5].

Auditors face complex challenges in collecting and analyzing large amounts of data from various sources to form judgments [6]. The large volume and complexity of company data transactions makes it very important to use data analytics. Considering the vast quantity and intricate nature of processed data transactions, big data analytics is poised to shape the future of the audit field. Consequently, the creation of data analytics that enhance the efficiency and effectiveness of audit procedures is of utmost significance [7]. The application of big data analytics offers auditors a valuable tool for scrutinizing and interpreting data sourced from clients to facilitate the completion of audits [4]. Additionally, [8] asserts that embracing big data analytics allows for more comprehensive transaction testing, thereby enhancing audit outcomes and evidence quality, surpassing the results achieved through conventional audit methods.

Based on the description above, auditors are expected to make more references regarding big data analytics in the audit process to improve their profession. Bibliometric research is required for mapping analysis. Bibliometric analysis research regarding the role of big data analytics in the audit process has not been carried out extensively. So, this study aims to fill the research gap by providing bibliometric analysis of Scopus indexed articles related to the role of big data

analytics in the audit process; then the results of the data obtained from Scopus will be entered into the VOSviewer and visualized into a map.

Based on the background outlined above, the aim of this research is to establish (1) the growth in the number of articles and citations of research publications, (2) the trend of researchers who published their articles, (3) the country of publication of the articles, (4) the relationship between researchers (co- authors), and (5) the relationship between words (co-occurrence).

The research questions are: (1) How the number of articles and citations of research publications regarding the adoption of big data analytics in financial auditing is growing? (2) What are the trends in the characteristics of researchers who publish research regarding the adoption of big data analytics in financial audits? Financial audit? (3) What is the geographical distribution of research publishing countries regarding the adoption of big data analytics in financial audits? (4) What are the patterns of relationships between researchers reflected in research on the adoption of big data analytics in financial auditing? (5) What is the pattern of relationships between words that reflects the main focus in research on the adoption of big data analytics in financial auditing?

1. Review of the literature

As described by [9], auditing entails a methodical approach that seeks to objectively acquire and assess evidence pertaining to statements concerning policies and economic occurrences, with the objective of ensuring alignment between these assertions and established criteria. Within the realm of audit procedures, several stages exist. Initially, the audit planning process commences by understanding the client's business, assimilating their accounting policies and procedures to gauge the preliminary materiality threshold, assessing risks, examining elements impacting opening balances, formulating an audit strategy and gaining insight into the client's internal control [10]. Second, the process of implementing audit testing has the main objective of obtaining audit evidence about the effectiveness of the client's internal control and the fairness of the client's financial statements [10]. Third, there is the final audit reporting process, namely the auditor must combine the information obtained to reach an overall conclusion about whether the financial statements have been presented fairly.

Big data refers to a dataset of such magnitude or intricacy that conventional databases and tools cannot effectively analyze it [11]. The attributes of big data encompass volume, diversity, speed, reliability and value [12]. As outlined by [13], big data analytics entails the procedure of scrutinizing extensive and heterogeneous data to uncover concealed patterns, unrecognized correlations and other beneficial insights.

The use of big data analytics within the audit process offers convenience across multiple audit stages. This technology enables auditors to grasp the client's internal and external context, carry out analytical procedures, evaluate client risk and comprehend the internal control framework [4]. According to [7], embracing data analytics yields positive effects on amassing audit evidence, leading to an enhanced comprehension of the audit approach and improvements in audit procedure quality, spanning from planning to conclusion. The application of big data analytics is also beneficial for fraud detection and bolstering audit quality [1]. However, keep in mind that the use of big data analytics must be supported by appropriate infrastructure and human resources and requires a sizable investment [14].

Research on big data analytics in the audit process often highlights aspects such as increasing audit efficiency, better fraud detection, more accurate risk analysis, using machine learning techniques to identify anomaly patterns, and applying sophisticated analytical tools to analyze the volume of data that is generated. big and varied. In addition, research can also focus on data integration from various sources and data protection. However, there is an area that has not been explored, namely the sustainability and environmental impact of implementing big data analytics in the audit process.

