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An overview of blockchain research and future agenda: Insights from structural topic modeling

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ABSTRACT

As a disruptive technology, blockchain has become a strategic priority for many businesses. A vast amount of research exists on blockchain's innovative nature and immense potential for multiple industries. This study aims to synthesize the existing research to classify the findings into various themes and propose avenues for further research. A total of 2,360 academic articles were analyzed using the text-mining method of structural topic modeling. The identified fifteen topics were mapped to the four quadrants of the Datatopia model, leading to the development of the Datatopia-blockchain (DBlock) framework. The results present future scenarios that provide an understanding of what is known about blockchain, its characteristics, and potential research areas. The contributions to the theory and implications to the practitioners are discussed in detail.

Introduction

Blockchain is a disruptive technology that has become a strategic priority for many businesses (Chittipaka et al., 2023; Pawczuk et al., 2020). The technology is expected to contribute 1.76 trillion USD to the global economy by 2030 (Davies, 2020). The trust issues with the existing technologies inspired practitioners and governments to focus on alternative options such as blockchain (Rainie & Anderson, 2017; Tan & Saraniemi, 2023). It is a decentralized, transactional database technology that facilitates validated and consistent transactions across numerous participants (Beck et al., 2018). Technology is known for its transparency and traceability, which drive significant innovations across diverse domains, including crowdfunding and supply chain (Agi & Jha, 2022; Aslam et al., 2021). Furthermore, blockchain and NFTs in real estate emphasize their capability to fractionate and track assets (Chen et al., 2024; Souza et al., 2024). A vast amount of research exists on blockchain's innovative nature and potential, highlighting the need for studies to synthesize and integrate the existing research to identify emerging possibilities (Nguyen & Nguyen, 2023; Toufaily et al., 2021).

Recent research has focused on various aspects of blockchain. For example, some research scholars highlight the benefits of the decentralized nature of blockchain applications (Zheng et al., 2022), while others focus on challenges like transparency and flexibility in its scalability (Sheikh & Sifat, 2024). A literature review of 443 articles from 77 Information Systems journals (2016 to 2022) reflected highly skewed research on blockchain system design (Lei & Ngai, 2023). However, the impact of recent advancements in blockchain on society and its immense prospective across industries has not yet been explored in detail (Sheikh & Sifat, 2024).

A vast amount of research has examined the role of blockchain across industries such as agriculture (Sharma et al., 2022), supply chain (Jain et al., 2020), food safety (Yadav et al., 2023) and E-Waste (Chaudhary et al., 2021). Blockchain has numerous applications to improve efficiency (Charles et al., 2023; Chittipaka et al., 2023), accuracy (Gauthier & Brender, 2021), and sustainability (Treiblmaier & Garaus, 2023; Vu et al., 2023). However, on the negative side, it may raise concerns about privacy (Chenthara et al., 2020) and security (Warkentin & Orgeron, 2020). Furthermore, many questions need to be answered about the future of blockchain and its acceptance in society. Hence, there is a need to integrate the fragmented research, particularly emphasizing social acceptance of technology, its characteristic, and avenues for future research. Thus, this study aims to answer the following research

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questions based on extensive literature review:

RQ1: What are the focus areas and topics related to blockchain technology in academic research?
RQ2: What are the emerging research questions that can help shape future scenarios for blockchain research?

We examined the academic progress of blockchain technology by analyzing 2360 articles extracted from the Scopus database. We use structural topic modeling (STM) to uncover the underlying semantic structures that shape academic discussion in blockchain. The topics identified by STM were mapped to the Datatopia model (Gartner, 2014), which led to four possible scenarios. We discover three layers of knowledge for each quadrant inspired by the eWOM model (King et al., 2014). At the first layer, we evaluated the available knowledge under the heading. In the second layer, the literature review led to the identification of the characteristics of blockchain. The third layer presents the emerging research questions from the integration of STM results, characteristics of blockchain, and literature review. The study results provide theoretical foresight for industry stakeholders, policymakers, and academicians. For example, blockchain can make faster global transactions (Sharma et al., 2022), more secure financial dealings (Liu et al., 2023; Warkentin & Orgeron, 2020), and efficient supply chain decisions (Zheng et al., 2022). Further, in the oil industry, operational performance can be improved (Aslam et al., 2021), and cost efficiency can be achieved using blockchain. The study also presents emerging research questions for future researchers, such as exploring measures to reduce carbon footprint, identification of skills needed for people in the blockchain industry, or how to create trust among the masses towards the technology.

