sciendo

Impact of Artificial Intelligence in Audit. Bibliometric Analysis

Elena Claudia BADEA (FLOREA) *
Bucharest University of Economic Studies, Bucharest, Romania
**Corresponding author, claudiaflorea9737@gmail.com*

Mădălina PREDA
Bucharest University of Economic Studies, Bucharest, Romania
predamadalina17@stud.ase.ro

Andreea Larisa OLTEANU (BURCĂ)
Bucharest University of Economic Studies, Bucharest, Romania
larisa.olteanu@gmail.com

Abstract. *In the current economic context, marked by a significant acceleration of digital transformation, artificial intelligence (AI) is increasingly integrated into business processes, including audit activities. This paper aims to analyze the challenges of using AI in the audit process within companies. Through this research, we aimed to conduct a bibliometric analysis of the literature on the use of AI in auditing. This study performs mapping analyses using VOSviewer software starting from the concepts of "audit" and "artificial intelligence". The analysis was performed through a quantitative research methodology applied to a sample of a total of 422 research documents published between 1992 and 2024, extracted from the Web of Science (WOS) online database. Recent academic publications highlight three main themes: the presence of artificial intelligence (AI), its role in audit work and concerns about the limits of technology in audit. This study provides information for policy makers, researchers, students and auditors on how AI can be integrated into audit activities, providing findings and suggestions for its application. The paper contributes to the audit literature on AI by highlighting its ability to analyze large data sets. However, it also highlights the lack of clear limitations and ethical guidelines, which are necessary to prevent AI from making independent decisions. Although AI learns autonomously and adapts, it lacks human ethics, being linked to the goals and conditions set by humans. Thus, responsibility should be shared between humans and AI. Research suggests that the use of AI in auditing needs to be adapted to ensure ethical decision making.*

Keywords: audit, artificial intelligence, automation, bibliometric analysis, technology.

Introduction

This paper explores the impact of artificial intelligence (AI) on auditing, analyzing the challenges and opportunities generated in the decision-making process.

The main objective of this research is to provide a detailed bibliometric analysis of trends, influential authors, and research gaps in the field of artificial intelligence in auditing, thus contributing to a deeper understanding of the impact of this technology on decision-making processes and its implications for professional practice and auditing ethics.

Artificial intelligence (AI) is increasingly transforming the auditing profession, offering new opportunities but also significant challenges. Despite the increasing integration of AI into the audit, there is still a lack of comprehensive analysis of its long-term impact, best practices and associated risks. Current research focuses primarily on the technical applications of AI but provides limited insights into its broader implications for decision making, regulatory compliance, and

DOI: 10.2478/picbe-2025-0010

professional ethics. This study addresses this gap by conducting a bibliometric analysis to identify key research trends, influential contributions, and evolving discussions on AI in audit.

In addition, recent research addresses the management of "tangible data" actively used by AI, as well as challenges related to "dark data", untapped information that is an important source for future analysis (Johnson, 2015; Trajanov et al., 2018). AI certification by independent entities such as O'Neil Risk Consulting and Algorithmic Audit (ORCAA) or audit companies such as Deloitte and KPMG plays an important role in promoting a regulatory framework and responsible use (Blösser & Weihrauch, 2024).

In this context, starting from the literature, this paper aims to answer the following research questions:

RQ1: What are the research trends regarding the impact of artificial intelligence in the field of auditing?

RQ2: How are key topics in AI research interlinked in the audit?

RQ3: Which authors, affiliations, countries, and papers are cited most frequently in this field?

To answer these questions, the study examined 422 papers published between 1992 and 2024, collected from the Web of Science database, in order to create a considerable period for the evaluation of previous studies. The bibliometric analysis of the literature was carried out using the VOSviewer software, which will reveal the patterns and links between the articles and will provide an enlightening analysis of the literature.

As it turns out from the analyzed documents, starting with 1990, research on the involvement of AI in audit is emerging, but in the last 20 years several papers have been published. Thus, the choice of period guarantees an in-depth analysis of both early and most current progress in the discipline.

The applied quantitative research methodology helps analyze trends and recent developments in the use of AI in auditing, identifying key research topics, relevant authors, and citation networks.

Bibliometric analysis provides a more methodical and repeatable way to map research trends and identify gaps than standard literature reviews, as well as adapting the academic and professional environment to new trends that require documentation.

In conclusion, this paper aims to deepen the understanding of the impact of AI on audit, and by addressing these issues, research will contribute to the development of more informed and ethical audit practices, while providing a solid foundation for future studies that support the responsible integration of AI technologies into audit processes.

The other sections of the paper are structured as follows; the AI concepts that have been briefly revised, the methodology section and the analysis of the findings, ending with the presentation of a conclusion with limitations and paths for future research.

Literature review

Companies and financial services firms are increasingly using AI to aggregate and transform data from various sources and to gain more relevant insights, to make decisions in complex environments and for economic benefits (Joseph & Gaba, 2020).

In terms of data processing speed, it already exceeds any human workforce, in terms of more repetitive but cognitively demanding tasks in accounting and auditing (Kokina & Blanchette, 2019).

Analyzing this theme, Lehner et al. (2021) find different conceptualizations of human-machine collaborations (AI) throughout the literature: Agrawal et al. (2019), for example, argue that in the near future, AI will only improve human decision-making, instead Mulgan (2018), Jarrahi (2018) and also Lehner et al. (2021) already foresee a shift to partially autonomous digital actors as decision makers in the future.

The Fourth Industrial Revolution speech highlights the field of financial audit as being exposed to a particularly high risk of imminent disruption (Frey & Osbourne, 2017; World Economic Forum, 2020). The perceptions of the audit activity as routine, computational, prescribed and process-oriented, together with the quantitative nature of the processed financial data, contributed to this vision of the audit's susceptibility to automation and to the implicit imminent disappearance. However, technological innovation in auditing has a long history (Wang, 2022), showing that technology has often failed to deliver on its bolder promises in the past. In addition, the diffusion of new technologies, such as big data analysis, can be more difficult and slower than many technology change reports imply, due to internal tensions of audit firms and lack of guidance provided by regulators. This is even more likely to happen when it comes to implementing more advanced technologies, such as machine learning (ML) and artificial intelligence (AI), which promise to mimic the auditor's reasoning. Previous studies on the impact of the Fourth Industrial Revolution focused primarily on either the reproducible and repetitive aspects of audit work (Frey & Osbourne, 2017) or abstract projections of the future (World Economic Forum, 2020).