2. Research method

This research uses the bibliometric analysis method. Bibliometric analysis is carried out to map concepts or topics, see a research trend and monitor the development of research on a particular topic. Bibliometric analysis is a combination of mathematical and statistical methods aimed at identifying patterns in the literature [15]. Bibliometric analysis is useful for analyzing publication production and research trends in various research fields. Bibliometrics can determine the intended target by grouping the metadata that has been obtained from the indexing journal database and examining the acquired outcomes to derive significant insights [16].

The process of collecting data in this study was carried out by searching the Scopus database article titles with the keywords "big AND data AND analytics AND audit" which have been published since 2010−2022. The type of document obtained is the CSV extension. The population of this research is scientific publications about big data analytics in financial audits of all countries in the world which are indexed and published on Scopus, as many as 153 scientific publication articles. The criteria for the journal are that each journal's data must be indexed by Scopus and in accordance with the search for the theme needed in this research. The reason researchers choose to use Scopus is the strict peer-review process and its reputation. As a database used in indexing international scientific publications that are highly reputable, Scopus offers a database abstract in the form of excerpts from peer-review results of some literature, scientific journals, books and proceedings of conferences. Information and comprehensive descriptions of various research results published internationally in various fields of knowledge are available on Scopus. Search towards scientific literature sources can be done easily in Scopus by exploring its advanced search features which allows searches by author, word key, publisher, year of publication and geography [17].

The data is refined using OpenRefine, resulting in 137 scientific publication articles, which are then imported into VOSviewer. Following the import, the data undergoes processing to align with the specified or chosen keywords. Furthermore, VOSviewer then transforms the input data into an interconnected data map. In bibliometric research, there are several tools that can be used, including VOSviewer, Gephi and Leximancer [29]. The reason for using VOSviewer is the ease of use and interpretation of analysis results. VOSviewer also offers text mining functionality that can be used to build and visualize co-occurrence networks of key terms drawn from scientific literature. VOSviewer can present and represent special information about bibliometric graphic maps. VOSviewer can be used to display large bibliometric maps in a way that is easy to interpret relationships. This tool uses text mining functions to identify relevant noun phrase combinations with an integrated mapping and clustering approach to examine data co-citation and co-occurrence networks. Although there are many other tools for analyzing text units and similarity matrices, VOSviewer's strength is in its visualization. Interactive options and functions make it easy to access and explore its bibliometric data network [18].

The bibliometric analysis research on the adoption of big data analytics in financial audits goes through several stages:

Stage 1: **Collecting data from Scopus.** The research was conducted by collecting indexed and published scientific article data on Scopus. The data search process entailed specifying keywords as a guide for the data source search process. The keywords used in this study are "big AND data AND analytics AND audit". The selected data comes from the last 13 years, from 2010−2022. The results showed that 153 articles were collected. The data that obtained can be saved in CSV format.

Stage 2: **Cleansing data.** The second stage is data cleansing using Openrefine software. The goal is to better clean, organize and format data for better quality and easier analysis. After cleansing the data, 137 articles were obtained.

Stage 3: **Bibliometric analysis.** The next stage is data processing from selected sources. The data processing uses VOSviewer software. This software was developed by Eck and Waltman; it has been widely used in scientific writing [19]. The VOSviewer software can visually depict connections among data, aiding the process of

data analysis. The data analysis process uses data stored in the form of CSV [20]. The results of data analysis are shown in the form of relationships with the help of node symbols (small circles) and lines. There are two-line variants in the visual appearance, namely straight lines and curved lines. The results of the research can be seen in the form of network, overlay and density visualization [21].

Stage 4: **Discussion of bibliometric analysis.** The results of data processing obtained are data on the number of publications and article citations, article development and citation rates, trends among publication researchers, country of publication articles, relationships between researchers, and data on the development of research topics based on co-occurrence. The citation level indicates how much a study has been referred to as a reference for other research; a higher citation level indicates the research is a strong reference for other research. The results of data processing on the number of publications indicate the development of research in terms of quantity; the higher the number of articles published, the stronger the research interest in this theme [22]. The article development data shows the progress of the research that has been carried out. The trend of publication researchers is to find researchers who publish a lot of their articles. Country of article publication tells us the country that publishes the most articles. Other data processing results are presented, namely data between researchers (co-authors) which shows the relationship between researchers. The relationship formed indicates a link between researchers. The results of the co-occurrence data show a connected relationship between the keywords which are the main points of the research. The processed results of co-occurrence data based on clusters are intended to strengthen the explanation formed on the occurrence.