Theoretical framework

The concept of blockchain and distributed ledger technology (DLT) came into existence with the launch of Bitcoin (Nakamoto, 2008) in early 2008 (Treiblmaier & Sillaber, 2021). Since then, blockchain has revolutionized online transactions.

Blockchain can disrupt the industry's functioning as it is a tamper-proof technology (Casey & Vigna, 2018). Blockchain mechanism functions at three levels - public, private, and consortium (Xiao et al., 2020). Public blockchain allows anyone to integrate with the network by enabling robust encryption methods that provide security and ensure secure transactions worldwide in an unrestricted environment. Public blockchains work centrally by providing transparency and mitigating the challenges of handling transactions at scale and velocity (Tyma et al., 2022). In contrast, private blockchains focus on high performance and faster transactions at scale. Here, the participants are verified, and transactions are controlled in a firm-specific centralized way (Gourisetti et al., 2020). Such blockchain provides access to only authorized users. The third type of blockchain is a consortium, managed by selected participants or organizations called nodes. Consortium blockchain is helpful because it provides a secure network at scale (Zohar, 2017), an ongoing challenge in public blockchain.

Blockchain technology (BCT) has progressively integrated into multiple domains, transforming traditional operational frameworks (Table 1). For example, tracking funds in NGOs (Kuruppu et al., 2022; Tripathi & Maas, 2022) and bank financial transactions (Zhang & Huang, 2022). However, blockchain also poses a threat of funding terrorism through untraceable transactions (Antonyan & Aminov, 2019). Thus, technology may outgrow human control and run the world due to the centralization of power in the case of a public blockchain. In contrast, a private blockchain system can overcome this challenge.

Implementing blockchain in contracting and corporate governance can revolutionize these areas by reducing specific transaction costs and introducing new costs not present in traditional contracts (Ziolkowski et al., 2020). Additionally, it may mitigate agency costs in organizations

Table 1
Application of blockchain technology across various domains.

S. No.	Field	Application	Authors
1	Finance	Improving how transactions are processed and records are kept.	Chen and Bellavitis (2020); Tapscott and Tapscott (2016)
2	Agriculture	Facilitating improved traceability and promoting sustainable agricultural practices.	Chen and Bellavitis (2020); Sharma et al. (2022)
3	Public Sectors	Refining governance protocols and the maintenance of public records.	Warkentin and Orgeron (2020); Xiao et al. (2020)
4	Supply Chain Management	Amplifying product traceability and enhancing supplier trustworthiness, fostering quality assurance, and ensuring current data accessibility for all stakeholders.	Jain et al. (2020); Treiblmaier and Garaus (2023); Tian (2017); Vu et al., (2023); Charles et al. (2023)
5	Healthcare	Reinforcing patient data confidentiality and streamlining medication traceability. Facilitating the design of robust information systems that potentiate patient empowerment, elevate patient confidence in record control, minimize medical inaccuracies, and optimize disease management.	Hajian et al. (2023); Tanwar et al. (2020); Yue et al. (2016)
6	Food Safety	Blockchain introduces a realm of transparency, potentially a deterrent to contamination incidents.	Murray (2018); Yadav et al. (2023)
7	E-Waste Management	Enhancing waste management's monitoring and tracking capabilities leads to sustainable and efficient disposal methods.	Chaudhary et al. (2021)
8	Academic Research & Data Analysis	Blockchain provides a secure platform for academic papers, ensuring the authenticity and permanence of research. This extends to protecting and validating datasets used in complex data analyses, such as trend prediction via topic modeling, ensuring the data's consistency and legitimacy.	Xu et al. (2023)

(Murray, 2018). Han et al. (2023) emphasizes the transformative potential of blockchain and AI in auditing and accounting, stressing the importance of transparency and reliable decision-making in modern accounting practices. Blockchain necessitates a comprehensive approach to regulatory efforts, particularly in asset tokenization within financial markets. Integrating blockchain with existing legal structures, such as in bankruptcy scenarios, highlights the need for collaboration among lawyers, coders, and lawmakers to ensure regulatory effectiveness (Hughes, 2021). Furthermore, blockchain can potentially automate compliance processes, leading to more trustworthy regulatory developments (Hughes, 2021).