The structure-judgment debate in the audit has persisted for decades and often takes on new life when the audit encompasses new technologies. However, it is curious that few studies have attempted to empirically detail the dynamics of this interrelationship (Kohler et al., 2021). Based on the conceptual work on habit (Camic, 1987), we can look at the ways in which audit reasoning is both shaped and reshaped by the advent of audit technologies.

More recently, the increase in robotic process automation (RPA) (Eulerich & Eulerich, 2020) and big data as well as data analysis (collectively, BDA) in audit has gathered significant practitioners, regulations (Financial Reporting Council, 2020; 2018; PCAOB, 2018) and academic interest (Appelbaum & Nehmer, 2017; Munoko et al., 2020; Salijeni et al., 2021, cited by Yang et al. (2024).

Based on previous literature exploring the possibilities of such tools (Cao et al., 2015) and related challenges or determining urgent research needs (Appelbaum et al., 2017, cited by Yang et al., 2024), emerging studies have begun to empirically explore the current use of BDA in audit (Salijeni et al., 2018, 2021). For example, Salijeni et al. (2021) find that the BDA has reconfigured aspects of the audit process and changed the relational dynamics between different groups within audit firms, with some of the wider industry dynamics and relational tensions. Taking a sociometrical perspective and specifically focusing on the technical possibilities of BDA, Salijeni et al. (2021) concluded that further research is needed to understand how judgments are made in places where BDA technologies are implemented.

The literature explores the research directions needed to better understand the impact of AI in auditing (Issa et al., 2016), the effects on auditors' identity and professional role (Goto, 2023), and the associated ethical implications (Munoko et al., 2020). Identified risks include the exclusion of some professionals from the field and the danger of auditors becoming overly reliant on IA, thereby relinquishing their own ability to make professional judgments (Munoko et al., 2020).

The increasing predictive power of machine learning (ML) models stimulates both advances in research and the creation of business opportunities. Because many of these models are

not equipped to differentiate between correlation and causality, they could use false correlations and unwanted biases to improve their performance. Although there is a growing interest in the AI community to engage in interdisciplinary efforts to define, investigate, and provide guidance for addressing issues of bias and equity (Obermeyer et. al., 2019; Pedreschi, et al., 2008), quantitative and systematic auditing of real-world datasets and machine learning models is still in its infancy.

Increased concern about the social implications of AI systems has inspired a wave of academic and journalistic literature in which implemented systems are audited for damage by investigators outside of organizations implementing algorithms. However, it remains difficult for practitioners to identify the damaging repercussions of their own systems prior to implementation, and once these are implemented, emerging problems can become difficult or impossible to trace back to their source.

With increased access to artificial intelligence (AI) development tools and Internet datasets, corporations, nonprofits, and governments are deploying AI systems at an unprecedented rate, often in mass production systems that affect millions, if not billions, of users. During this large-scale implementation, valid concerns arise about the effectiveness of these automated systems for the entire spectrum of users, and in particular criticism of systems that tend to reproduce, reinforce or amplify existing harmful social prejudices. External audits are designed to identify these risks outside the system and serve as accountability measures for these implemented models. However, such audits tend to be carried out after the implementation of the model, when the system has already adversely affected users.

A review of the existing literature highlights the role of internal algorithmic audits as a potential mechanism to ensure that the engineering processes involved in the creation and implementation of AI systems meet stated ethical expectations and standards, such as organizational AI principles. The literature suggests that although the audit process is necessarily slow, meticulous and methodical, in contrast to the rapid pace of AI technology development, it is essential to slow down the development process as algorithms continue to be implemented in increasingly risky areas.

AI represents the potential to benefit society as a whole; however, the distribution of risks remains unequal, with people already experiencing structural vulnerabilities or prejudice disproportionately bearing the costs and damage caused by these systems. To ensure fairness, justice and ethics, it is essential that those affected by these risks receive due attention. Organizations responsible for the development and implementation of AI systems must proactively address these social risks and be held accountable for ensuring their compliance with ethical principles.

Stakeholder engagement is crucial to effectively interpret and refine these principles, playing a key role in shaping requirements. This commitment also has significant ethical implications as it helps preserve democratic values in the face of the increasing integration of AI into society.

Digitalization is having a strong impact on the future of work and will require established firms to rethink their strategies, business models and organizational forms.

Although the growth trend of the professional services industry is observed, there are still no indications of digital disruption. For example, the top-rated companies in the audit industry – the Big Four – have seen steady growth over the past 10 years. This increase supports recent research claiming that established firms, facing technological discontinuities, are not condemned to be disrupted, but can turn these challenges into opportunities (Kammerlander et al., 2018). However, empirical studies providing “concrete answers” (Nylén & Holmström, 2015) on how to

do this in practice are “urgently needed” (Moll & Yigitbasioglu, 2019) – especially in the context of professional services (Pemer, 2021).

The use of AI in auditing can support the Internal Audit Function (IAF) by automating tasks, reducing manual procedures, and providing value-added services (Wassie & Lakatos, 2024). AI also enables auditors to more effectively identify associated risks and controls, detect fraud early, and monitor anomalies in real time (Couceiro et al., 2020). However, empirical data on the effects of AI adoption on risk assessment, audit quality and regulatory compliance are still insufficient. This study adds to the literature by revealing unexplored regions and methodically mapping the intellectual structure of AI audit research.

Technologies used in auditing using AI include: Robots Software (RPA) developed by UiPath, Blue Prism; Big Data Analysis, developed by Hadoop, Spark; Machine Learning and AI, developed by TensorFlow, PyTorch, Scikit-learn; Natural Language Processing (NLP), developed by NLTK, spaCy, BERT and Data Visualization, developed by Tableau, Power BI.

