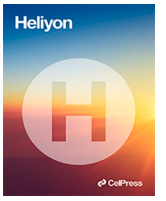
Heliyon 10 (2024) e32097

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Evolution of blockchain accounting literature from the perspective of CiteSpace (2013–2023)

Chengyu Liu [a], Volodymyr Muravskyi [b], Wenjun Wei [a,*]

[a] School of Economics and Management, Nanchang Institute of Science and Technology, Nanchang, 330108, China
[b] West Ukrainian National University, 11 Lvivska Street, Ternopil, 46009, Ukraine

ARTICLE INFO

Keywords:
Literature review
WoS
Blockchain accounting
Visualized analysis
CiteSpace

ABSTRACT

Against the backdrop of the Industrial Revolution 4.0, the advantages of blockchain technology in traceability, transparency, safety improvement, and efficiency improvement have made it possible to reduce the work of accounting personnel by 50 %, thus saving billions of dollars for global companies by combining this technology with accounting. However, the blockchain technology associated with accounting is in the experimental stage and has several problems to be solved including limited data processing capacity, information confidentiality, and regulatory difficulties. This innovation and progress in science and technology has provided more abundant, efficient, and professional technical support for the research of blockchain accounting documents. Among these advances, CiteSpace software has promoted the development of blockchain and accounting in the direction of visualization, comprehensiveness, security, and relevance. In this study, we used the knowledge map drawn by CiteSpace to search the core Blockchain Accounting database from 2013 to 2023 on the Web of Science (WoS). We obtained 1414 documents measured according to co-citation analysis, log-likelihood ratio (LLR) network clustering, co-occurrence keywords, and emergent time zone diagram method. We analyzed and summarized the important documents, research keywords, key research fields, and knowledge evolution related to "blockchain accounting" by network, literature integration, and popular research topics. We found that adopting blockchain technology in accounting information systems is expected to improve recordkeeping and reporting. Blockchain, as an innovative technology, provides a tamper-proof, traceable, and shareable platform for accounting information by using a distributed ledger system. By implementing blockchain, artificial intelligence can improve safety, transparency, and accuracy, and also may completely change the way we manage financial records. With its ability to improve overall efficiency and reduce errors, blockchain technology may change our familiar accounting methods. In addition, blockchain technology, intelligent contract, artificial intelligence, the Internet, information systems, and supply chain are the most important keywords, while blockchain technology, intelligent contract, and artificial intelligence are important components of blockchain accounting knowledge system. This research provided an important opportunity to advance the understanding of the crucial contribution of blockchain to the accounting field.

* Corresponding author.
E-mail address: weiwj@ncpu.edu.cn (W. Wei).

https://doi.org/10.1016/j.heliyon.2024.e32097
Received 29 February 2024; Received in revised form 23 May 2024; Accepted 28 May 2024
Available online 29 May 2024

1. Introduction

Over the past two decades, many accounting studies have explored the potential of cloud computing, artificial intelligence, and big data [1–4]. Integrating blockchain with accounting in the context of Industry Revolution 4.0 is expected to deliver significant benefits by disrupting market structures and business models across various industries. This technology is projected to eliminate 50 % of accountants' work and save companies billions of dollars worldwide as technological progress and digital innovation continue redefining the nature of accounting, auditing, and reporting [5]. Several articles suggest that blockchain technology brings advantages such as traceability, transparency, improved security, increased efficiency, automation, trust, auditability, and fewer risks of fraud or human error [6–9]. Recent reports from the BIG FOUR auditing firms claim that the accountants, auditors, and regulators are concerned about blockchain applications regarding initiating, processing, recording, reconciling, auditing, and reporting transactions [10–14].

Past studies increasingly focused on blockchain accounting, resulting in a rise in published papers, creating difficulties in understanding which specific they are focusing on and gaps missing in the literature. Previous studies on the efficiency of CiteSpace in blockchain analysis have shown its limitations. Some studies found that CiteSpace is quite useful for determining the core research topics in the blockchain field, whereas others have pointed out that it is not sufficient to obtain relevant information comprehensively. According to an analysis of the China HowNet database, the credit research of blockchain is concentrated primarily in the financial field, but the quality of the literature is uneven, the authors have lacked cooperation, and the application scope is limited, which have affected the accurate evaluation of research conducted in the blockchain field [15]. In contrast, Wang et al.'s research has made a quantitative statistical analysis on the related literature of intelligent accounting in the China National Knowledge Infrastructure (CNKI) and web of science (WoS) databases. According to the results, emerging digital technology will have an impact on research in the field of intelligent accounting, and the overall research is developing toward achieving the goal of realizing the decentralization of intelligent finance [16]. Additionally, through text mining and visual analysis of existing documents in the CNKI database, Li et al. found that big data, management accounting, financial sharing, cloud accounting, and blockchain technology have become popular research topics in recent years [17].

Moreover, there is a risk of overlooking critical questions and missing opportunities for enhancing research and practice. To overcome this challenge, a thorough field analysis using scientific econometric software or a literature review can provide a greater understanding of the particular research area. Reviewing the existing research makes identifying trends, gaps, and current research status possible, informing future research direction [18]. Notably, knowledge is dynamic, and scientific literature is continually evolving. Therefore, relying solely on non-visualization technology may not be sufficient to keep up with the latest developments in the field.

Recent advancements in science and technology have led to the development of several visualization tools, such as VOSviewer, CoPalRed, Bibexcel, Sci2, VantagePoint, and CiteSpace. These tools can support document co-citation analysis, keyword co-occurrence analysis, and quantify objective analysis of the relevant field literature. They are also valuable for establishing relationships between the various studies [19], as shown in Table 1. Guo et al. conducted a cluster and knowledge evolution analysis on Blockchain using CiteSpace and VOSviewer [20]. CiteSpace is a valuable software for scientific analysis that allows readers to better participate in and understand the overall situation in specific research areas and highlight critical documents [21]. The CiteSpace has been launched in more than 60 countries. Its version has been updated to ensure reliability, making it an effective tool for scientometrics [22].

Based on the WoS database, this research discusses the specific field of "blockchain accounting." The research results show that this field has become a popular research topic in recent years. Compared with traditional research on blockchain and accounting visualization, since the advent of blockchain technology in 2008, the focus of visualization research has not been limited just to the accounting field and also has been more widely used in the self-improvement of finance, supply chain, and blockchain technology. In recent years, research in the accounting field has focused mainly on the impact of technological progress on accounting, including financial sharing technology, cloud computing, and big data. In this study, we focus on the integration of blockchain technology and accounting and also discuss how to solve the information asymmetry problem in the accounting field by using blockchain technology. Because of the sample size, data collection methods, research design and other factors that may affect the research results, this study

Table 1
Analysis of knowledge mapping tools.

Tool name	Functional description
VOSviewer	Through the relationship construction and visual analysis of "network data" (mainly literature knowledge units), we can draw a map of scientific knowledge, showing the structure, evolution, and cooperation of the knowledge field, and apply it to large-scale sample data.
CoPalRed	Using co-word units to analyze documents can transform and refine existing knowledge and find new knowledge; in data preprocessing, keywords can be standardized.
Bibexcel	Mining macro data of literature provides users with functions of bibliometrics analysis, citation analysis, co-citation analysis, coupling analysis, clustering analysis, and data visualization.
Sci2	Modular tools used to study the scientific structure can analyze individual, local, and whole knowledge units from the perspectives of time, space, theme, network analysis, and visualization.
VantagePoint	Discovering patterns and relationships from a large number of structured data, and quickly determining knowledge content, it can enter almost all data formats and can also deal with different knowledge units in bibliographic data.
CiteSpace	Can track and study the hot spots and development trends in a certain field in the form of scientific knowledge maps, and understand the research frontiers and key paths, important documents, authors, and institutions in this research field by using the relationships among documents; its "appearance" helps the author to keep up with advancements in this field.

also has some limitations. Nevertheless, sorting out the research on blockchain technology and accounting in the past 10 years holds certain reference value for other scholars in this field.

This paper aims to advance the practical application of blockchain in the field of accounting based on existing literature, conducting deeper and more innovative research to explore the prospects for future development. The goal is to enrich the relevant literature on blockchain application in accounting, propose more innovative technical frameworks for its application in accounting, contribute to enhancing accounting transparency, reducing redundancy in accounting work, improving accounting efficiency, and providing more valuable potential directions for its future development. The remaining of this paper is organized as follows. Section 2 describes the research method. Section 3 discusses the results of citation analysis. The key conclusions are summarized in Section 4.

2. Research method

Blockchain accounting has recently become a hot spot in the field of accounting. Studying the existing literature can provide theoretical and practical insights into the development of this field. This study analyzes the WoS database to check published annual literature. We also used CiteSpace to analyze the co-citation documents, the key cluster, and the keywords of the existing literature between 2013 and 2023. Through this analysis, the readers gain a comprehensive understanding of the literature, including the relationship among them, the model of knowledge evolution, the current situation, and the prospects for the future. Although this paper does not provide a detailed analysis of all the blockchain accounting literature, it presents a similar result by checking the sample literature with higher reference values.

This study makes the following contributions: We present a comprehensive analysis of blockchain accounting literature from 2013 to 2023 using advanced functions of CiteSpace, such as document co-citation analysis, cluster analysis, and keyword co-occurrence analysis. This study also analyzed the literature on blockchain accounting obtained from 2013 to 2023 to develop the knowledge base and the knowledge domain of blockchain accounting. Moreover, we identify citation bursts on blockchain accounting and analyze their knowledge evolution to form a well-structured knowledge graph comprising knowledge base, knowledge domain, and knowledge evolution. The knowledge base consists of the keywords related to the research topic, while the knowledge domain refers to the concrete areas of interest in the research topic. Additionally, knowledge evolution pertains to the references of the evolutionary process in the concerned area, where citation bursts are expected to exist.

2.1. Data collection

On December 28, 2023, we collected articles related to blockchain and accounting from online databases version of WoS. We searched keywords, including "blockchain" and "accounting," in titles, abstracts, or keywords in the published documents. "Blockchain+" accounting is split into two keywords, blockchain, and accounting, considering singular and plural variations, lexical properties, and lexical meaning to avoid semantic multiplicity interference. Moreover, blockchain technology has evolved from blockchain 1.0 to blockchain 3.0, starting from the Bitcoin-based cash payment system. Three aspects should be covered when searching for related keywords. The first is blockchain 1.0, which includes bitcoin, cryptocurrency, digital currency, public chain, distributed ledger, and proof of work. The second is blockchain 2.0, which includes ether, smart contracts, federation chains, and byzantine fault tolerance mechanisms. The third is blockchain 3.0, which includes cross-chain, private chain, and prophecy machine. Accounting is also a critical keyword, and the principal function of accounting is to reflect and supervise the economic activities of a unit. Therefore, appropriate keywords related to accounting should effectively convey these functions and may include keywords such as accounting and financial reporting [23].