The Datatopia model (Gartner, 2014) presents scenarios for the future of blockchain. According to this model, society will be conflicted or connected (Fig. 1). In the conflicted world, technologies are often used to block other technologies since the goals conflict. In contrast, in the connected world, all kinds of technologies interact with each other since the goals are aligned. Further, the technology will either be amok or in control. When technology runs amok, society does nothing but

		Society/ World	
		Conflicted	**Connected**
		(In the conflicted world, technologies are often used to block other technologies. Goals are conflicting)	(In the connected world, all kinds of technologies interact. Goals are aligned.)
Technology	**Control** (In the controlled world, we know what we want technology to do and make it so)	**Scenario 1: Society, Inc. "Whatever"**	**Scenario 2: Datatopia "Aspiring Creativity"**
	Amok (When technology runs amok, society does nothing but respond)	**Scenario 3: Digital Wild West "State of the Nature"**	**Scenario 4: Sorcerer's Apprentice "Ruled by Machines"**

Fig. 1. Datatopia Model (Gartner, 2014).

respond. However, in the controlled world, we know what we want technology to do and make it so. The combination leads to the generation of four possible scenarios. First, the scenario is named Society "Whatever". Here, the technology is controlled, and society and goals are conflicting. The second scenario is Datatopia - "Aspiring Creativity." Here, the technology is under control, society is connected, and goals are aligned. The third scenario is the Digital Wild West "State of Nature." Here, the technology is amok (uncontrolled), and society and goals conflict. When technology behaves uncontrollably, society responds to disruptions. The fourth scenario is named Sorcerer's Apprentice, "Ruled by Machines." Here, the technology is amok, society is connected, and goals are aligned.

Methodology

Data collection

We selected the Scopus database for a keyword search to synthesize emerging blockchain research by analyzing academic articles due to its more comprehensive coverage (Fahimnia et al., 2015), better data management, and filter options (Verma et al., 2021). We used a single database for analysis to avoid the potential human errors associated with combining multiple databases (Donthu et al., 2021; Shukla et al., 2024). Search keywords "blockchain", "block-chain", "blockchain" were used to derive data on titles, abstracts, and keywords for 44,13 articles (Fig. 2). The search was limited to three filter criteria. First, extracted papers were limited to business management to make the data relevant for the management practitioners. Second, the selection was limited to journal articles, and third, articles published in English were considered, resulting in 2360 articles, which were further taken ahead for analysis.

Two steps were followed while analyzing the text from the extracted articles. First, STM was used to derive topics from the textual data of all

Database: Scopus
Search Date: 10 June 2023
Search keywords: "blockchain" or "block-chain" or "block chain"

Filter Criteria: Title, abstract, keywords, subject area – business management, language – English, type – article

No. of articles retrieved =2360

Analysis Technique: Structural topic modeling

Fig. 2. Data retrieval process.

2360 articles. Further, the literature review was done to identify the characteristics of blockchain and emerging research questions from the research articles. The following filter criteria was used to include studies in the literature analysis:

1) the study is published in a peer-reviewed journal
2) the study's focus is on applications of blockchain in management
3) the study addresses the adoption, diffusion, or challenges of blockchain

Descriptive analysis

There has been a significant increase in the number of articles published in the field of blockchain (Fig. 3). Total 690 articles were