As platforms, where AI can be used in audit we mention the following: KPMG clear - Intelligent Audit Platform using AI for advanced data analysis and anomaly detection; PwC Halo-Solution using AI for transaction analysis and risk identification and Deloitte Cortex - Platform using AI to improve audit quality through financial data analysis.

The way in which the practical implementation of AI is intended refers to: the needs assessment, which is related to the determination of audit processes, the selection of technology, i.e. the choice of appropriate tools and platforms, the training of algorithms, i.e. AI models using historical and relevant data, and as well as the integration of systems, i.e. the integration of AI solutions into the existing audit workflow.

Methodology

Broadus (1987) defined bibliometrics as the statistical and mathematical analysis of the quantitative characteristics of research. According to the Online Dictionary of Library and Information Science (ODLIS), bibliometrics is defined as the application of statistical and mathematical techniques to examine and detect trends in the use of materials and services within a library or to examine the evolution over time of a particular body of literature.

This research applied bibliometric analysis to examine the overall perspective on the impact of AI in auditing, building on criteria established in previous research by Shamsul et. al., (2021).

This study examined articles published between 1992 and 2024 collected from the Web of Science database to bake a significant period to evaluate previous studies, using the words "audit" and "artificial intelligence" as filters. Thus, a number of 422 papers published during this period resulted, as shown in (Figure 1), highlighting the evolution and distribution of articles published during the analyzed period, with a sharp increase starting with 2019, the year of the Covid-19 pandemic, involving 352 authors.

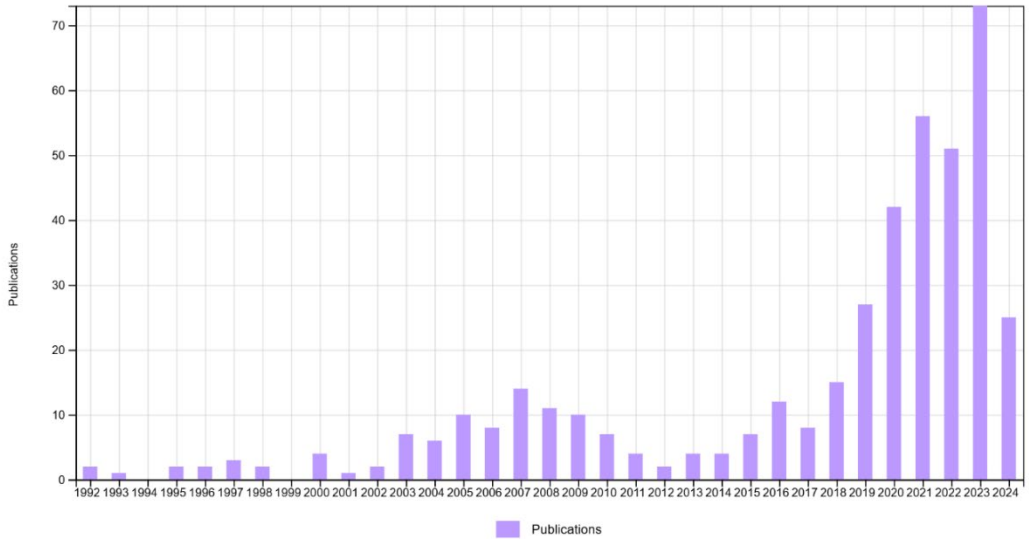

Figure 1. Evolution of articles between 1992 and 2024

Source: Authors' own research based on data extracted from the Web of Science.

Out of the 422 papers, as shown in (Table 1), it was only in 2007 and 2008 that several papers began to be published that addressed the topic of AI in audit, after which a period in which the number of publications decreases significantly can be observed. Starting with 2016, the number of publications increases, and after the Covid19 pandemic, the number of publications is significant, which can be considered a reference year in the AI area, because it was the year in which technology made its presence felt at most levels, humanity used technology for the first time at the macro level and thus opened the way to a new era, if we can say so. For 2024, the number of publications is higher, but the database was extracted on August 31, 2024.

Table 1. Evolution of publications with the most citations between 1992 and 2024

Year	Publication number	Percentage
2024	35	8%
2023	75	18%
2022	47	11%
2021	54	13%
2020	37	9%
2019	26	6%
2018	15	4%
2017	8	2%
2016	12	3%
2015	7	2%
2014	4	1%
2013	4	1%
2012	2	0%
2011	4	1%
2010	7	2%
2009	10	2%

Year	Publication number	Percentage
2008	11	3%
2007	14	3%
2006	8	2%
2005	10	2%
2004	6	1%
2003	7	2%
2002	2	0%
2001	1	0%
2000	4	1%
1999	0	0%
1998	2	0%
1997	3	1%
1996	2	0%
1995	2	0%
1994	0	0%
1993	1	0%
1992	2	0%
TOTAL	422	

Source: Authors' own research based on data extracted from the Web of Science.

Applying quantitative scientific mapping research methodology, bibliometric analysis was performed using VOSviewer software, which builds networks to describe relationships between keywords, concepts and authors, generating maps that reflect similarities with maximum mathematical accuracy. Co-occurrence networks based on the keywords "audit" and "artificial intelligence" were created within the paper. Nodes in these networks represent keywords, and their size indicates the frequency of occurrence.

Results and discussions

1. Performance analysis

Starting from the research question R.Q.1. What are the research trends regarding the impact of artificial intelligence in the field of auditing? a performance analysis was performed based on data published in the Web of Science for the 422 papers. For a better explanation of the research results the author may use graphical illustrations or tables.

According to Shamsul et. al., (2021), performance analysis aims to evaluate the contributions of academic research to the business environment, highlighting both research trends and its relevance and impact. This type of analysis focuses on collecting, analyzing and interpreting data such as the number of publications, the number of citations, the topics addressed, the authors involved, as well as the institutions and countries contributing to the research.