Document types such as articles, review articles, and proceeding papers were treated separately by being defined as different types of documents. Only original articles were chosen as the application data, which were found to be unique [24]. We also investigated the

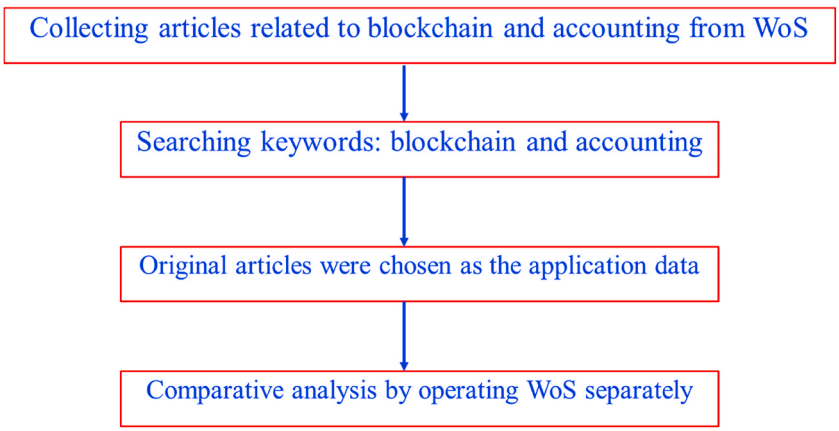


Fig. 1. The flow diagram of data collection.

completeness of the metadata of different document types in the WoS article data selection. By setting the time from 2013 to 2023, we collected all data related to blockchain accounting. We sourced the data from the WoS core databases from 2013 to 2023, and we set 2013 as the earliest appearance of blockchain accounting. The specific process is illustrated in Fig. 1.

Moreover, we operated the WoS separately to enhance better comparative analysis results because the documents collected may come from these databases and may be from different disciplines. We used the retrieval mentioned above strategy to extract 1414 articles from WoS core databases on May 22, 2018. The articles were downloaded and saved in "full record," " record content," and "cited reference," and the "file format" is "plain text." The count of documents for each year is illustrated in Fig. 2, indicating the number of documents per year represents the number of papers published over time in the field.

The discounted cumulative number of annual documents in Fig. 2 implies that the number of documents will increase rapidly annually before 2022. However, the number of documents published in the past four years tends to be stable at more than 150. Notably, blockchain accounting has increased from only 1 in 2013 to more than 245 documents in 2022, suggesting growing research interests in blockchain accounting. Fig. 1 illustrates a steadily increasing trend in the total documents from 1992 to 2022, confirming that blockchain accounting research has entered the stable growth stage and academic attention to blockchain accounting is growing.

2.2. Data analysis

This study uses the CiteSpace tool to draw the bibliographic map. Various maps, such as co-authors, co-cited documents, and co-occurrence keywords, are drawn using CreateSpace. Document co-citation network, clustering network, keyword co-occurrence network, and knowledge evolution pattern are mainly applied to analyze the bibliographic map of blockchain accounting.

Highly cited documents are identified using document co-citation analysis, and these documents are often considered the foundational literature of the research field. Two documents may be related to the same content if they are cited simultaneously. Through statistical clustering, closely related documents are identified and connected to the graph. From this observation, these clusters correspond to different knowledge nodes, and the same cluster corresponds to the research node, while shared interactive clusters reflect the association between them [25]. Moreover, analyzing keywords' co-occurrence networks can detect high-frequency keywords and central words in two documents to extract important key phrases within a particular time, forming a critical knowledge base for the blockchain accounting book. Another helpful approach is to use CiteSpace to identify references with strong citation peaks [26]. Articles with vital citations are the milestone in developing the blockchain accounting discipline. Finally, the nodes of strong bursts representing the paper's documents have received special attention in a particular period and can indicate the frontier and hot spots of the discipline [27].

3. Results of citation analysis

3.1. Knowledge domain in the core database

In scientific research, a knowledge domain refers to the scope and connotation of the knowledge of a discipline or specialty, covering the theoretical system, research methods, research direction, and academic achievements in this field [28]. At the same time, the core database refers to the main literature resource library that is widely recognized and frequently cited in a particular discipline [29]. These types of databases usually collect important journal articles, conference papers, and academic monographs in this field. The correlation between core database and the knowledge field lies in its collection of a large number of literature records, which reveal the whole picture of the corresponding knowledge field in detail. Researchers can use the core database for literature retrieval and analysis and can gain an in-depth understanding of key information, such as research trends, focus issues, and academic influence in this field. In addition, the core database provides a wealth of information, including literature citations, author data, and keywords, thus enabling researchers to review literature, explore knowledge, and communicate with each other [30].

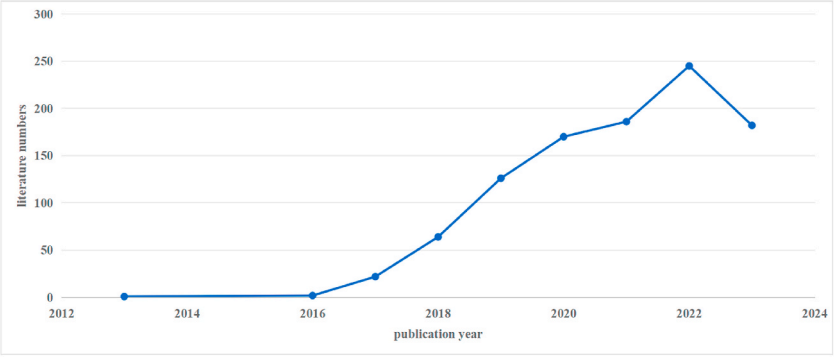


Fig. 2. The number of documents from 2013 to 2023.

3.1.1. Document Co-citation analysis

We analyzed the co-citation network related to blockchain accounting, entailing a network of 288 nodes and 946 links representing the most frequently cited documents in the core database [31]. On a node, each pointed link represents a co-citation relation between two nodes, and the volume of each node reflects the number of citations. In this process, a larger node represents higher citation frequency, implying a more critical document in the research field of blockchain accounting. CiteSpace divided the timeline from 2013 to 2023 into several periods, divided the periods into three years to get the analysis slice, and picked up the top 50 most frequently cited documents from each analysis slice. Afterward, this approach forms the co-citation network. Finally, we selected the top 10 highest-frequency co-cited documents from the network for further analysis. Fig. 3 presents the top 10 frequently co-cited articles, and Table 2 includes the details.

Using Blockchain to improve the existing accounting information system (AIS) record-keeping and reporting is promising. It offers a tamper-proof, traceable, and shareable accounting information system by adopting distributed ledger technology. Dai et al. developed a triple bookkeeping information system that considered blockchain a new accounting database capable of achieving automatic accounting processing and reporting using smart contracts [32]. Kokina et al. highlighted the potential of distributed ledger technology to achieve distributed consensus without relying on third parties, reduce transaction costs, and enhance trust. This technology has significant implications for the accounting field, transforming how invoices, payment processing, contracts, and documents are handled [35]. Schmitz et al. introduced the concept of shared books that address issues such as governance, transparency, and continuous auditing. Since accounting information covers the core information of an enterprise, privacy is a core concern for the enterprise and relevant users [34]. Bons proposed a private blockchain architecture that enables instant information sharing and enhances information integrity through automatic control and intelligent contract transactions [40].

Although discussions about the potential of blockchain are increasing, research related to blockchain in the field of accounting remains scarce and lacks systematicity. In the current accounting landscape, the impact of blockchain technology and its applications is still an emerging research area that has not received sufficient attention from scholars. There is an urgent need to fill this gap by conducting in-depth research on the potential and challenges of blockchain technology in accounting practice and research. In the design phase of blockchain accounting applications, researchers investigate how to integrate blockchain into the field of accounting, addressing issues such as designing data flows and architectures. These studies are not empirical; they require describing how the system should function. The most cited work in this field is the paper by Dai [32]. They primarily study the application of blockchain technology in the accounting domain, specifically adding a third record step to the traditional double-entry bookkeeping system. Their concept draws from Grigg's proposal that "receipts are the transactions," meaning digitally signed receipts of financial cryptographic data backup between parties can be viewed by a shared third party for transaction fraud prevention and reduction of redundancy in internal records. Initially, the triple-entry system requires transaction processing authorization from a neutral intermediary, with each party (the two parties involved in the transaction and the intermediary) creating a record for the transaction, totaling three records. However, this mechanism necessitates an independent and reliable intermediary to verify each transaction, and the records stored by

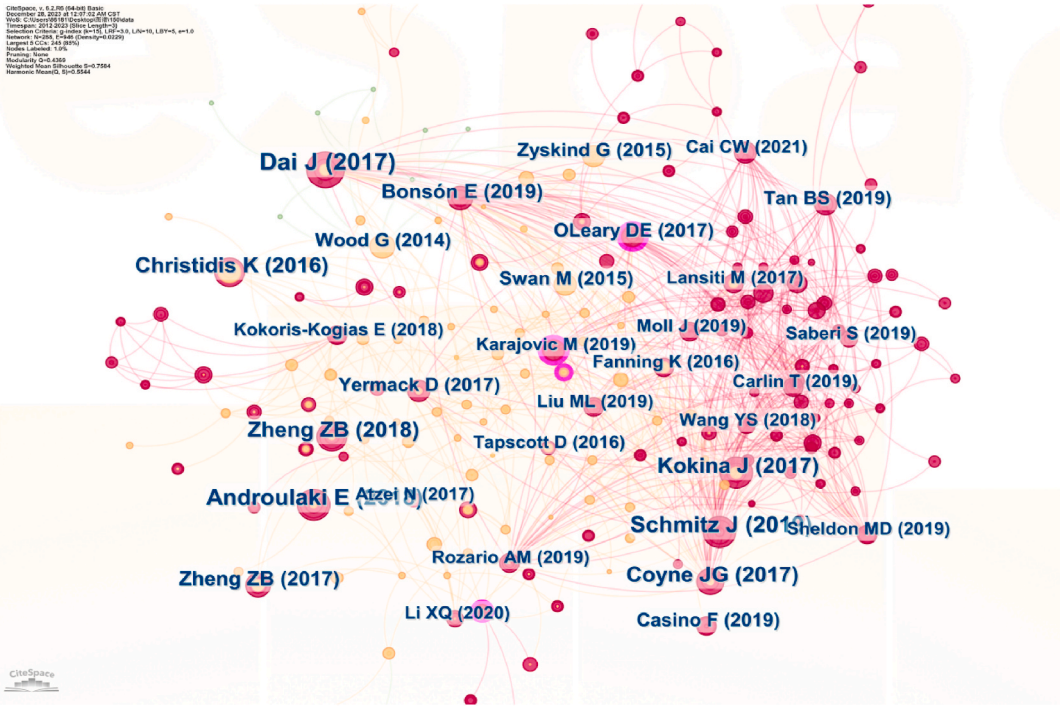


Fig. 3. Document co-citation network of blockchain accounting.