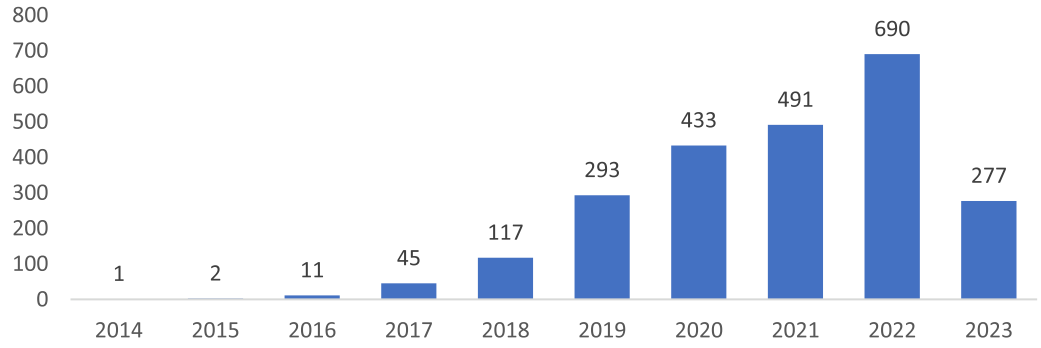

Fig. 3. Number of papers published from 2014–2023* (*as of the date of data retrieval).

published in 2022, an increment from 491 articles in 2021 and 433 in 2020, thus representing the growing interest in the field of blockchain.

Structural topic modelling

This study employs the rigorous text-mining technique of STM to examine qualitative data from academic articles (Karmakar & Shukla, 2023; Manning et al., 2009). STM is a machine learning-based text--mining technique identifying latent topics within a document corpus (Roberts et al., 2014). STM has been used in previous research to identify topics in multiple types of text data, such as open-ended survey responses, hotel and restaurant reviews, airline reviews, and employees' online reviews (Hu et al., 2019;Kuhn, 2018). STM is similar to the Latent Dirichlet Allocation (LDA) topic modeling method with the added advantage of incorporating metadata into the analysis (Blei et al., 2003; Sharma et al., 2021).

STM was performed in RStudio, an open-source software. First, we cleaned the data by removing white spaces, lower case and custom stop words. Then, we used searchK function to identify the optimum number of topics. SearchK allows the user to specify a range of values for k and then provides multiple goodness-of-fit measures to decide the best fit for the data (Shukla et al., 2024). The intersection of held-out likelihood and semantic coherence was met at 15, thus providing an optimum number of topics (Fig. 4).

Further, semantic coherence and exclusivity were used to measure topic models' quality (Röder et al., 2015). A topic's semantic coherence measures the degree of similarity between its top words, whereas its exclusivity measures the degree of difference between the top words and those in other topics (Lau et al., 2014). The average exclusivity scores for all topics range from 9.245 to 9.983, and the average semantic coherence ranges from -210.359 to -54.704 (Table 2). According to the difference in semantic coherence values between two topics, the top words of one topic do not co-occur equally with the top words of the other topic.

Table 2 summarizes the top 10 words associated with each latent topic based on FREX and Lift scores. Kuhn (2018) defines FREX as the ratio of term frequency compared to topic exclusivity. The topic labels were coded per identified words in highest probability and FREX by