Following the processing of data taken from the Web of Science for the 422 articles published between 1992 and 2024, there has been a growing academic interest in this field, highlighting the significant contributions of research to the use of artificial intelligence in the field of auditing. The Web of Science results indicated a total of 6,221 citations, with an average of 14.74 citations per article, which suggests a considerable impact on the literature, while confirming the relevance of these articles in the literature.

On the other hand, the performance analysis was performed in relation to the indicator taken from the Web of Science: H-index. It combines both the number of articles published and the number of citations per article received, providing a balanced measure of the impact and consistency of academic contributions. The indicator taken from the Web of Science: H-index was evaluated at 41, indicating the relevance of the articles addressing internal audit topics in the context of artificial intelligence, namely the impact of the sample articles on scientific papers, which are frequently used and mentioned in other scientific papers.

From a productivity perspective, the study shows an average of 23.44 articles published annually, indicating a steady growth trend in academic contributions in this field. Also, the analysis of the collaboration between the authors reveals an average of almost two authors per document (Indicator taken from Web of Science, CI = 0.83), which highlights the importance of interdisciplinary cooperation and teamwork in generating results.

The performance of the articles on the involvement of artificial intelligence (AI) in the audit, segmented by main economic areas, is presented in Table 2.

Table 2. Distribution of articles by field of activity

Field of activity	No. of published articles	% of articles at domain level out of 422 articles
Artificial Intelligence & Machine Learning	88	21%
Communication	59	14%
Economics	55	13%
Security Systems	44	10%
Education & Educational Research	44	10%
Software Engineering	35	8%
Knowledge Engineering & Representation	29	7%
Robotics	14	3%
Management	32	8%
Computer Vision & Graphics	22	5%

Source: Authors' own research based on data extracted from the Web of Science as at August 31, 2024.

Current research trends in artificial intelligence (AI) reflect its diversified application across multiple sectors, supported by rapid technological advances. The field of Artificial Intelligence and Machine Learning dominates, with 88 articles (21%) highlighting the major interest in emerging technologies, while the field of Communications (14%) highlights the relevance of AI in the field of communications, and Economics (13%) reflects the applicability of AI in economic analysis. Areas such as security systems and education and educational research (each with 10%) emphasize the application of AI in cybersecurity and education, and software engineering (8%) and management (8%) highlight the integration of AI in software engineering and organizational management. Knowledge engineering and representation (7%) focuses on the organization of knowledge, and robotics (3%) and Computer Vision & Graphics (5%) reflect the use of AI in automation and image processing. Thus, current research focuses in particular on machine learning, communication, economics, security and AI applications in education, software engineering and management.

Next, to add insight into the types of scientific sources where artificial intelligence (AI) research is published most frequently, we present in Figure 2 the detailed distribution of articles published within different indices in the Web of Science database.

Figure 2. Distribution of articles after indexing: Top 5 Web of Science Index

Source: Authors' own research based on data extracted from the Web of Science.

Thus, most articles are indexed in the Conference Proceedings Citation Index – Science (CPCI-S), with a number of 216 articles, which suggests a significant interest in presentations and discussions at scientific conferences, followed by the Science Citation Index Expanded (SCI-Expanded) with a number of 96 articles, indicating the global relevance of AI research papers. Also, indexing in the Emerging Sources Citation Index (ESCI), with a number of 69 articles, which reflects the emergence of new research sources. The following areas are social sciences, the Social Sciences Citation Index (SSCI) comprising 67 articles, followed by the Conference Works Citation Index – Social Sciences and Humanities (CPCI-SSH) comprising 36 articles, highlighting scientific contributions in the field of social sciences and humanities in this context.

This data suggests a clear trend in the application of AI in various fields, from exact sciences and engineering to social sciences and humanities, and the extensive network of publication sources reflects the diversity of fields of interest and interdisciplinary collaborations in current research.

In order to complete the analysis, we present below the geographical distribution of the sample of articles analyzed for the first 10 countries with the most publications as can be seen in Table 3.

Table 3. Geographical distribution of items: Top 10 countries

Country	No. of articles	% articles at country level out of 422 articles
USA	115	27.25%
PEOPLES R CHINA	60	14.22%
ENGLAND	42	9.95%
GERMANY	24	5.69%
AUSTRALIA	23	5.45%
SPAIN	21	4.98%
INDIA	20	4.74%
ITALY	20	4.74%
CANADA	17	4.03%
BRAZIL	12	2.84%

Source: Authors' own research based on data extracted from the Web of Science.

The analysis shows that the United States (USA) leads in terms of the number of publications, with 115 publications (27.25%), China with 60 publications (14.22%) and the United Kingdom with 42 publications (9.95%), which highlights the dominant position of these countries in the research in the field of artificial intelligence applied in the audit. Canda ranks 9th with 17 publications (4.03%), and Brazil ranks 10th with 12 publications (2.84%).

2. Scientific mapping

Considering the research question *RQ.2 How are the key topics from the research on artificial intelligence in auditing interconnected? as well* as *RQ.3. Which authors, affiliations, countries, and papers are cited most frequently in this field?* mapping analyses were performed. Scientific mapping examines the interconnections between research elements, exploring both the intellectual connections and the structural networks of its components. This method includes techniques such as citation analysis, bibliographic coupling, co-citation analysis, co-participation networks and collaborations between researchers. When integrated with network analysis, these techniques become fundamental for visualizing the bibliometric structure and intellectual architecture of the research field, providing a clearer understanding of the relationships and developments within it. (Donthu et al., 2021).

2.1.Citation Analysis

Citation analysis is an essential method for scientific mapping, based on the idea that citations reflect the impact and intellectual contributions of published works, thus helping to identify influential works and to understand the evolution of thinking in a particular field (Garfield, 1972).

This helps to identify the most influential works and to understand the evolution of thinking in a particular field. Table 4 shows the 20 most important impact and influence documents in the field of artificial intelligence and auditing.