Table 2
Top 10 frequent co-cited documents in the blockchain accounting discipline.

Author	Title	Year	Freq	Source
Dai, J; M, Vasarhelyi	Towards blockchain-based accounting and assurance [32]	2017	78	Journal of Information Systems
Androulaki, E	Hyperledger fabric: a distributed operating system for permissioned blockchains [33]	2018	56	EuroSys'18: Proceedings of the Thirteenth EuroSys Conference
Schmitz, J.; G, Leoni	Accounting and auditing at the time of blockchain technology: a research agenda [34]	2019	56	Australian Accounting Review
Kokina, J; Mancha, R.; Pachamanova, D.	Blockchain: Emergent industry adoption and implications for accounting [35]	2017	53	J. Emerge. Techol. Account.
Zibin Zheng	Blockchain challenges and opportunities: a survey [36]	2018	53	International Journal of Web and Grid Services
Coyne, J.; P, McMickle	Can Blockchain serve an accounting purpose? [37]	2017	47	Journal of Emerging Technologies in Accounting
Christidis, K	Blockchains and Smart Contracts for the Internet of Things [38]	2016	46	IEEE Access
Zibin Zheng	An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends [39]	2017	40	IEEE International Congress on Big Data (BigData Congress)
Bonsón E	Blockchain and its implications for accounting and auditing [40]	2019	40	Meditari Accountancy Research
Swan M	Blockchain: Blueprint for a new economy [41]	2015	31	O'Reilly Media

the intermediary are also at risk of being lost or unauthorized alterations due to network attacks. Blockchain technology has the potential to improve this mechanism. It can act as an intermediary by distributing and automating the storage and verification process, providing a secure foundation to prevent tampering and irregular accounting entries. Due to the nature of blockchain, once an accounting entry is confirmed and added to the chain, it becomes difficult to alter or destroy. Furthermore, smart contract technology can swiftly verify transaction records based on accounting standards or predetermined business rules. By encoding the third accounting entry entering the blockchain, a transparent, encrypted, and self-verified accounting information system can be generated, facilitating reliable data sharing among business parties and continuous reporting to stakeholders. Building upon Grigg's research, Dai propose the application of trusted blockchain technology as a third party to implement the third record, storing information that is agreed upon and digitally signed by the parties involved in the transaction [32]. The primary achievement of Dai is introducing triple-entry bookkeeping into academic discussions about blockchain and accounting [32].

Incorporating blockchain technology into business administration can offer a more streamlined accounting information record-keeping approach. This practice allows for a more precise representation of reporting during production and operation activities. Zheng acknowledged that Blockchain possessed key characteristics of decentralization, persistence, anonymity, and auditability [39, 36]. Swan suggested that Blockchain be viewed as an integrated information technology similar to the Internet. They also proposed that Blockchain can be used for asset registration, inventory, and trading. The technology can combine centralized and decentralized modes and exist in a larger ecosystem, with its primary applications being in the fields of currency and payment. Additionally, blockchain 2.0 focuses on market and financial applications, such as smart contracts, while blockchain 3.0 encompasses blockchain governance, intellectual property protection, and digital authentication [41]. Christidis defines Blockchain as a decentralized, shared database that achieves consistency between nodes through a consensus mechanism. Each node updates its database by verifying transaction validity and referring to the previous block's hash value. Due to its unique features, blockchain has various applications, including asset transfer, tracking, and running code [38].

Distributed ledger technology is crucial for ensuring accounting responsibility and authenticity of accounting information in blockchain technology. According to Coyne et al., the coordination problem and identity verification in a distributed network are the primary focus when applying distributed blockchain to accounting [37]. Androulaki designed Hyperledger Fabric, a permissioned blockchain distributed operating system. This system evaluates the endorsement strategy for all transactions in the block to verify if they meet the endorsement strategy. After that, it checks the read-write conflicts for each transaction one by one, comparing the version of the key in the reading set with the version in the local ledger. Finally, it updates the account book, adds the block to the locally stored account book, and updates the blockchain status [33].

The future research trend will integrate blockchain, accounting, and AI, exploring their interactions and synergistic effects. This involves leveraging artificial intelligence techniques to analyze blockchain data, uncover patterns and trends, and combining smart contracts with AI technology to achieve more intelligent accounting processes and decision support. Future research may pay more attention to interdisciplinary studies and practical applications among blockchain, accounting, and artificial intelligence. This includes integrating blockchain accounting with disciplines such as finance, information technology, and law, exploring the applications of blockchain technology in various fields, and addressing specific problems and challenges encountered in practice.

3.1.2. Cluster identification and analysis (knowledge domain)

Highly cited documents will be identified through the document co-citation analysis, and we will categorize them into key research domains based on the noun phrases of each cluster. Using this process, we can select one cluster label based on the cluster's noun phrase. Different clustering label extraction methods used in CiteSpace include a log-likelihood ratio (LLR), term frequency-inverse document frequency of clustering label extraction, and mutual information test-clustering label extraction. Moreover, the LLR test is the default method for extracting cluster labels in CiteSpace. The likelihood ratio test is a statistical test that compares two nested

models, with the restricted model being a subset of the full model [42]. This information is based on a previous study using the bank risk management (BRM) LLR test [43].

We used the LLR clustering algorithm to cluster and analyze the keywords in this field, resulting in a keyword co-occurrence map. We selected 6 clusters with more content from this process to obtain the final map of keyword clustering analysis. Fig. 4 displays the clustering map presented by CiteSpace, showing that the biggest cluster is labeled as 0, and the smallest minimum cluster is labeled as 5. The cluster size indicates the number of papers that the cluster contains.

Table 3 lists the largest six clusters, using the CiteSpace software to analyze the results of clusters, where the Q value of clusters is 0.8118, indicating that the cluster's structure is significant. Additionally, the silhouette value in each cluster is greater than 0.94, indicating that the clustering results are robust and significant.

The biggest category, with 21 sources, is artificial intelligence (AI). The combination of AI technology and blockchain technology has dramatically improved the reliability and transparency of accounting information systems, guaranteeing the authenticity of transaction information, traceability, the shareholders' rights to master the financial information of corporations, and alleviating the issue of information asymmetry. Therefore, AI and Blockchain-based accounting models have brought financial data closer to real-time across currency cash flow, and integrating the Internet of Things can effectively close revenue recognition and cost fraudulent practices. The retrospective money cash flow can help avoid corporate-related transaction fraud to reinforce accounting information quality [44]. Moreover, blockchain can provide shared, verified, and consensus-driven auditable data, which can be audited using AI tools to make sense of traceable and auditable blockchain data. Han et al. used the agency and stakeholder theories to explain that the blockchain can be used in accounting to avoid information asymmetry and achieve multi-stakeholder participation, providing new possibilities for organizational patterns [45]. Similarly, Fang et al. have investigated the impact of blockchain technology adoption on the quality of the accounting information of listed companies in China. Their study found that blockchain technology has strengthened corporate governance and increased positive information loops with the Biggest Four auditing firms, leading to significant financial benefits and increased stock returns [46].

Cloud computing is the second largest cluster, with 20 articles indicating that blockchain technology in the accounting industry aims to solve three main issues: securing storage accounting information, appeasing storage capacity, and ensuring the trustworthiness of the access control system. Zhang and Zhu discussed secured storage information using blockchain, but it could not cater to the storage capacity. To tackle these problems, they have extended blockchain to cloud storage and improved privacy data shared by multiple users using the Paillier Cryptographic system. Ethereum's blockchain has also benefitted the cloud by ensuring data provenance and enabling better monitoring [47]. Khan et al. proposed an Ethereum-based blockchain model concerning data storage security in cloud computing [48]. The trustworthiness of the access control system is another critical issue. According to Rouhani.

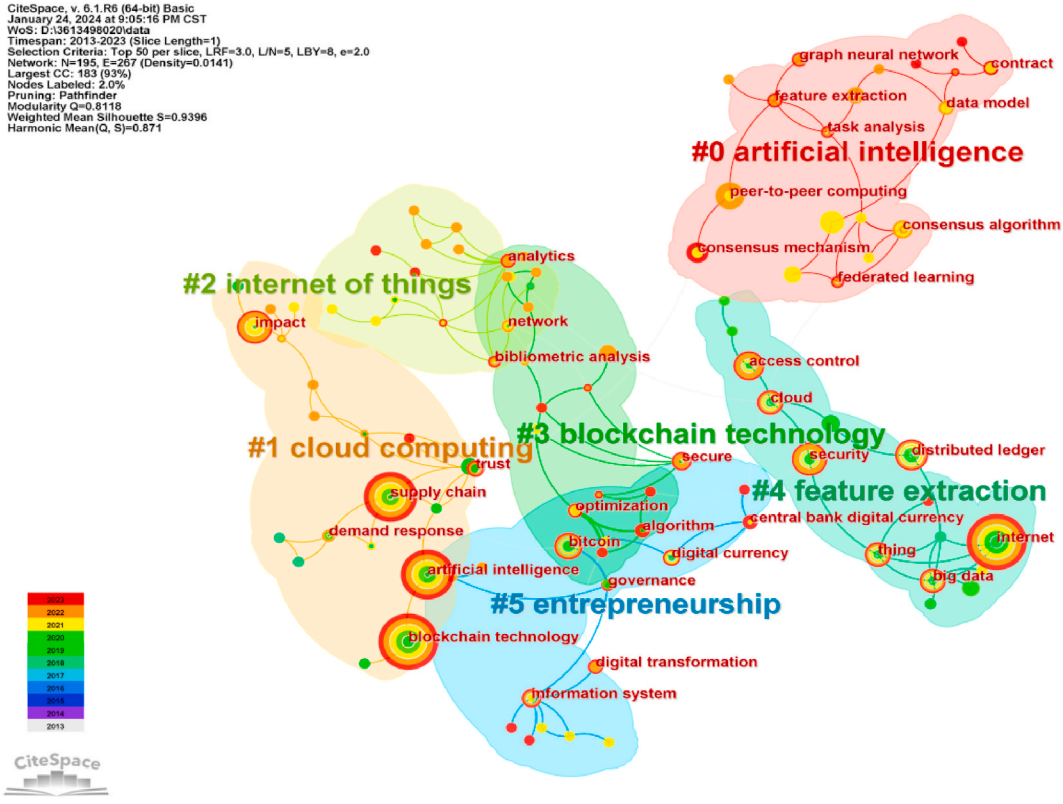


Fig. 4. Clusters of knowledge domain within blockchain accounting.