3. Results and discussion

3.1. Analysis of the number of publications and citations

This section aims to address RQ1: What the number of articles and citations of research publications tell us about the adoption of big data analytics in financial auditing?

Enclosed are the figures detailing the number of articles released from 2010 to 2022 alongside the citation counts.

The data contained in *Table 1* shows that in 2010–2022 there was a trend of increasing publications. The highest number of articles published in 2022 was 32 (23.36%). The results of data processing on the number of publications indicate research progress, so the higher the number of articles published, the stronger the research interest in this theme. The largest citations in 2019 were 912 citations (36.91%). Large citations indicate that research is a strong reference source for another research.

The following shows details of 10 articles published from 2010 to 2022, ordered by the largest number of citations.

The results of article data processing and citation levels are presented in *Table 2*. Based on the data, the first most cited article was [23] with 258 citations from Accounting Horizons. This study demonstrates that the rise of novel, automatically generated data formats of ever-expanding proportions is driving the integration of technology to ensure accurate procedures. Employing data analysis aids auditors in mitigating cognitive errors arising from vast and diverse data sets.

The second article with the most citations is [6] with 195 citations from Accounting Horizons. The research reveals that big data analytics in the audit process is an added value proposition for auditors because it can help strengthen audit findings and identify risks.

The third article that has the most citations is [2] with 187 citations from Accounting Horizons. The research reveals that auditors who use big data will use data in relatively messy large sets and will focus more on correlation. Big data analytics can be used to identify business patterns and trends. When making changes with big data, analytics can identify fraud or mistakes that were missed in the past.

3.2. Analysis of publication trends

This section aims to address RQ2: What are the trends in the characteristics of researchers who publish research

Table 1.

Number of publications and citations

Year	Article	Percentage (%)	Citation	Percentage (%)
2010	1	0.73%	6	0.24%
2011	0	0.00%	0	0.00%
2012	0	0.00%	0	0.00%
2013	2	1.46%	20	0.81%
2014	2	1.46%	21	0.85%
2015	7	5.11%	912	37.03%
2016	7	5.11%	53	2.15%
2017	11	8.03%	385	15.63%
2018	12	8.76%	176	7.15%
2019	20	14.60%	441	17.90%
2020	14	10.22%	168	6.82%
2021	29	21.17%	184	7.47%
2022	32	23.36%	97	3.93%
Total	**137**	**100%**	**2463**	**100%**

regarding the adoption of big data analytics in financial audits? Financial audit?

The following illustration shows the 10 largest authors of published articles published in 2010 to 2022.

The productivity of the top 10 researchers on the topic "big data analytics and auditing" in 2010−2023 indexed by Scopus shows that the productivity of researchers ranges from 2−8 publications. Based on *Fig. 1*, the researcher Vasarhelyi has the highest productivity, namely 8 publications, while the lowest is researchers Abu Afifa, Appelbaum, De Santis, Drews, Handoko, Jacky, and Kantarcioglu, each of whom had 2 publications. Researchers Kogan and Pedrosa had 3 publications each.

The research results of Vasarhelyi suggest that big data implies a large amount of data that is beyond the limits of what can be stored and processed. Thus, the use of data analysis helps auditors reduce cognitive errors that arise from large and diverse data sets.

3.3. Analysis of researcher country

This section aims to address RQ3: What is the geographical distribution of research publishing countries regarding the adoption of big data analytics in financial audits?

Figure 2 provides information on the country of origin of researchers for articles published in 2010−2022.