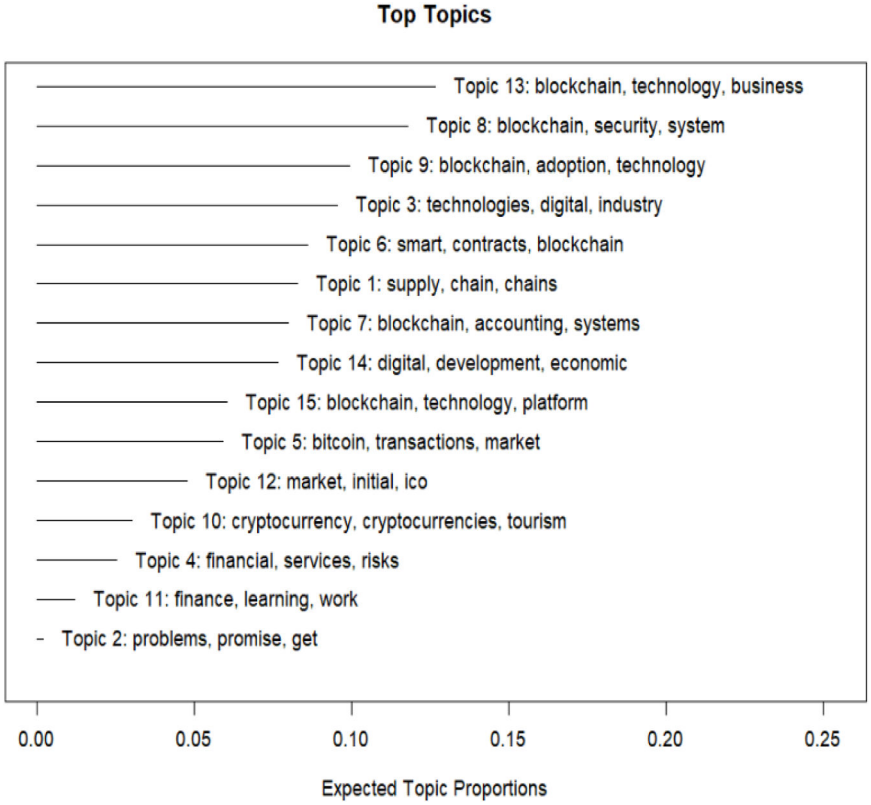

Fig. 4. Extracted topic labels and proportions.

Table 2
Extracted topics from STM.

S. No.	Topic Labels	Highest Prob	FREX	Semantic Coherence	Exclusivity
1	Supply chain and technology	supply, chain, agriculture blockchain, food, traceability, management, logistics, transparency, technology	food, supply, chains, chain, traceability, agricultural, logistics, agriculture, supplier, pandemic	-54.704	9.543
2	Problem-solving in Pharma	problems, promise, get, hype, work, opportunity, pharmaceutical, block, increasing, professionals	problems, promise, hype, get, solid, deeper, accordance, profound, strategically, conducts	-176.834	9.983
3	Emerging sustainable technology	technologies, digital, industry, emerging, intelligence, artificial, sustainable, sustainability, management, authors	intelligence, artificial, systematic, circular, technologies, bibliometric, papers, analytics, trends, themes	-85.079	9.585
4	BFSI	financial, services, risks, risk, sector, fintech, banking, institutions, companies, service	financial, fintech, banking, risks, services, banks, institutions, insurance, sector, risk	-102.497	9.96
5	Transaction and mining	bitcoin, transactions, market, transaction, network, blockchain, media, price, time, exchange	bitcoin, stock, miners, media, correlation, portfolio, period, mining, sentiment, fees	-99.526	9.304
6	Smart Contracts	smart, contracts, blockchain, system, trust, energy, sharing, contract, proposed, network	smart, contracts, energy, carbon, contract, sharing, trust, power, electricity, emissions	-88.953	9.548
7	Accounting and audit	blockchain, accounting, systems, information, technology, solutions, challenges, audit, case, construction	accounting, audit, auditing, case, standards, reporting, auditors, construction, solutions, accountability	-109.299	9.355
8	Data Privacy	blockchain, security, system, IoT, privacy, information, technology, healthcare, proposed, secure	privacy, records, healthcare, medical, health, security, secure, devices, IoT, authentication	-87.192	9.245
9	Adoption of Blockchain	blockchain, adoption, technology, barriers, experts, performance, industry, management, framework, limited	barriers, limited, perceived, adoption, diffusion, acceptance, readiness, structural, fuzzy, experts	-78.194	9.343
10	Payments using crypto	cryptocurrency, cryptocurrencies, tourism, crypto, payment, currency, payments, asset, industry, virtual	tourism, crypto, cryptocurrency, propositions, hospitality, payments, cryptocurrencies, currency, payment, monetary	-125.788	9.877
11	Cyber security	finance, learning, work, money, machine, currencies, patent, deep, cybersecurity, crisis	Crisis, learning, patent, machine, finance, laundering, money, technology, cybersecurity, deep,	-210.359	9.974
12	Initial coin offering	market, initial, nft tokens, icos, coin, capital, investors, offerings, token	ico, tokens, market, entrepreneurial, funding, offerings, coin, nft, initial, token	-63.528	9.926
13	Governance	blockchain, technology, business, applications, innovation, potential, application, governance, organizations, models	business, innovation, applications, creation, organizations, ecosystem, governance, actors, ecosystems, organizational	-85.954	9.805
14	International law and economy	digital, development, economic, technologies, global, international, economy, public, legal, rights	international, legal, national, economic, enterprise, property, law, tax, trade, estate	-90.996	9.822
15	Challenges in adoption	blockchain, technology, platform, information, cost, quality, demand, platforms, adoption, strategy	optimal, game, demand, retailer, cost, strategy, platform, channel, technology, profit	-101.343	9.576