Table 3
Top-ranked clusters and the terms within the clusters. LLR-log-likelihood ratio.

NO	Size	Silhouette	Mean	Label (LLR) (p-value)
0	21	0.967	2021	artificial intelligence (14.69, 0.001); accounting information (10.13, 0.005)
1	20	0.908	2019	cloud computing (17.67, 1.0E−4); access control (13.45, 0.001); data sharing (13.28, 0.001); privacy protection (10.4, 0.005)
2	16	0.971	2021	Internet of things (42.15, 1.0E−4); smart contract (16.82, 1.0E−4)
3	16	0.841	2019	blockchain technology (24.78, 1.0E−4); distributed ledger technology (17.84, 1.0E−4); digital transformation (17.46, 1.0E−4)
4	16	0.931	2019	feature extraction (22.23, 1.0E−4); computational modeling (17.76, 1.0E−4); data models (17.05, 1.0E−4); peer-to-peer computing (15.92, 1.0E−4); collaborative work (13.31, 0.001)
5	15	0.876	2021	central bank digital currency (16.7, 1.0E−4); digital currency (13.67, 0.001); cbdc (12.03, 0.001); cryptocurrencies (6.68, 0.01)

et al., permission blockchains are an effective tool for auxiliary auditing with trustable backends in access control systems [49]. Creating a blockchain data-sharing platform is another way to share big data accounting information, involving extracting, transforming, and loading data from the accounting system for integration using the ETL tools. Then, the integrated data is standardized to ensure that different systems, such as unified naming and data format specifications, can understand and share data. In contrast, confidentiality and data integrity are maintained through encryption technology, access control, and data-sharing protocols. Additionally, rules and constraints for data sharing are defined for secure and reliable information sharing [50].

Developing a trading floor offers an avenue to merge the business and finance disciplines, as mentioned in one of the 16 articles in the third largest cluster, focusing on the Internet of Things, blockchain technology, and feature extraction.

Wu et al. constructed a new AIS model using the EABAT (Events Approach to Basic Accounting Theory) to build interrelationships among blockchain, the Internet of Things, and intelligent audits. The software testing as a service framework combined with the AIS model and iterative development can help achieve entire cycle automatic identification, automatic analysis/auditing and automatic judgment of contract, automatic execution of contract, automatic transmissions-data capture event information, recording and storing event information, generation of personalized financial information [51].

Emerging smart contracts can objectively evaluate the business' financial positions and reduce information asymmetry risks due to equal access to reliable financial information. Moreover, globally recognized accounting standards used as a reference for different countries will positively impact corporate executives. Using smart contacts will influence managers' thinking about information technology and its effects on financial reporting [52]. Nonetheless, business transactions are often innovative yet confusing, and financial statements are not remarkably clear-cut, making market participants suspicious of whether the insiders may use asymmetric private information to mislead stakeholders about the firms' earnings [53].

The emergence of computerized accounting in the 1980s marked a significant shift from manual accounting to the digital era. Blockchain technology is used in accounting to enhance the governance mechanisms of management accounting for manufacturing companies. As a result, digitization possesses a positive relationship with the regulation of the relationship between blockchain technology and the management accounting systems of manufacturing companies [54]. Applying blockchain technology to management accounting systems can reduce waste in production activities and create more sustainable results. In the digital age, accountants must undergo a digital transformation, and accounting professionals should focus on data analysis and decision-support abilities rather than traditional accounting thinking [55]. To achieve this aim, learning and mastering digital-related technologies, such as data analysis, artificial intelligence, and Blockchain, can enable individuals to identify problems from data, analyze trends, and make informed data-driven decisions [56]. Distributed ledger technology in accounting records will shift the focus of financial reporting from enterprise-centered to exchange-centered and significantly improve the quality and credibility of financial reports. Weigand et al. introduced the shared ledger design based on blockchain into the accounting information system. The study adopts the COFRIS (Core Ontology for Financial Reporting Information Systems) economic exchange model based on accounting ontology. This model combines the concept of economic exchange with accounting standards. Smart contracts are also introduced to automate and enforce shared account books [57].

The four fundamental features of Blockchain are designed to meet the requirements of constructing a new accounting model. Moreover, blockchain technology's decentralized nature has transformed fund-raising and investment activities. The supply and demand sides of funds can be directly connected at different nodes instead of depending on intermediaries to link the two sides using the client side of blockchain technology. In production and marketing activities, the payer signs the transfer amount and addresses it with their private key. Then, the signed transaction is broadcasted to the network with the public key during fund collection and payment. In addition, each node must decrypt the information with its private key to verify the transaction's legitimacy [58]. In profit distribution activities, smart contracts can now record the detailed rules of enterprise profit distribution stages on the blockchain and automatically implement them according to the rules. This game-changing development optimizes enterprises' profit distribution mechanism through benefit sharing and economic incentive distribution mechanisms [59]. Asymmetric encryption algorithms can also enhance the security of accounting information, while Merkle Trees can ensure the authenticity of the original voucher, making it difficult to be tampered with. In addition, distributed ledgers can improve the transparency of accounting information and effectively prevent the risk of financial fraud. Blockchain can now establish a trust relationship and build an open, transparent, complete, and self-auditing general ledger [60].

The rise of central bank digital currency is a topic of discussion, with 15 articles dedicated to it. Bitcoin issuance has enabled digital

currency to be a payment and investment tool in commercial transactions, and its property attributes have been recognized [61]. However, its market stability is poor, and its supervision is challenging due to its unofficial issuance. Therefore, countries have different opinions on confirming and measuring such new assets in financial statements [62]. The United States and Britain consider encrypted digital currency an intangible asset with an unlimited service life, measured at a historical cost [63].

On the other hand, Japan acknowledges virtual currency as an asset but does not classify it under any existing asset categories [64]. However, cryptocurrency transactions are prohibited in China [65]. The technical development, exploration, and application of cryptocurrencies, such as Bitcoin, have led to a digital currency breakthrough in the Central banks. Central banks are now exploring statutory digital currency with five essential functions of money: currency value stability, unlimited legal compensation, and the circulation of money freely in the market. Central banks use currency regulation as a crucial means of controlling circulation, which is universally accepted and can measure the value of goods worldwide [66]. With the help of electronic invoices and accounting files, real-time and rigorous digital currency bookkeeping is possible. Moreover, freeing accountants from essential and tedious work allows them to focus on accounting management [67].

3.1.3. Keyword Co-occurrence network (knowledge base)

This subsection comprehensively analyzes the relationship between keywords and the cores of documents in blockchain accounting research. We can identify the cores of blockchain accounting research by analyzing similar keywords. We also analyze synonyms and singular and plural words by merging their vocabulary. Fig. 5 presents a keyword co-occurrence network of 195 nodes and 267 links generated from the core database. The font size of the words is proportional to the co-occurrence frequency of the words [68].

Table 4 contains the top 30 co-occurring word pairs in the blockchain accounting research based on their keywords, identified by their severity index. Therefore, in this study, we screened out 30 high-frequency co-occurring keywords, and the total frequency of these keywords reached 1205. Among all of the co-occurring keywords, their total frequency reached 1643, which means that the 30 selected keywords cover 73 % (1205/1643) of the most popular research topics.

According to Table 4, the most frequently used keywords are blockchain technology (179 times), smart contract (141 times), AI (138 times), Internet (89 times), information system (87 times), and supply chain (78 times). Therefore, blockchain technology, smart contracts, and AI are the essential components of the blockchain accounting knowledge system.

The integration of accounting and information systems in enterprise management has been the focus of accounting computerization. Today, internet-based and platform-oriented businesses are the world's most valuable [69], and it is impossible to separate accounting from IT. Various IT tools such as enterprise resource planning (ERP) systems, big data, AI, blockchain technology, the Internet of Things, and cloud computing have been shown to improve accounting practices [70]. According to the Institute of Chartered Accountants in England and Wales (ICAEW; 2018), blockchain is considered accounting technology that facilitates the transfer of assets ownership and maintains an account of accurate financial information through a ledger built on trust in the systems' integrity [71]. Blockchain technology offers various benefits, such as providing up-to-date financial records, inventory records, and capital investments to relevant parties, including business partners, clients, auditors, and regulators. Moreover, businesses continually view current balance sheets, income statements, cash statements, inventory records, and capital investments [72,73], helping them to

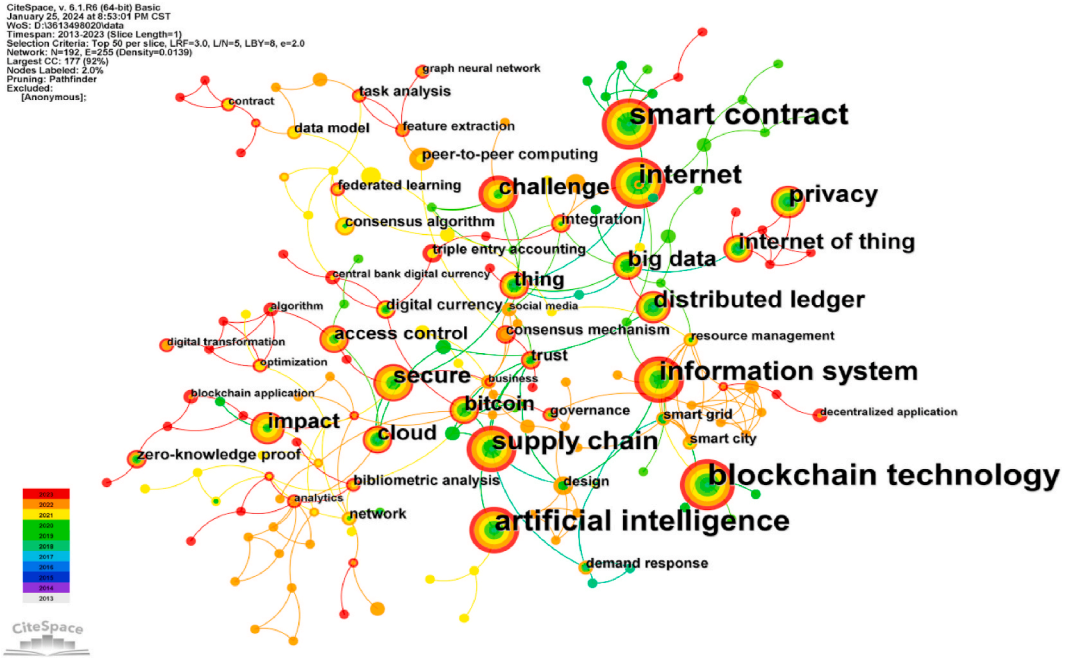


Fig. 5. Keywords co-occurrence network.