Table 4. Top 20 impact and influence documents in the field of artificial intelligence and auditing

Author	year	Date	Bibliographic references	Quotes
Raji, ID; Smart, A; White, RN; Mitchell, M; Gebru, T; Hutchinson, B; Smith-Loud, J; Theron, D; Barnes, P	2020		83	255
Van Dijk, M; Juels, A; Oprea, A; Rivest, RL	2013		25	178
Gronsund, T; Aanestad, M	2020	J CRYPTOL	64	131
Issa, H; Sun, T; Vasarhelyi, MA	2016	J STRATEGIC INF SYST	100	129
Hutchinson, B; Smart, A; Hanna, A; Denton, E; Greer, C; Kjartansson, O; Barnes, P; Mitchell, M	2021	J EMERG TECHNOL ACCO	157	106
Albitar, K; Gerged, AM; Kikhia, H; Hussainey, K	2021		43	97
Yu, HY; Yang, Z; Sinnott, RO	2019	INT J ACCOUNT INF MA	31	69
Kreutzer, J; Caswell, I; Wang, L; Wahab, A; van Esch, D; Ulzii-Orshikh, N; Tapo, A; Subramani, N; Sokolov, A; Sikasote, C; Setyawan, M; Sarin, S; Samb, S; Sagot, B; Rivera, C; Rios, A; Papadimitriou, I; Osei, S; Suarez, PO; Orife, I; Ogueji, K; Rubungo, AN; Nguyen, TQ; Müller, Müller, A; Muhammad, SH; Muhammad, N; Mnyakeni, A; Mirzakhalov, J; Matiraang, T;	2022	Access	58	54.

Author	year	Date	Bibliographic references	Quotes
Leong, C; Lawson, N; Kudugunta, S; Jernite, Y; Jenny, M; Firat, O; Dossou, BF; Dlamini, S; de Silva, Ni; Balli, BÇiderman, S; Batt, A; Barwa; Balna, jud. Aapar, BJ; Azime, AJ; Azime, AO; Awakia, AO; Ahamania, O; Ahamania; Ahamania, M; Semi-finished, Adey;				
Falco, G; Viswanathan, A; Caldera, C; Shrobe, H	2018	T ASSOC COMPUT LING	35	53
Ghanem, MC; Chen, TM	2020	Access	32	53
Coston, A; Guha, N; Ouyang, D; Lu, L; Chouldechova, A; Ho, DE	2021	INFORMATION	149	40
Cong, Y; Du, H; Vasarhelyi, MA	2018		55	45
Díaz-Rodríguez, N; Del Ser, J; Coeckelbergh, M; de Prado, ML; Herrera-Viedma, E; Herrera, F	2023	J EMERG TECHNOL ACCO	37	40
Pemer, F	2021	INFORM MERGER	34	42
Hrazdil, K; Novak, J; Rogo, R; Wiedman, C; Zhang, R	2020	J SERV RES-US	83	42
Krieger, F; Drews, P; Velte, P	2021	J BUS FINANCING ACCOUNT	73	39
Mökander, J; Axente, M; Casolari, F; Floridi, L	2022	INT J ACCOUNT INF SY	75	40
Mökander, J; Floridi, L	2021	Mach.	4.	39
Amparore, E; Perotti, A; Bajardi, P	2021	Mach.	63	41
Panigutti, C; Perotti, A; Panisson, A; Bajardi, P; Pedreschi, D	2021	SCI compute PEERJ	97	36

Source: Authors' own research

The analysis found that a total of 88 publications selected as most relevant, i.e. approximately 72% received global citations. Global citations refer to the total number of citations received by articles from all databases.

However, 34 articles (about 26%) were not cited at all. However, 35 articles, approximately 28% did not receive any subpoena. Meanwhile, 14 articles, about 11% received a single subpoena. Raji et.al (2020) received the highest number, namely 255 citations, an article that was published in 2020. The second most influential document was written by Van Dijk et.al (2013) and received a total of 178 citations, followed by the document written by Aanestad et al. (2020) which received 131 citations. Most citation-free documents were published in a recent period 2023 and 2022, as follows: in 2023 there were 20 articles, and in 2022 there were 5 articles indicating that they are relatively new and could receive citations in the future as they become more popular. It can be seen that 2020 was the most influential year in terms of citations, indicating a total of 386 citations distributed as follows: 255 citations related to the research conducted by Raji et al. (2020) and 131 citations related to the research conducted by Gronsund et al. (2020), as shown in the database used for this analysis.

Research published in recent years, especially in 2020, has had a significant impact in the field of AI and auditing. While there are recent publications without citations, this is normal for new articles, and their impact will be assessable in the long run. On the other hand, several papers published in 2020 have already become very influential, with a large number of citations.

2.2 Keywords Analysis

Co-occurrences of two or more keywords are the number of publications where keywords appear together in the title, summary, or keyword list (Van Eck & Waltman, 2010). For keyword analysis, the larger the nodes or keywords on the bibliometric map, the greater the weight and appearance in the sample. Consequently, the distance between two nodes or words shows the strength of association between nodes with a shorter relationship suggesting a stronger connection between nodes (Liao et al., 2018). The lines between keywords also denote their appearance together. Li et al. (2016) elucidate that the concomitant emergence of keywords can effectively replicate core areas of research in areas and provide support for research.

In the present study, 1,500 keywords of the author were obtained. However, restricting the minimum number of occurrences to 2 resulted in 303 keywords in determining the total power of co-occurrence links between keywords. The first keywords resulting are: artificial intelligence, audit, big data, machine learning, management, blockchain, etc. and are presented in Figure 3 with the total frequency and power of links.

The keyword occurrence map Figure 3 gave 14 clusters with a total link strength of 3,483. AI and audit have emerged as the keywords with the largest nodes and a shorter connection, showing the frequency with which scientists simultaneously use them in their studies. Thus, the increase in AI research encompasses the various aspects of the involvement of these applications in the audit activity.