Article development and citation resources

Rating	Citation	Topic	Authors	Year	Resources
1	258	Big data in accounting: An overview	Vasarhelyi M.A., Kogan A., Tuttle B.M. [23]	2015	Accounting Horizons
2	195	Behavioral implications of big data's impact on audit judgment and decision making and future research directions	Brown-Liburd H., Issa H., Lombardi D. [6]	2015	Accounting Horizons
3	187	Big data analytics in financial statement audits	Cao M., Chychyla R., Stewart T. [2]	2015	Accounting Horizons
4	171	Towards an Autonomous Industry 4.0 Warehouse: A UAV and blockchain-based system for inventory and traceability applications in big data-driven supply chain management	Fernández-Caramés T.M., Blanco-Novoa O., Froiz-Míguez I., Fraga-Lamas P. [24]	2019	Sensors (Basel, Switzerland)
5	166	Big data and analytics in the modern audit engagement: Research needs	Appelbaum D., Kogan A., Vasarhelyi M.A. [25]	2017	Auditing
6	135	'Big data' for pedestrian volume: Exploring the use of Google Street View images for pedestrian counts	Yin L., Cheng Q., Wang Z., Shao Z. [26]	2015	Applied Geography
7	120	Data analytics in auditing: Opportunities and challenges	Earley C.E. [8]	2015	Business Horizons
8	87	The ethical implications of using artificial intelligence in auditing	Munoko I.,Brown- Liburd H.L., Vasarhelyi M. [27]	2020	Journal of Business Ethics
9	72	An accounting information system perspective on data analytics and big data	Huerta E., Jensen S. [28]	2017	Journal of Information Systems
10	69	Big data and changes in audit technology: Contemplating a research agenda	Salijeni G., Samsonova-Taddei A., Turley S. [5]	2019	Accounting and Business Research

Contributors to the research results in big data analytics and auditing articles on the Scopus application show that the authors of big data analytics and auditing articles are spread across various countries. The most countries issuing big data analytics and audits are the United States with 43 articles, followed by the United Kingdom with 15 articles, China and India with 10 articles each, Malaysia with 9 articles, Portugal with 6 articles, Canada, Germany and Indonesia with 5 articles each and Brazil with 4 articles.

Several articles published from the United States state that the adoption of big data analytics in auditing really helps audit work because it can help process large volumes of data thereby minimizing errors.

3.4. Analysis of relations between researchers (co-author)

This section aims to address RQ4: How are the patterns of relationships between researchers reflected in research on the adoption of big data analytics in financial auditing?

Analysis of the relevance map of network visualization between researchers in articles published from 2010 to
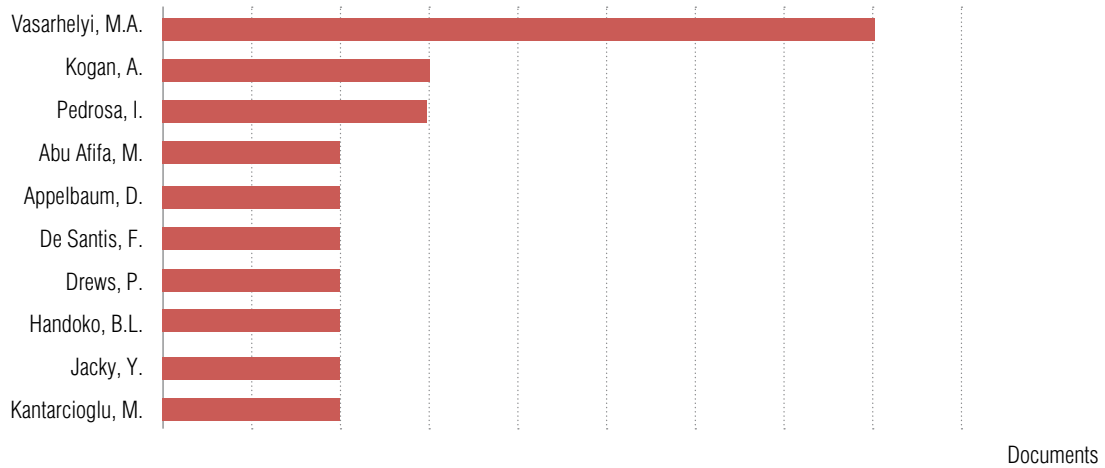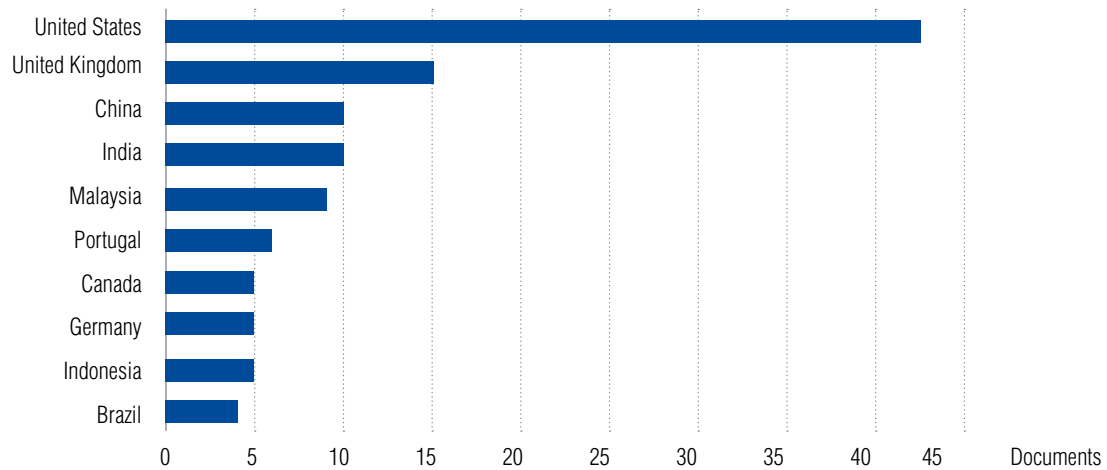
Fig. 1. Top 10 authors of article publication.