Table 4
Top keywords with their frequencies in blockchain accounting.

No.	Keywords	Freq.	No.	Keywords	Freq.
1	blockchain technology	179	16	thing	23
2	smart contract	141	17	access control	18
3	artificial intelligence	138	18	trust	12
4	internet	89	19	digital currency	10
5	information system	87	20	integration	10
6	supply chain	78	21	zero-knowledge proof	10
7	privacy	52	22	peer-to-peer computing	10
8	distributed ledger	47	23	network	9
9	secure	40	24	task analysis	8
10	challenge	39	25	bibliometric analysis	8
11	internet of thing	37	26	consensus mechanism	8
12	big data	37	27	consensus algorithm	8
13	impact	31	28	design	7
14	Cloud	29	29	federated learning	7
15	bitcoin	26	30	demand response	7

stay on top of their financial situation and make informed decisions about their operations.

Furthermore, the use of big data has expanded to include new types of data, such as video, audio, and image data from transactions [74]. Moreover, IT, such as AI, can produce high-quality accounting information without many fraudulent transactions among all industries with fragile internal control [75].

The combination of blockchain technology and accounting information technology has been researched extensively. The use of smart contracts, distributed ledger, peer-to-peer computing, consensus algorithms, and encryption algorithms in their technical design are highly related to the attributes of the accounting industry. Transparency, accurate distribution, immutability, and the distribution of computer logic blockchains are also critical aspects of research. Therefore, blockchain technology can significantly benefit companies by providing precise information symmetry, reducing ethical hazards through more excellent knowledge through technology, and helping eliminate some of the contractual tools via automated smart contracts [45]. Blockchain can also provide a real-time, verifiable, and transparent accounting ecosystem where everyone in the entire network, including managers, accountants, business partners, and investors, can collaborate to validate the transactions and provide reliable evidence for multi-party validation [76]. A decentralized distributed ledger platform uses the consensus mechanism by third parties to complete accounting records on the Blockchain by implementing electronic signatures, transaction records, and electronic certificates. These platforms make it much easier to integrate and share accounting information, allowing accounting information users to participate in generating accounting information. Standardizing accounting processes and digitalizing business operations have made integrating and sharing accounting information easier [77]. The agency theory perspective has profound implications for the future of data fraud and manipulation. Then, data manipulation is much more challenging within a blockchain as it uses smart contracts and precise recording of all data, which is validated on a multi-party secure consensus rather than individual bits. This characteristic of blockchain technology is ideal for preventing managers from easily manipulating data. Similarly, AI-powered systems are also highly effective at detecting subtle anomalies in a company's key financial drivers, making it nearly impossible for managers to hide financial fraud [78].

In accounting, ensuring maximum security management and minimizing risks are critical. Hackers often target computer accounting systems, and corporate accounting professionals emphasize the need to protect themselves from hacker attacks [79] because computer accounting systems carry a significant amount of information that can be the target of hackers. Therefore, many business accounting software were developed to secure data with a strong password [80]. Blockchain technology operates with decentralized accounting instead of being a centralized entity, allowing participants in the network to validate, approve, and record transactions [81]. Accountants often store their files online, but the difference lies in accountants having confidential customer data. Insecure practices like downloading and saving files locally and sharing them internally or with customers by email can expose sensitive data to hackers [82]. Instead, an accountant should use a secure and encrypted vault to share a secure and encrypted vault. Accountants should also be on alert to spear phishing and phishing attacks. Moreover, the company's employees must log in only with the hidden URL and passwords since the company's login credentials are stored in the password manager [83].

Keywords such as supply chain, digital currency, bitcoin, and integration are becoming increasingly crucial for businesses. Many enterprises are forming strategic alliances based on the supply chain through a 'horizontal integration' organizational model because neither core nor non-core enterprises can bear the risk of a supply chain shutdown. Supply chain accounting involves collecting, analyzing, and evaluating information to predict and identify potential risks and opportunities on time, enabling accurate evaluation of each link and the overall situation of supply chains, ultimately achieving cost control and efficiency [84,85]. Additionally, using blockchain to record the transactions in the consortium and generate the corresponding business documents and accounting records is becoming more popular. Finally, smart contracts can be used as the fire "entries" related to the credit terms of payables, which are then recorded on the blockchain [86]. These digital assets become easier to use and are increasingly popular, with some companies using the crypto assets as a means of payment or as investment alternatives [87]. This study found that current accounting standards may not cover digital currencies. A study found that the cryptocurrency's estimated market capitalization was approximately $200 billion in 2022 [88]. The Australian Accounting Standards Board (AASB) has recently defined digital currencies as either belongings or assets. Cryptocurrencies can be classified as belongings, inventory, money, or investments, depending on the reason for acquiring them. There

are also debates about whether cryptocurrency should be classified under the same asset class, such as being 'cash' (IAS 7 Statement of Cash Flows, 1994), 'inventory' (IAS 2 Inventory, 1991), 'financial instruments' (IFRS 9 Financial Instruments, 2018) or 'intangible assets' (IAS 38 Intangible Assets, 2004) [89]. Deloitte and KPMG suggest that digital currencies are more likely to be considered intangible assets for accounting purposes and more likely to meet the definition of property for tax purposes [12,90]. According to AASB, cryptocurrencies are measured at fair value, and changes in fair value are recognized through profit or loss [91]. Therefore, it is crucial to be familiar with blockchain technology, which is the technology that powers most digital currencies to develop relevant accounting and taxation standards and regulatory frameworks.

With the rapid development of information technology, especially the widespread application of artificial intelligence and blockchain, the accounting profession is facing unprecedented challenges and opportunities. These emerging technologies are characterized by efficiency, accuracy, and automation, greatly changing the way the accounting industry operates. Therefore, in the continuous development and application of AI and blockchain technology, the accounting profession needs to actively adapt to and utilize new technologies to improve the quality and efficiency of work. The impact of AI technology on the capabilities required by the accounting profession is mainly reflected in data analysis and processing abilities. AI technology can achieve automated data cleaning, classification, and organization, reducing the cumbersome workload of accountants and allowing them to focus more on data analysis and business decision-making. In addition, AI technology can also use big data and algorithm models for prediction and early warning, helping accountants to identify risks and issues in advance, and reducing the probability of errors and mistakes. Furthermore, the impact of blockchain technology on the capabilities required by the accounting profession is mainly reflected in information security and data sharing. The decentralized nature of blockchain technology can ensure the security and credibility of accounting information, reducing the possibility of data tampering and fraud. Accountants need to understand the principles and operation of blockchain technology to ensure the authenticity and integrity of data when processing accounting information. Moreover, blockchain technology also promotes the sharing and transparency of accounting information. Accountants need to be adept at using blockchain technology to achieve cross-organizational data sharing and collaboration, thereby enhancing the effectiveness and quality of accounting information. Lastly, the impact of AI and blockchain technology on the capabilities required by the accounting profession is also reflected in technical applications and innovation. Accountants need to continuously learn and master the relevant knowledge and skills of emerging technologies to adapt to the trend of rapid technological updates and developments. They need to be proficient in applying AI and blockchain technology to solve practical accounting problems, improving work efficiency and quality. At the same time, accountants also need to have innovative thinking and keen market insights to seize the opportunities brought by AI and blockchain technology, providing more value and services to businesses.

3.2. *Knowledge evolution of blockchain accounting*

Previous studies have analyzed the citation bust (or citation burst interval) in the top 25 references, sorting them through the three functions of CiteSpace. Sorting our references by starting time with the burst rather than by the strength of the burst is a reasonable choice, given there are two ways to display the burst on CiteSpace: sorting by starting time of the burst or sorting by the burst's strength.

All of these citation bursts started in 2017, as shown in Fig. 6. The sudden increase in the paper citation explosion of 2017 and 2020 can be attributed to various aspects related to data security and privacy protection, architecture design, decentralization, smart contracts, cryptocurrency, distributed ledger, and the use of blockchain to promote accounting growth. Zyskind et al. argued that

Fig. 6. Top 25 references with the strongest citation bursts.

sensitive data should never be handed over to third parties since they can be attacked or exploited. This goal can be accomplished by combining off-blockchain data storage with a blockchain repurposed as an access-control moderator. This platform allows businesses to safely use data without overly securing and compartmentalizing them [92].

Zheng et al. have discovered that Blockchain is highly effective when combined with big data. They also found that Blockchain can be utilized to securely store critical data as it operates on a distributed basis and ensures data authenticity [39]. Risius et al. also argued that users lack understanding about where and how to use blockchain technology effectively and its contribution to societal effects despite all high expectations [36]. Pilkington evaluated the advancement in blockchain technology to develop this taxonomy that can assist users in analyzing and designing software architectures using blockchain technology [93]. Xu et al. believed that the blockchain could bring about significant improvements in the performance and quality of architectural attention, such as usefulness, usability, versatility, expansion, information reconciliation, information quality, and security/privacy., required to outline and break down [94]. Antonopoulos provided attendees with technical details on Bitcoin and peer-to-peer cryptocurrencies. This paper reviews cryptography criteria, data structures, network protocols, and the consensus mechanism (’mining’) underpinning Bitcoin [95]. We also demonstrate that combining blockchain technology, multi-signature, and anonymous encrypted message propagation streams outperforms traditional trading solutions by presenting a feasible and reliable trading solution with more privacy and security [96].

According to Bahga and. Madisetti, smart contracts are "agreements" either on-chain or off-chain, whose execution, termination, and consequences are judged and enforced by a computer program. These "agreements" are modeled as a computer program indicating that a network of mutually distrusting nodes can correctly execute without needing an external trusted authority [97]. Any code that locks up and transfers assets must be implemented without bugs or back doors that could be exploited by looking to steal or tamper the assets [98]. Christidis argued that blockchains combined with IoT can be very powerful as they provide resilient, truly distributed peer-to-peer systems and the ability to interact with peers in a trustless, auditable manner. Smart contracts facilitate automated complex multi-step processes. The IoT ecosystem devices also deliver points of contact with the physical world. These combined devices automate time-consuming workflows, achieving cryptographic verifiability and significantly enhancing cost and time savings in the process [99].

The strength of the citation burst has been robust since 2021, with a lot of credit given to the articles of Wang et al., Carlin, Qasim et al., Pimentel et al., OLeary, and Cai. These works are related to real-time accounting, accounting curriculum reform, financial reporting for crypto assets, integration of accounting and supply chain, and triple-entry accounting. The first writings on blockchain technology discussed its potential to reduce redundant reconciliations by providing synchronized and identical transaction records and by improving information quality (Deloitte, 2016a, 2016b) [100,101]. Carlin suggests this is insufficient because a maturing blockchain may be as radical as the advent and adoption of double-entry accounting [102].