Furthermore, the density view map, the second map in Figure 3, was used to show the degree of co-occurrence, as each keyword has a color indicating its density on the map. The density view map shows higher weights between neighboring elements based on colors. Specifically, the color of a keyword depends on the number of occurrences in the

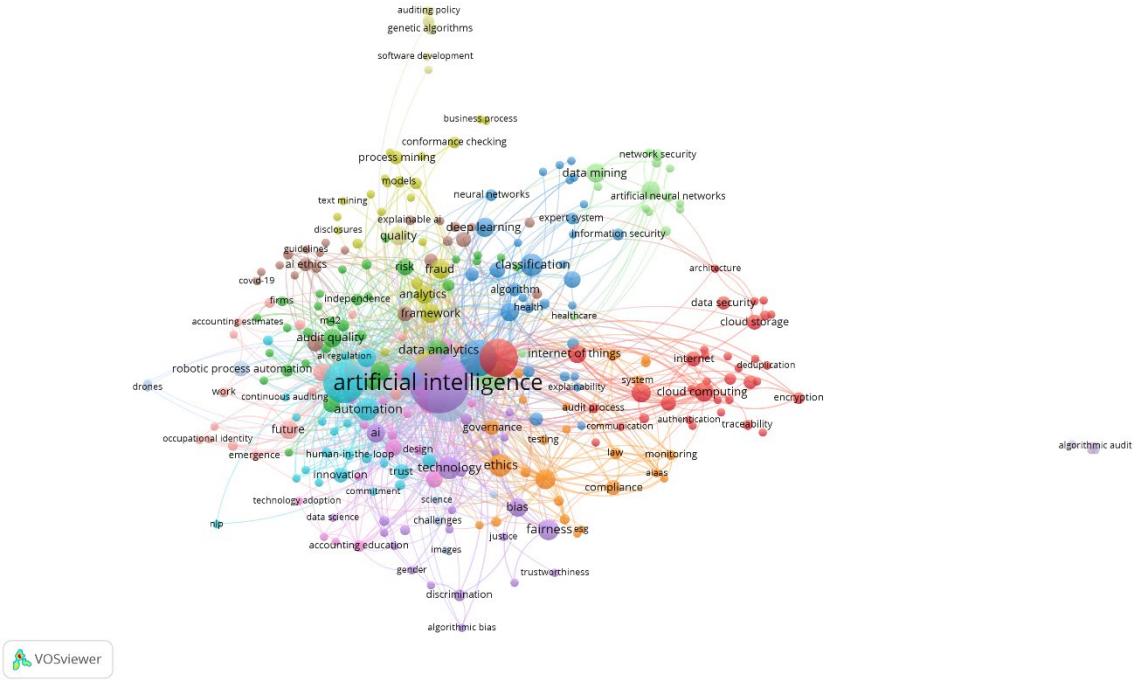

Figure 3. Keyword/map of common occurrence and visualization of the density of simultaneous occurrence of keywords

Source: Authors' own research.

2.3 Countries with the most publications

The countries where the authors produce the most articles on AI in audit can be seen both in Figure 4, where the 12 important clusters highlight the activity and interest of research in certain countries. Thus, the United States is in the top of the countries, being the most visible cluster, followed by China and England.

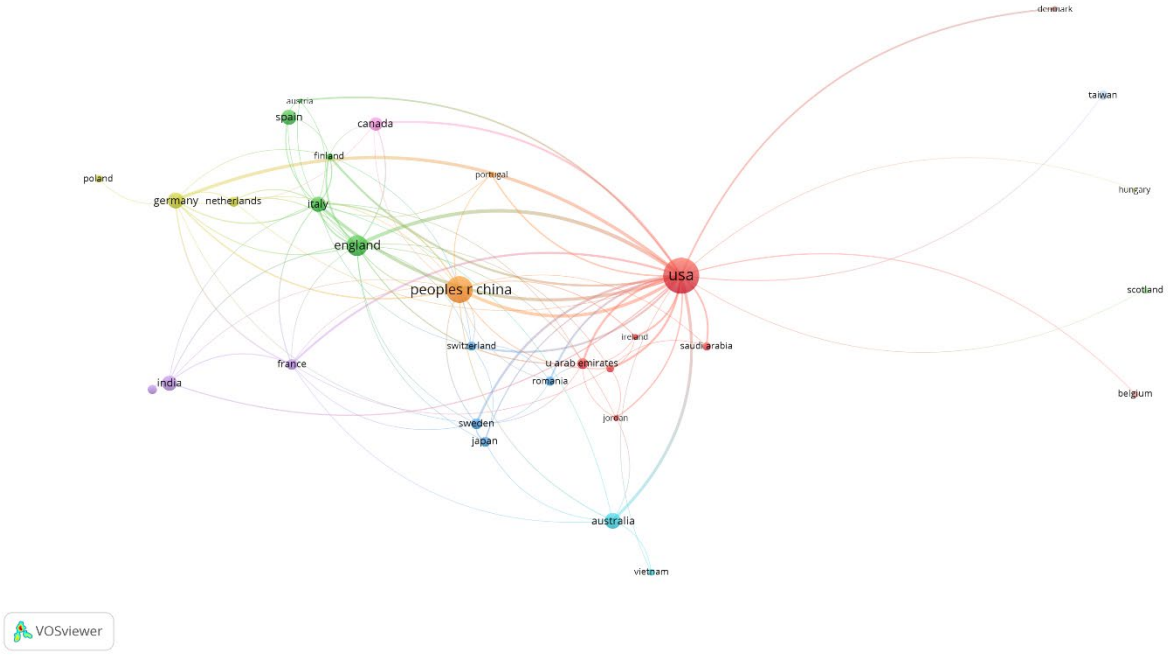

Figure 4. Countries with the most publications on AI in audit

Source: Authors' own research.

On a more detailed analysis, as shown in Table 5, the United States ranks first with the highest number of articles and citations. Researchers in the US have at least 2,516 citations per published paper, with 113 papers. The second place in the calculation of citations per article is the Netherlands with a number of 706 citations, for a number of 10 articles. In terms of number of articles, China ranks second with 60 articles and 482 citations. The next top countries in terms of number of citations are England, China and Canada, and in terms of number of articles are England and Australia.

Examination of citations on publications for the Netherlands and China shows that, although the number of articles published by China is more, the articles of the Netherlands are much more quoted, possibly contributing to the quality of the articles published.