Fig. 2. Author distribution by country.

2022 shows that there are 4 independent groups (clusters) of researchers (co-authors). There is no relationship between the researchers in the relevant research scope.

3.5. Analysis of relations between words (co-occurrence)

Figure 3 shows a network visualization map of the relationships between words in articles published from 2010 to 2022.

The keywords that appear most frequently are big data, data analytics and audit. Big data refers to a large volume of complex and diverse data that is challenging to process using traditional methods. Meanwhile, big data analytics involves techniques and tools for analyzing, interpreting and gaining insights from such large and complex datasets. Thus, big data is a vast and intricate dataset, while big data analytics is the process of extracting meaning and value from this data through various analytical techniques. Audit is a systematic and independent process to
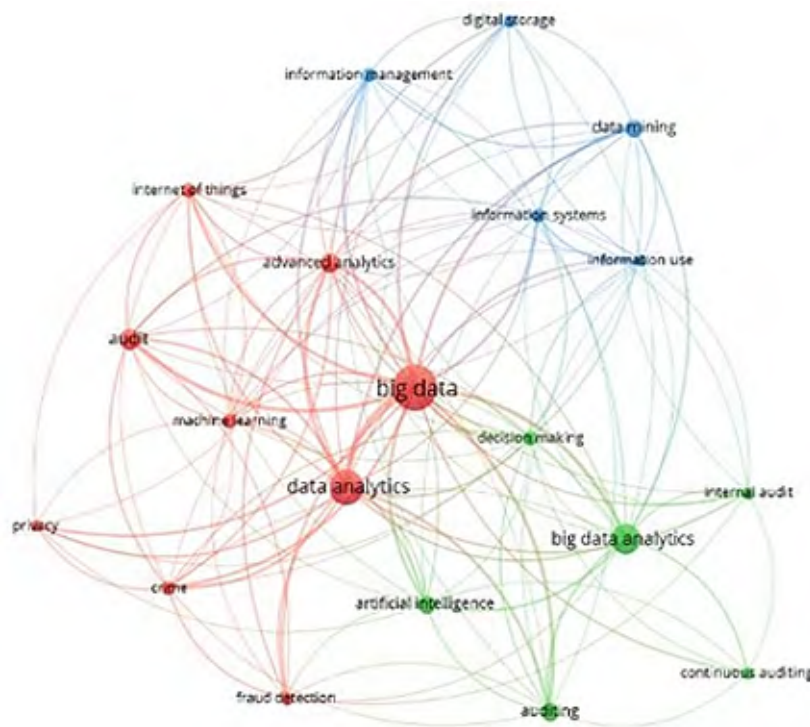
Fig. 3. Network Visualization (co-occurrence).