The accountancy profession had also realized that blockchains were more than just hype. However, much work must be done before the technology reaches its full potential. In 2018, there was a shift in practitioner literature from what blockchain can do at a high level to a deep dive into accounting and auditing for crypto-assets and auditing firms. Accounting scholars have observed a significant increase in the engagement of the accountant profession with various technologies [102,103]. The constant change in the business environment poses ongoing and ever-changing challenges for higher learning institutions as they produce employable graduates [104]. As this dilemma persists, the accounting industries can shift towards employing IT graduates with technical skills in blockchain, data analytics, and AI rather than accounting graduates. Therefore, academicians responsible for designing accounting curricula must seriously consider incorporating the latest technologies in their accounting curriculum. The sudden increase in the price of bitcoin and boom in initial coin offerings in 2017 (Cryptus, 2019) suggest that blockchains and crypto-assets are here to stay. Some publications have even suggested that the disintermediation of financial transactions could make the accountant obsolete [105]. Pimentel et al. focused on crypto-asset financial reporting considerations, including how to account for crypto assets held by entities [106]. O’Leary presented a hypothesis where the company used a single private blockchain to capture each of its accounting or supply chain transactions, rather than public or consortium blockchains. The article suggested that this process can be easily adopted in a context where the systems currently exist. This approach involves hashing portions of the ledger, checking for any changes in the halves, and maintaining information about that hashing if the halves changed [107]. The current double-entry accounting system businesses use has existed for over 600 years, and the emergence of blockchain and technology is disrupting the traditional accounting approach. However, adopting triple-entry accounting is a significant development in the accounting world. While single and double bookkeeping have been around for centuries, they come with limitations; this is where the triple-entry accounting system comes in. With blockchain and FinTech technologies, triple-entry accounting can provide high security and transparency, prevent errors and fraud, and establish a permanent accounting system with a traceable audit trail. This method combines the benefits of the existing double accounting system with blockchain technology to develop a permanent accounting system. McMickle incorporated the feasibility of blockchain into accounting practices, where blockchain is not currently practical in accounting due to three key limitations [108]. According to Cai, the first step is to have many nodes to establish a blockchain ecology, which requires a sufficient number of participants as a settlement layer, which Pacio meets. Second, a better solution must be developed to protect the privacy of records, such as zkLedger, which allows authorized auditors to verify transaction history data without revealing the content of the transaction. By moving from a ’double-entry system’ to a ’triple-entry system,’ Coyne and McMickle (2017) ’s second and third observations would become irrelevant [109].

The practical implications of blockchain and accounting research have significant relevance for professionals in the fields of accounting and finance. The application of blockchain technology can significantly improve the transparency and security of financial data [110]. Through distributed ledger technology, all transactions are recorded in an immutable database, eliminating the possibility of data tampering and fraud [111]. This means more reliable and accurate financial reporting for accounting professionals, enhancing trust among investors and regulators. The adoption of blockchain technology can lower transaction intermediary costs and time [112].

In the financial sector, smart contracts and distributed ledgers enable faster and more convenient transaction settlements, reducing the time and costs associated with traditional settlement methods [113]. This enables accounting professionals to handle transaction data more efficiently and improves the timeliness and accuracy of financial reporting. The adoption of blockchain technology may have profound effects on the auditing industry [114]. Due to the transparency and traceability of blockchain, auditors can more easily verify the authenticity and integrity of transactions, thereby reducing audit risks and costs. This prompts accounting professionals to reassess their audit methods and processes and strengthen their understanding and application of new technologies. The widespread application of blockchain technology will drive innovation and development in the financial industry. The application of smart contracts can automate financial transactions and contract execution, thereby enhancing the efficiency and accessibility of financial services [115]. Accounting professionals need to keep pace with these changes, continuously learning and adapting to new technologies to remain competitive and provide better services to clients.

3.3. Optimization of blockchain accounting theoretical model—new public double-entry ledger

It is evident that despite the increasing attention drawn to blockchain accounting research in recent years, progress in related studies has been slow. Many obstacles persist throughout the research process, and there remains a scarcity of detailed discussions on how blockchain specifically functions within the accounting domain. Among these, Dai's work undoubtedly provides substantial value. Dai proposes the utilization of "triple-entry accounting" as an independent and secure paradigm, leveraging smart contract technology to swiftly verify transaction records according to accounting standards or predetermined business rules [32]. Subsequently, the third accounting entry entering the blockchain is encoded, generating a transparent, encrypted, and self-verifying triple-entry accounting information system. This fosters reliable data sharing among business parties and sustains shareholder reporting. While scholars like Dai have explored and researched triple-entry accounting in blockchain accounting, areas for improvement persist. Therefore, building upon the literature review of blockchain accounting, we propose a more optimized theoretical model: the new public double-entry ledger. This novel theoretical model revolves around the design of a public double-entry ledger accounting information system, whereby businesses place all transactions on a blockchain with embedded Enterprise Resource Planning (ERP) functionality through smart contracts. The aim is to simplify business accounting procedures, enhance accounting efficiency, save time and labor costs, and ensure the reliability of corporate accounts.

From the perspective of accounting entities, the triple-entry accounting framework does not significantly improve accounting efficiency. Businesses not only have double-entry ledgers in ERP systems but also need to add a third accounting entry in the blockchain. In contrast, the new public double-entry ledger only requires transactions to be recorded in a journal entry format in the system to complete accounting processing, thus maximizing efficiency in accounting. Secondly, Dai's designed triple-entry accounting theoretical framework requires ERP as an intermediary. However, ERPs are costly, diverse in types, and vary in performance, making it difficult to achieve uniformity in accounting procedures and unfavorable for standardized accounting. In contrast, the new public double-entry ledger integrates ERP into the blockchain, striving to include ERP functionality within the blockchain to ensure that all entities in the system use a unified ERP, thereby ensuring the standardization of accounts. Thirdly, most scholars only focus on using blockchain to resolve conflicts and the Byzantine Generals' Problem among external parties of the enterprise but overlook how to handle conflicts among internal parties within the enterprise. As a result, their research on blockchain accounting often only discusses the handling of external business, while ignoring or avoiding internal business. However, the accounting treatment of internal business is equally important, and financial fraud within enterprises often occurs in internal business, posing risks to the reliability of corporate accounts. Dai's triple-entry accounting theoretical framework also falls into this category, as it only focuses on the research of external business of enterprises, lacking exploration of internal business. In contrast, the new public double-entry ledger theoretical framework can fill this gap.

The new public double-entry ledger theoretical framework integrates ERP systems into the blockchain and combines them with smart contracts and artificial intelligence technology to create fast, reliable, and reproducible processes. This eliminates the need for individual accounting by enterprises, as all transactions are recorded on the blockchain. This integration of information and processes within and between companies using blockchain, coupled with emerging technologies, aims to streamline and accelerate business processes, strengthen cybersecurity measures, and reduce or eliminate the need for intermediaries.

4. Conclusions

This study used bibliometrics to build a blockchain accounting knowledge graph using CiteSpace to visualize and analyze the knowledge base. The study was based on 1414 articles in the core library related to blockchain accounting based on the knowledge domain and knowledge evolution of blockchain accounting. Three main concepts of the knowledge graph for blockchain accounting are knowledge base, knowledge domain, and knowledge evolution. We derived the blockchain accounting knowledge keywords from the co-occurrence network. The major keywords for centrality analysis include blockchain, blockchain technology, smart contract, artificial intelligence, Internet of things, information system, supply chain, and the other 30 keywords with higher importance. Based on cluster analysis, the blockchain accounting knowledge domain can be divided into technical and management systems. Specifically, our blockchain research focuses on AI blockchain accounting, cloud computing, the Internet of Things, preference extraction, blockchain technology, and the Central bank's digital currency. The clusters are divided into a technical system and a management system. Specifically, the technical system aims to meet the needs of digital gradient accounting, while blockchain accounting project management involves cryptocurrency, supply chain, and digital assets. These two systems are critical features for the better application of blockchain accounting. In the early stages of blockchain accounting development, most of the attention is focused on data security

and privacy protection (2017) and architecture design (2018), smart contracts (2018–2020), cryptocurrencies (2018–2020), and distributed ledgers (2018–2020). Others research focus is the maturity of blockchain technology and its continuous deepening in the business field, real-time accounting (2021), accounting curriculum reform (2021), financial reporting for crypto assets (2021), accounting and supply chain mix (2021), and triple-entry accounting (2021). Moreover, the management system for blockchain accountings received extensive attention in 2021–2023.

By constructing the knowledge base, knowledge domain, and knowledge evolution of blockchain accounting, we can fully understand the knowledge frame and develop a course on blockchain accounting. A margin in blockchain accounting is a new and rapidly growing specialty. This new concept can change the knowledge base, model of the knowledge domain, and knowledge growth. A platform for blockchain accounting should be set up based on modern advanced information technology to speed up the development of blockchain accounting. By analyzing many literatures, this study found that the role of blockchain technology in the filling stage has not been fully explained. Therefore, future studies should focus on the all-round realization of blockchain accounting collaborative management in each phase, which will be combined with advanced information technology. This approach is to develop a more convenient and safe comprehensive information environment of accounting statements.

This study builds the knowledge graph for blockchain accounting with keywords, clusters, and citation bursts using the CiteSpace systematic quantitative analysis function. In the future, we aim to regularly update the data to conduct related research to improve the knowledge graph of blockchain accounting.

Data availability statement

All data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

Funding

This research received no external funding.

CRediT authorship contribution statement

Chengyu Liu: Writing – original draft. **Volodymyr Muravskyi:** Conceptualization. **Wenjun Wei:** Resources, Methodology, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We thank LetPub (www.letpub.com) for linguistic assistance and pre-submission expert review.

This paper was funded by the Strategies for Enhancing Innovative Thinking Ability in Landscape Architecture under the Background of New Agricultural Science (231106434205204) and Research on Strategies for Enhancing Accounting Professional Competence under the 1+X Certificate System Background (231105522204939).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32097.

References

[1] K.W. Chun, H. Kim, K. Lee, A study on research trends of technologies for industry 4.0; 3D printing, artificial intelligence, big data, in: Cloud Computing, and Internet of things[C]//Advanced Multimedia and Ubiquitous Engineering: MUE/FutureTech 2018 12, Springer, Singapore, 2019, pp. 397–403.

[2] J. Kumar, Integration of artificial intelligence, big data, and cloud computing with internet of things, Convergence of Cloud with AI for Big Data Analytics: Foundations and Innovation (2023) 1–12.

[3] H. Han, Z. Liu, X. Wang, et al., Research of the relations among cloud computing, internet of things, big data, artificial intelligence, block chain and their application in maritime field[C], J. Phys. Conf. 1927 (1) (2021) 012026. IOP Publishing.