Table 5. Countries with the most publications and number of citations

No	Country	Publication number	Citation number	Total link strenght
1	USA	113	(1700-2516)	276
2	United kingdom	41	601	75
3	Italy	20	399	57
4	China	60	482	51
5	Germany	24	149	43
6	Australia	23	280	27

No	Country	Publication number	Citation number	Total link strenght
7	Canada	17	445	23
8	Sweden	11	172	25
9	Switzerland	10	142	26
10	France	11	238	23
11	United Arab	11	117	18
12	Netherlands	10	706	15

Source: Authors' own research.

Conclusion

The paper presents the results of a bibliometric analysis on the impact of artificial intelligence on audit activity. Using the quantitative method and VOSviewer software, the analysis included 422 papers from the Web of Science database, published between 1992 and 2024, selected through rigorous filtering steps using audit words and artificial intelligence as filters.

The literature indicates that the use of artificial intelligence (AI) in auditing is rapidly expanding, significantly affecting the way audit processes and decision making in organizations are conducted. There is a global consensus that AI, especially through machine learning and Big Data, has the potential to revolutionize audit by automating repetitive tasks, improving the efficiency of data processing, and increasing overall productivity.

Starting from the research questions RQ.1, RQ.2 and RQ.3 that address artificial intelligence in the audit context, during the research, the analysis of the performance of the articles was carried out by means of a statistical analysis, to identify the research trends between 1992 and 2024. Thus, a notable increase in interest in this area was observed. With a total of 6,221 citations and an average of 14.74 citations per article, published papers demonstrate their significant impact and relevance. This trend is further validated by the Web of Science: H-index indicator evaluated at the date of this research at the value of 41, confirming that works in this field are frequently cited and used. In terms of productivity, AI audit research continues to grow, with an annual average of 23.44 published articles. Most of them focus on artificial intelligence and machine learning, followed by communication, economics and security systems. Geographically, the United States, China and England dominate the publication of these works, and in terms of number of citations, although they have fewer articles, the first places after the United States are occupied by the Netherlands and England.

At the same time, to answer the research questions, the bibliometric analysis was developed, which consisted of the analysis of citations, the co-occurrence of keywords, the analysis of the countries with the most publications, with the highest number of citations as well as the most cited and influential recent articles. In addition, content analysis was performed to identify research directions, objectives, methodologies, and key findings.

Automation and emerging technologies have the potential to significantly transform the audit profession but also pose risks to auditors' professional judgement and reasoning. Thus, this study provides a scientifically grounded but critical exploration of the ethical challenges posed by AI-based decision making in auditing. Our goal is to help researchers deepen the complexity of AI-driven decision-making processes and the ethical challenges they present.

Despite the inherent limitations of database selection, this study provides a solid basis for exploring the impact of artificial intelligence on the audit process. Future research could benefit

from extending this analysis by including additional databases and applying more diverse selection criteria to capture a wider range of perspectives.

In addition, priority should be given to ethical challenges and the impact on auditors' critical judgment. As AI becomes more and more present in the audit, it is essential to find a balance between automation and human involvement, ensuring that auditors retain their crucial role in the decision-making process. In this respect, future research should investigate in more detail the risks and benefits of such a balance and contribute to the development of innovative solutions that support not only the efficiency but also the integrity and transparency of audit processes.

In the long run, the integration of artificial intelligence into auditing could transform not only technical processes, but also the role of the auditor, moving towards close collaboration between people and technology. This could lead to a redefinition of the skills required by auditors, emphasizing the importance of critical analysis and strategic interpretation of data, along with the ability to understand and regulate technological complexity. In such a context, future studies should explore in depth how auditors' education and training should evolve to meet the challenges and opportunities offered by AI. These studies could provide the framework for implementing sustainable and responsible audit solutions, ensuring that the technology is used in a way that respects fundamental ethical principles and contributes to public confidence in financial systems.

This paper was co-financed by The Bucharest University of Economic Studies during the PhD program

References

Agrawal, A., Gans, J.S., & Goldfarb, A. (2019). The Economics of Artificial Intelligence: An Agenda. *Chicago Scholarship Online*, 23.

Appelbaum, D., Kogan, A., & Vasarhelyi, M.A. (2017). Big Data and Audit: Opportunities and Challenges. *Journal of Emerging Technologies in Accounting*, 14(1), 23-44.

Appelbaum, D., Nehmer, R.A., (2017). Using drones in internal and external audits: an exploratory framework. *Journal of Emerging Technologies in Accounting*, 14(1), 99-113.

Blösser, M., & Weihrauch, A. (2024). A consumer perspective of AI certification – the current certification landscape, consumer approval and directions for future research, *European Journal of Marketing*, 58(2), 441-470.

Broadus, R.N. (1987). Towards a definition of "Bibliometrics". *Scientometry*, 12, 373-379.

Camic, C. (1987). The Matter of Habit. *American Journal of Sociology*, 91 (5), 1039-1087.

Cao, M., Chychyla, R., Stewart, T., 2015. Big data analytics in financial statement audits. *Accounting Horizons,* 29 (2), 423-429

Couceiro B., Pedrosa I., & Marini A. (2020). The current state of artificial intelligence in the context of internal audit. *Iberian Conference 2020 on Information Systems and Technologies (CISTI'2020).*

Eulerich, A., & Eulerich, M. (2020). What is the value of internal auditing? A literature review on qualitative and quantitative perspectives. *Maandblad Voor Accountancy En Bedrijfseconomie,* 94(3/4), 83-92.

Financial Reporting Council (FRC). (2018). *The Use of Technology in Audit: Regulatory Developments and Considerations. Financial Reporting Council. Retrieved from https://www.frc.org.uk/* .

Financial Reporting Council (FRC) (2020). *The Impact of Emerging Technologies on Auditing. Financial Reporting Council.* Retrieved from https://www.frc.org.uk/;

Frey, C.B., & Osbourne, M.A. (2017). The future of employment: How susceptible are jobs to computerization?. *Technological Forecasting and Social Change*, 114, 254-280.