examine, evaluate and verify the financial records, procedures or business systems of an entity. The goal of an audit is to provide assurance that the financial or operational information presented is accurate, reliable and in compliance with applicable standards. Thus, big data analytics in audit refers to the use of sophisticated analytical techniques to analyze large and complex volumes of data (big data) in the audit process. The aim is to enhance effectiveness, efficiency and gain deeper insights into audit quality and financial risk management.

The information depicted in *Fig. 3* illustrates the connections between words. The most prominent word is represented by the largest node. There are three clusters:

1. Cluster 1: advance analytics, audit, big data, crime, data analytics, fraud detection, internet of things, machine learning and privacy.

2. Cluster 2: artificial intelligence, auditing, big data analytics, continuous auditing, decision making and internal audit.

3. Cluster 3: data mining, digital store, information management, information systems and information use.

The occurrence value in cluster 1 indicates that advance analytics, including big data analytics, uses machine learning in auditing for fraud detection to detect anomalous patterns and avoid crime, as well as maintain privacy in the realm of the internet of things.

The occurrence value in cluster 2 indicates that the use of artificial intelligence in big data analytics and continuous auditing supports better decision making in the internal audit process.

The occurrence value in cluster 3 indicates that data mining, digital store, information management, information systems and information use are interconnected for effective and efficient use of data.

The results of the co-occurrence data show a connected relationship between the keywords which are the main points of the research. Processed results of co-occurrence

data based on clusters can strengthen the explanation formed on the occurrence.

Conclusion

Bibliometric analysis is a scientific method that can be useful for researchers wishing to expand their research fields. The bibliometric methodology uses bibliometric software and databases that make it easy to acquire and assess large volumes of data. An important and relatively new bibliometric research is big data analytics in the audit process. Bibliometric analysis research regarding the role of big data analytics in the audit process has not been carried out extensively. Thus, this study aims to fill the research gap by providing a bibliometric analysis of Scopus indexed articles relating to the role of big data analytics in the audit process.

The study results show that research topics on the adoption of big data analytics in financial audits are increasingly in demand. This can be seen from the growth of articles. In 2010−2022 the highest number of published articles was in 2022, with 32 published articles. The article that obtained the most citations had the title "Big data in accounting: An overview" [23]. It achieved the most (258) citations. This research takes the topic of an overview of big data in accounting. Vasarhelyi is a researcher who has the greatest productivity, with as many as 8 published articles. The United States as a country published the most articles, namely 43 articles. The results of mapping the relationship between researchers (co-authors) found 4 clusters that did not show any interrelated relationships. The keywords that appear most frequently are big data, data analytics and audit. Big data encompasses vast and complex datasets which are challenging to process traditionally. Big data analytics employs techniques for extracting meaning from such datasets. Audit is a systematic, independent process verifying financial records to ensure accuracy and compliance. Big data analytics in audit uses advanced techniques to analyze large datasets, aiming to improve effectiveness, efficiency, and insights into audit quality and financial risk management. The results of the relationship between words (co-occurrence) consist of 3 clusters which show the relationship between words and can strengthen the explanation.

There are several limitations in the research, namely that bibliometric analysis often relies on keywords which can produce limited results if the keywords used do not cover all aspects of the adoption of big data analytics in financial audits, and bibliometric analysis can have limitations in covering the latest developments, especially if the data is obtained over a certain period of time

Given the limitations already mentioned, some recommendations for future research could include expanding the list of keywords used in bibliometric analysis to cover various aspects of big data analytics adoption to improve the completeness of the results and conducting regular monitoring to update the data/ Performing dynamic analysis could provide a more accurate understanding of the latest developments.

For further research exploring the adoption of big data analytics in financial audit, it is advisable to concentrate on variables such as effectiveness, efficiency and security of using the technology. The research context can be centered around the integration of big data analytics into the audit process, its impact on audit quality and factors hindering or supporting adoption in the financial audit environment. ∎

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