[4] B.B. Gupta, D.P. Agrawal, S. Yamaguchi, et al., Advances in applying soft computing techniques for big data and cloud computing, Soft Comput. 22 (2018) 7679–7683.

[5] M.J. Casey, P. Vigna, Blockchain we trust, MIT Technology Review 121 (3) (2018) 10–16.

[6] M. Javaid, A. Haleem, R.P. Singh, et al., A review of Blockchain Technology applications for financial services, BenchCouncil Transactions on Benchmarks, Standards and Evaluations 2 (3) (2022) 100073.

[7] P. Dutta, T.M. Choi, S. Somani, et al., Blockchain technology in supply chain operations: applications, challenges and research opportunities, Transport. Res. E Logist. Transport. Rev. 142 (2020) 102067.
[8] R. Jothikumar, Applying Blockchain in Agriculture: A Study on Blockchain Technology, Benefits, and challenges[M]//Deep Learning and Edge Computing Solutions for High Performance Computing, Springer, Cham, 2021, pp. 167–181.
[9] S. Manski, Building the blockchain world: technological commonwealth or just more of the same? Strat. Change 26 (5) (2017) 511–522.
[10] S. Manski, Building the blockchain world: technological commonwealth or just more of the same? Strat. Change 26 (5) (2017) 511–522.
[11] Deloitte:The blockchain galaxy, a comprehensive research on distributed ledger technologies ,Available online: https://www2.deloitte.com/content/dam/Deloitte/it/Documents/financial-services/Deloitte_Blockchain_galaxy.pdf. (Accessed 5 February 2023).
[12] KPMG:Blockchain and digital currencies challenge traditional accounting and reporting models,Available online: https://assets.kpmg/content/dam/kpmg/bm/pdf/2018/10/defining-issues-18-13-blockchain.pdf. (Accessed 5 February 2023).
[13] PwC M.:Time for trust: How blockchain will transform business and the economy. Available online:https://www.pwc.com/gx/en/industries/technology/publications/blockchain-report-transform-business-economy.htm. (Accessed 5 February 2023).
[14] Brody, P.:Going Public: EY Global Blockchain Summit 2020,Ernst & Young.Available online:https://pub.ey.com/content/dam/ey-dam/public/documents/meeting-materials/KEYNOTE_Going%20Public_FINAL_EYG%20no.%20002210-20Gbl.pdf.(Accessed 5 February 2023).
[15] Y. Zhang, P. Zhu, Y. Kang, et al., Hot spots and trends of credit research based on blockchain technology—a CiteSpace visual analysis, Automation and Machine Learning 4 (3) (2023) 60–70.
[16] S. Wang, Y. Wang, Accounting and auditing research trends under the development of new information technology in the digital economy era based on CiteSpace[C], in: Proceedings of the 2nd International Conference on Bigdata Blockchain and Economy Management, ICBBEM 2023, 2023. May 19–21, 2023, Hangzhou, China.
[17] X. Li, J. Zhang, K. Nan, et al., An analysis of trends and problems of information technology application research in China's accounting field based on CiteSpace [C]//Advanced intelligent virtual reality technologies, in: Proceedings of 6th International Conference on Artificial Intelligence and Virtual Reality (AIVR 2022), Springer Nature Singapore, Singapore, 2023, pp. 217–236.
[18] L. Ferri, R. Spanò, G. Ginesti, et al., Ascertaining auditors intentions to use blockchain technology: evidence from the Big 4 accountancy firms in Italy, Meditari Account. Res. 29 (5) (2021) 1063–1087.
[19] J. Zuo, Z.Y. Zhao, Green building research–current status and future agenda: a review, Renew. Sustain. Energy Rev. 30 (2014) 271–281.
[20] Y. Shi, X. Liu, Research on the literature of green building based on the Web of Science: a scientometric analysis in CiteSpace (2002–2018), Sustainability 11 (13) (2019) 3716.
[21] Y.M. Guo, Z.L. Huang, J. Guo, et al., A bibliometric analysis and visualization of Blockchain, Future Generat. Comput. Syst. 116 (2021) 316–332.
[22] J. Zhu, W. Hua, Visualizing the knowledge domain of sustainable development research between 1987 and 2015: a bibliometric analysis, Scientometrics 110 (2) (2017) 893–914.
[23] H.N. Su, P.C. Lee, Mapping knowledge structure by keyword co-occurrence: a first look at journal papers in Technology Foresight, Scientometrics 85 (1) (2010) 65–79.
[24] Wang Ni, Wang Peng, Visual analysis of "blockchain+" accounting research at home and abroad, Finance and Accounting Monthly 44 (4) (2023) 69–78, https://doi.org/10.19641/j.cnki.42-1290/f.2023.04.009.
[25] Q. Yao, K. Chen, L. Yao, et al., Scientometric trends and knowledge maps of global health systems research, Health Res. Pol. Syst. 12 (2014) 1–20.
[26] I.I.C.C. CiteSpace, Detecting and visualizing emerging trends and transient patterns in scientific literature 57 (2006) 359–377, https://doi.org/10.1002/asi,20317.
[27] S.C. Wong, N. Abe, Stakeholders perspectives of a building environmental assessment method: the case of CASBEE, Build. Environ. 82 (2014) 502–516.
[28] H. Wang, X. Yan, H. Guo, Visualizing the knowledge domain of embodied language cognition: a bibliometric review, Digital Scholarship in the Humanities 34 (1) (2019) 21–31.
[29] X.R. Guo, X. Li, Y.M. Guo, Map** knowledge domain analysis in smart education research, Sustainability 13 (23) (2021) 13234.
[30] C. Xu, T. Yang, K. Wang, et al., Knowledge domain and hotspot trends in coal and gas outburst: a scientometric review based on CiteSpace analysis, Environ. Sci. Pollut. Control Ser. 30 (11) (2023) 29086–29099.
[31] C.M. Chen, Z.G. Hu, S.B. Liu, H. Tseng, Emerging trends in regenerative medicine: a scientometric analysis in CiteSpace, Expert Opin. Biol. Ther. 12 (2012) 593–608.
[32] J. Dai, M.A. Vasarhelyi, Toward blockchain-based accounting and assurance, J. Inf. Syst. 31 (3) (2017) 5–21.
[33] E. Androulaki, A. Barger, V. Bortnikov, et al., Hyperledger fabric: a distributed operating system for permissioned blockchains[C], in: Proceedings of the Thirteenth EuroSys Conference, 2018, pp. 1–15.
[34] J. Schmitz, G. Leoni, Accounting and auditing at the time of blockchain technology: a research agenda, Aust. Account. Rev. 29 (2) (2019) 331–342.
[35] J. Kokina, R. Mancha, D. Pachamanova, Blockchain: emergent industry adoption and implications for accounting, J. Emerg. Technol. Account. 14 (2) (2017) 91–100.
[36] Z. Zheng, S. Xie, H.N. Dai, et al., Blockchain challenges and opportunities: a survey, Int. J. Web Grid Serv. 14 (4) (2018) 352–375.
[37] J.G. Coyne, P.L. McMickle, Can blockchains serve an accounting purpose? J. Emerg. Technol. Account. 14 (2) (2017) 101–111.
[38] K. Christidis, M. Devetsikiotis, Blockchains and smart contracts for the Internet of things, IEEE Access 4 (2016) 2292–2303.
[39] Z. Zheng, S. Xie, H. Dai, et al., An overview of blockchain technology: architecture, consensus, and future trends[C], in: 2017 IEEE International Congress on Big Data (BigData Congress), Ieee, 2017, pp. 557–564.
[40] E. Bonsón, M. Bednárová, Blockchain and its implications for accounting and auditing, Meditari Account. Res. 27 (5) (2019) 725–740.
[41] M. Swan, Blockchain: Blueprint for a New economy[M], O'Reilly Media, Inc, 2015.
[42] T. Dunning, Accurate methods for the statistics of surprise and coincidence, Comput. Ling. 19 (1993) 61–74.
[43] S. Gao, H. Gu, G.A. Buitrago, et al., Will off-balance-sheet business innovation affect bank risk-taking under the background of financial technology? Sustainability 15 (3) (2023) 2634.
[44] W Zhang, M Zhu, Environmental Accounting System Model Based on Artificial Intelligence Blockchain and Embedded Sensors, Computational Intelligence & Neuroscience (2022).
[45] H. Han, R.K. Shiwakoti, R. Jarvis, et al., Accounting and auditing with blockchain technology and artificial Intelligence: a literature review, Int. J. Account. Inf. Syst. 48 (2023) 100598.
[46] B Fang, X Liu, C Ma, et al., Blockchain technology adoption and accounting information quality, Accounting & Finance 63 (4) (2023) 4125–4156.
[47] W. Zhang, M. Zhu, Environmental accounting system model based on artificial intelligence blockchain and embedded sensors, Comput. Intell. Neurosci. (2022) 2022.
[48] N. Khan, H. Aljoaey, M. Tabassum, et al., Proposed model for secured data storage in decentralized cloud by blockchain ethereum, Electronics 11 (22) (2022) 3686.
[49] S. Rouhani, R. Belchior, R.S. Cruz, et al., Distributed attribute-based access control system using permissioned Blockchain, World Wide Web (2021) 1–28.
[50] S.L. Lambert, B.I. Davidson, S.A. LeMay, Survey of emerging blockchain technologies for improving the data integrity and auditability of manufacturing bills of materials in enterprise resource planning, J. Emerg. Technol. Account. 20 (2) (2023) 119–134.
[51] J. Wu, F. Xiong, C. Li, Application of Internet of Things and blockchain technologies to improve accounting information quality, IEEE Access 7 (2019) 100090–100098.
[52] S. Demirkan, I. Demirkan, A. McKee, Blockchain technology in the future of business cyber security and accounting, Journal of Management Analytics 7 (2) (2020) 189–208.
[53] C.C. Chou, N.C.R. Hwang, G.P. Schneider, et al., Using smart contracts to establish decentralized accounting contracts: an example of revenue recognition, J. Inf. Syst. 35 (3) (2021) 17–52.