Gronsund, T., & Aanestad, M. (2020). Augmenting the algorithm: Emerging human-in-the-loop work configurations. *Journal of Strategic Information Systems*, 26 (2).

Garfield, E. (1972). Scientific citation index: a new dimension in indexing. *Science*, 178(4060), 471-479.

Goto, M., (2023). Anticipatory innovation of professional services: the case of audit and artificial intelligence. *Research Policy*, 52 (8), 104-828.

Issa, H., Sun, T., & Vasarhelyi, M.A. (2016). Research Ideas for Artificial Intelligence in Auditing: The Formalization of Audit and Workforce Supplementation. *Journal of Emerging Technologies in Accounting*, 13(2), 1-20.

Johnson, H. (2015). *Digging Up Dark Data: What Puts IBM at the Forefront of Insight Economy. Silicon Angle.* Retrieved from https://siliconangle.com/2015/10/30/ibm-is-at-the-forefront-of-insight-economy-ibminsight/.

Joseph, J., & Gaba, V. (2020). Organizational structure, information processing, and decision-making: a retrospective and road map for research. *Academy of Management Annals*, 14 (1), 267.

Kammerlander, N., Voss, C., & Zeschky, M. (2018). Artificial Intelligence and Innovation in Family Businesses: Opportunities and Challenges, *Family Business Review*;

Kohler, T., Lütjen, A., & Behrendt, S. (2021). Artificial Intelligence in Business: How Artificial Intelligence is Changing Business Models, Industries, and the Future of Work, *Journal of Business Research*.

Kokina, J., & Blanchette, S. (2019). Early evidence of digital labor in accounting: innovation with robotic process automation, *International Journal of Accounting Information Systems*, 35, 100-431.

Lehner, O. M., Ittonen, K., Silvola, H., Ström, E., & Wuhrleitner, A. (2021). Artificial Intelligence as Decision-Maker: A Conceptual Framework. *Journal of Artificial Intelligence Research*, 72(3), 77-102.

Li, H., An, H., Wang, Y., Huang, J. & Gao, X. (2016). Evolutionary features of academic articles co-keyword network and keywords co-occurrence network: based on two-mode affiliation network. *Physica A,* 450, 657-669.

Liao, H., Tang, M., Luo, L., Li, C., Chiclana, F. & Zeng, X.J. (2018). A bibliometric analysis and visualization of medical big data research. *Sustainability Journal (Switzerland),* 10 (1), 1-18.

Jarrahi, M.H. (2018). Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. *Business Horizons*, 61(4), 577–586.

Moll, J., & Yigitbasioglu, O. (2019). The Role of Big Data and Artificial Intelligence in the Future of Accounting and Audit. *International Journal of Accounting Information Systems*, 1.

Mulgan, T. (2018). Corporate agency and possible futures. *Journal of Business Ethics*, 154 (4), 916.

Munoko, I., Brown-Liburd, H.L., Vasarhelyi, M., (2020). Ethical implications of the use of artificial intelligence in auditing. *Journal of Business Ethics,* 167 (2), 209-234.

Nylén, D., & Holmström, J. (2015). Digital Transformation: A Framework for Business Model Innovation, *Proceedings of the 48th Hawaii International Conference on System Sciences.*

Obermeyer, Z., Powers, B.W., Vogeli, C., & Mullainathan, S. (2019). Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations, *Science*, 366(6464), 447-453.

Pedreschi, D., Ruggieri, S., & Turini, F. (2008). Discrimination-aware data mining. *Proceedings of the 14th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD)*, 560-568.

Pemer, F. (2021). The Digitalization of Professional Services: How Technology is Shaping the Future of the Accounting Industry. *International Journal of Accounting and Information Management*, 29(1);

Public Company Accounting Oversight Board (PCAOB) (2018). *Audit Implications of Emerging Technologies. PCAOB.* Retrieved from https://www.pcaobus.org/.

Raji, I.D., Smart, A., White, R.N., Mitchell, M., Gebru, T., Hutchinson, B., Smith-Loud, J., Theron, D., & Barnes, P. (2020). Closing the AI Accountability Gap: Defining an End-to-End Framework for Internal Algorithmic Auditing. *Proceedings of the 2020 conference on fairness, accountability, and transparency*, 33-44.

Salijeni, G., Samsonova-Taddei, A. & Turley, S. (2018). Big data and changes in audit technology: contemplating a research agenda, *Accounting and Business Research*, 1, 119.

Salijeni, G., Samsonova-Taddei, A., & Turley, S. (2021). Understanding how big data technologies reconfigure the nature and organization of financial statement audits: a sociomaterial analysis, *European Accounting Review*, 30 (3), 531-555.

Shamsul Alam, S. M., Rahman, M. M., & Uddin, M. N. (2021). The Role of Artificial Intelligence in Transforming Business Practices and Strategies. *International Journal of Advanced Science and Technology*.

Trajanov, D., Zdraveski, V., Stojanov, R., & Kocarev, L. (2018). Dark Data in the Internet of Things (IoT): Challenges and Opportunities. *Proceedings of the 7th Small Systems Simulation Symposium*, 1-8.

Van Eck, N.J. & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84 (2), 538.

van Dijk, M., Juels, A., Oprea, A., & Rivest, R.L. (2013). FLIPIT: The Game of "Stealthy Takeover". *Journal of Cryptology*, 26(4), 655-713.

Wassie, F.A., & Lakatos, LP (2024). Artificial intelligence and the future of the internal audit function, *Humanities and Social Sciences Communications*, 11(386).

Wang, T.W. (2022). The impact of emerging technologies on the accounting profession. *Pacific Accounting Review*, 34(1), 526-535.

World Economic Forum. (2020). *Report on the Future of Jobs 2020*. Retrieved from https://www.weforum.org/reports/the-future-of-jobs-report-2020.

Yang, J.Q. Blount, Y., & Amrollahi, A., (2024). Artificial intelligence adoption in a professional service industry: A multiple case study. *Technological Forecasting and Social Change*, 201.