[54] N.M. Nguyen, M. Abu Afifa, D. Van Bui, Blockchain technology and sustainable performance: moderated-mediating model with management accounting system and digital transformation, Environ. Dev. Sustain. (2023) 1–23.
[55] E. Huerta, S. Jensen, An accounting information systems perspective on data analytics and Big Data, J. Inf. Syst. 31 (3) (2017) 101–114.
[56] M.C. Tavares, L.N. Zimba, G. Azevedo, The implications of industry 4.0 for the auditing profession, Int. J. Bus. Innovat. (2022) e27625.
[57] H. Weigand, I. Blums, J. de Kruijff, Shared ledger accounting—implementing the economic exchange pattern, Inf. Syst. 90 (2020) 101437.
[58] Yixi Lian, Blockchain research report: how far from trust machine to industrial wave, Development Research 8 (2018) 16–29.
[59] Li Kehong, Research on accounting model and application based on blockchain technology, Finance and Accounting Monthly (16) (2020) 76–81.
[60] Shuying Jin, Peng Wang, Zichen Zhang, Optimisation of accounting information generation path based on blockchain technology, Finance and Accounting Monthly 11 (2020) 76–82.
[61] C. Irina, Cryptocurrencies legal regulation, BRICS law journal 5 (2) (2018) 128–153.
[62] K Balakrishnan, A Ertan, Banks' financial reporting frequency and asset quality[J], The Accounting Review 93 (3) (2018) 1–24.
[63] K V Tu, M W Meredith, Rethinking virtual currency regulation in the Bitcoin age[J]. Wash, L. Rev. 90 (2015) 271.
[64] Bitcoin–a Currency or an Asset,2019.
[65] J. Riley, The current status of cryptocurrency regulation in China and its effect around the world[J]. China and WTO Review 7 (1) (2021) 135–152.
[66] Shanshan Lu, Analysing the impact of legal digital currency - based on the perspective of central banks, Financial Supervision (7) (2022) 100–104.
[67] A. Faccia, P. Petratos, Blockchain, enterprise resource planning (ERP) and accounting information systems (AIS): research on e-procurement and system integration, Appl. Sci. 11 (15) (2021) 6792.
[68] J.W. Schneider, Mapping scientific frontiers: the quest for knowledge visualization, J. Am. Soc. Inf. Sci. Technol. 55 (2004) 363–365.
[69] M. Iansiti, K.R. Lakhani, The truth about Blockchain, Harv. Bus. Rev. 95 (1) (2017) 118–127.
[70] P. Booth, Z. Matolcsy, B. Wieder, The impacts of enterprise resource planning systems on accounting practice–the Australian experience, Aust. Account. Rev. 10 (22) (2000) 4–18.
[71] ICAEW:Blockchain and the future of accountancy.Available online:https://www.icaew.com/technical/technology/blockchain/blockchain-articles/blockchainand-the-accounting-perspective. (Accessed 6 February 2024).
[72] Y. Cong, H. Du, M.A. Vasarhelyi, Technological disruption in accounting and auditing, J. Emerg. Technol. Account. 15 (2) (2018) 1–10.
[73] S.S. Smith, Implications of next step blockchain applications for accounting and legal practitioners: a case study. Austr. Account, Business Fin. J. 12 (4) (2018) 77–90.
[74] J.D. Warren, K.C. Moffitt, P. Byrnes, How big data will change accounting, Account. Horiz. 29 (2) (2015) 397–407.
[75] S. Askary, N. Abu-Ghazaleh, Y.A. Tahat, Artificial Intelligence and Reliability of Accounting information[C]//Challenges and Opportunities in the Digital Era: 17th IFIP WG 6.11 Conference on E-Business, E-Services, and E-Society, I3E 2018, Kuwait City, Kuwait, October 30–November 1, 2018, Proceedings 17, Springer International Publishing, 2018, pp. 315–324.
[76] J. Dai, M.A. Vasarhelyi, Toward blockchain-based accounting and assurance, J. Inf. Syst. 31 (3) (2017) 5–21.
[77] Pengcheng Qiao, Exploring the logical relationship between distributed ledger (Blockchain) and accounting theory, Finance and Accounting Monthly (18) (2021) 55–61, https://doi.org/10.19641/j.cnki.42-1290/f.2021.18.008.
[78] P. Centobelli, R. Cerchione, P. Del Vecchio, et al., Blockchain technology design in accounting: game changer to tackle fraud or technological fairy tale? Account Audit. Account. J. 35 (7) (2022) 1566–1597.
[79] A.S. Dunk, Product life cycle cost analysis: the impact of customer profiling, competitive advantage, and quality of IS information, Manag. Account. Res. 15 (2004) 401–414.
[80] A. Hayes, The socio-technological lives of bitcoin. Theory cult, Soc 36 (2019) 49–72.
[81] E. Abad-Segura, A. Infante-Moro, M.D. González-Zamar, et al., Blockchain technology for secure accounting management: research trends analysis, Mathematics 9 (14) (2021) 1631.
[82] L. Tauscher, S. Greenberg, How people revisit web pages: empirical findings and implications for the design of history systems, Int. J. Hum. Comput. Stud. 47 (1997) 97–137.
[83] L. Shi, X. Li, Z. Gao, P. Duan, N. Liu, H. Chen, Worm computing: a blockchain-based resource sharing and cybersecurity framework, J. Netw. Comput. Appl. 185 (2021) 103081.
[84] B.M. Beamon, Measuring supply chain performance, Int. J. Oper. Prod. Manag. 19 (3) (1999) 275–292.
[85] C. Shepherd, H. Günter, Measuring supply chain performance: current research and future directions, Int. J. Prod. Perform. Manag. 55 (3/4) (2006) 242–258.
[86] M. Liu, A. Robin, K. Wu, et al., Blockchain's impact on accounting and auditing: a use case on supply chain traceability, J. Emerg. Technol. Account. 19 (2) (2022) 105–119.
[87] I. Munteanu, K.A. Aivaz, A. Micu, et al., Digital transformansformations imprint financial challenges: accounting assessment of crypto assets and building resilience in emerging innovative businesses, Econ. Comput. Econ. Cybern. Stud. Res. 57 (3) (2023).
[88] N. Alsalmi, S. Ullah, M. Rafique, Accounting for digital currencies, Res. Int. Bus. Finance 64 (2023) 101897.
[89] R. Darbyshire, Accounting Issues for Central Bank Digital Currencies[J], 2020. Available at:. (Accessed 20 February 2022).
[90] Deloitte:Cryptocurrency: Financial reporting implications,Available online:https://www.iasplus.com/en/publications/global/thinking-allowed/2018/thinkingallowed-cryptocurrency-financial-reporting-implications. (Accessed 23 February 2022).
[91] A. Zubir, et al., Cryptocurrency technology and financial reporting, Int. J. Manag. Humanit. (IJMH) 4 (9) (2020) 103–108.
[92] G. Zyskind, O. Nathan, Decentralizing privacy: using Blockchain to protect personal data[C]//2015 IEEE security and privacy workshops, IEEE (2015) 180–184.
[93] A. Dorri, S.S. Kanhere, R. Jurdak, et al., Blockchain for IoT security and privacy: the case study of a smart home[C], in: 2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), IEEE, 2017, pp. 618–623.
[94] X. Xu, I. Weber, M. Staples, et al., A taxonomy of blockchain-based systems for architecture design[C], in: 2017 IEEE International Conference on Software Architecture (ICSA), IEEE, 2017, pp. 243–252.
[95] A.M. Antonopoulos, D.A. Harding, Mastering bitcoin[M], O'Reilly Media, Inc, 2023.
[96] N.Z. Aitzhan, D. Svetinovic, Security and privacy in decentralized energy trading through multi-signatures, Blockchain and anonymous messaging streams, IEEE Trans. Dependable Secure Comput. 15 (5) (2016) 840–852.
[97] A. Bahga, V.K. Madisetti, Blockchain platform for industrial Internet of things, J. Software Eng. Appl. 9 (10) (2016) 533–546.
[98] N. Atzei, M. Bartoletti, T. Cimoli, A survey of attacks on ethereum smart contracts (sok), in: International Conference on Principles of Security and Trust, Springer, Berlin, Heidelberg, 2017, April, pp. 164–186.
[99] K. Christidis, M. Devetsikiotis, Blockchains and smart contracts for the Internet of things, IEEE Access 4 (2016) 2292–2303.
[100] Deloitte:Lease, a Guide to IFRS 16,Available online: https://www2.deloitte.com/content/dam/Deloitte/sg/Documents/audit/sea-auditIFRS-16-guide.pdf. (Accessed 8 November 2017).
[101] Deloitte:New IFRS 16 leases standard, The impact on business valuation,Available online:https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/mergers-acquisitions/deloitte-nl-ma-ifrs16-impactonbusinessvaluation1.pdf. (Accessed 25 April 2018).
[102] T. Carlin, Blockchain and the journey beyond double entry, Aust. Account. Rev. 29 (2) (2019) 305–311.
[103] Y. Wang, A. Kogan, Designing confidentiality-preserving Blockchain-based transaction processing systems, Int. J. Account. Inf. Syst. 30 (2018) 1–18.
[104] A. Qasim, F.F. Kharbat, Blockchain technology, business data analytics, and artificial intelligence: use in the accounting profession and ideas for inclusion into the accounting curriculum, J. Emerg. Technol. Account. 17 (1) (2020) 107–117.
[105] Cryptus E.,Available online:https://bitcoinist.com/2017s-ico-boom-was-the-bubble-that-will-never-recover/(Accessed 25 April 2023).
[106] E. Pimentel, E. Boulianne, Blockchain in accounting research and practice: current trends and future opportunities, Account. Perspect. 19 (4) (2020) 325–361.

[107] D.E. O'Leary, Configuring blockchain architectures for transaction information in blockchain consortiums: the case of accounting and supply chain systems, Intell. Syst. Account. Finance Manag. 24 (4) (2017) 138–147.
[108] J.G. Coyne, P.L. McMickle, Can blockchains serve an accounting purpose? J. Emerg. Technol. Account. 14 (2) (2017) 101–111.
[109] C.W. Cai, Triple-entry accounting with Blockchain: how far have we come? Account. Finance 61 (1) (2021) 71–93.
[110] Wang Q, Ren F, Li R. Exploring the impact of geopolitics on the environmental Kuznets curve research,Sustainable Development,2023.
[111] Q. Wang, R. Huang, The impact of COVID-19 pandemic on sustainable development goals–a survey, Environ. Res. 202 (2021) 111637.
[112] Q. Wang, R. Li, L. Zhan, Blockchain technology in the energy sector: from basic research to real world applications, Computer Science Review 39 (2021) 100362.
[113] Q. Wang, M. Su, Integrating blockchain technology into the energy sector—from theory of blockchain to research and application of energy blockchain, Computer Science Review 37 (2020) 100275.
[114] Q. Wang, M. Su, R. Li, Is China the world's blockchain leader? Evidence, evolution and outlook of China's blockchain research, J. Clean. Prod. 264 (2020) 121742.
[115] Q. Wang, M. Su, M. Zhang, et al., Integrating digital technologies and public health to fight Covid-19 pandemic: key technologies, applications, challenges and outlook of digital healthcare, Int. J. Environ. Res. Publ. Health 18 (11) (2021) 6053.