analyzing specific words related to these topics within a given document corpus. Topic-1 is labeled as "Supply chain and technology," showing the topic distribution for words – 'supply, chain, chains, blockchain, food, traceability, management, logistics, transparency, technology food, supply, chains, chain, traceability, agricultural, logistics, agriculture, supplier, pandemic.' Topic 2 is labeled 'Problem-solving in pharmaceuticals'. Topic-3, which is titled 'Emerging sustainable technology,' contains probabilistic distributions over words that have semantic analogies to words like 'technology,' 'digital,' 'industry,' 'emerging,' 'intelligence,' 'artificial,' 'sustainable,' 'sustainable management' and 'authors'. A similar technique was used to add labels to the extracted topics.

An estimated marginal topic proportion and correlation matrix were determined to examine the relationship among the extracted topics (Fig. 5). In the literature, correlation values above 0.7 are considered vital, while correlation values between 0.3 and 0.7 are considered moderate (Ratner, 2009). Positive correlations between latent topics indicate that many documents include both topics equally. All correlation values for the extracted topics in this study were less than 0.3, indicating a weak or non-existent correlation between them (Sharma et al., 2021), verifying that each topic was unique and non-overlapping.

A histogram plot of MAP estimates topic loadings across all research articles (Fig. 6). This histogram assesses the distribution of topics among documents. In STM-based topic modeling, this plot provides a rough estimate of the distribution of topics across the documents. Based on the plot, several research documents appear to have little or no relationship with latent topics (no multi-collinearity). Further, the dendrogram was generated to represent a hierarchical clustering of the topics based on distance (Fig. 7). The identified 15 topics were arranged into hierarchical clusters to examine the interconnection of specific topics (Sievert & Shirley, 2014).

Results

STM was applied to 2360 Scopus articles leading to identification of 15 topics using 'searchK' function in RStudio. Four clusters emerged in the dendrogram by grouping 15 topics using hierarchical clustering (Fig. 7). The first cluster was composed of four topics (topic 12, topic 10, topic 4, topic 11), the second cluster was composed of three topics (topic 5, topic 6, topic 8), the third cluster was composed of four topics: topic 14, topic 3, topic 7, topic 13), fourth cluster composed of three topics: topic 9, topic 1, topic 15), whereas Topic 2 (Blockchain technology for enhancing IoT security) emerged as a separate overarching topic encompassing all clusters. This topic explains the importance of security in the blockchain, which is of utmost importance in all four scenarios. Further, the four clusters were mapped to the four quadrants of the Datatopia model (Gartner, 2014) to develop future scenarios for blockchain (Fig. 8).

Scenario 1: society, Inc. – "whatever" (Control-conflicted)

In the first scenario, labeled as "Society," goals conflict, and society controls technology. This segment is characterized by extensive blockchain adoption and includes four main topics: Initial Coin Offerings (Topic 12), Payments using crypto (Topic 10), Banking, Finance, and Insurance [BFSI] (Topic 4), and Cybersecurity (Topic 11). Blockchain's utilization in Initial Coin Offerings (ICOs) empowers businesses and governments to securely manage, verify, and enforce fundraising activities, which impacts societal structures. Furthermore, blockchain technology has made significant progress in facilitating financial

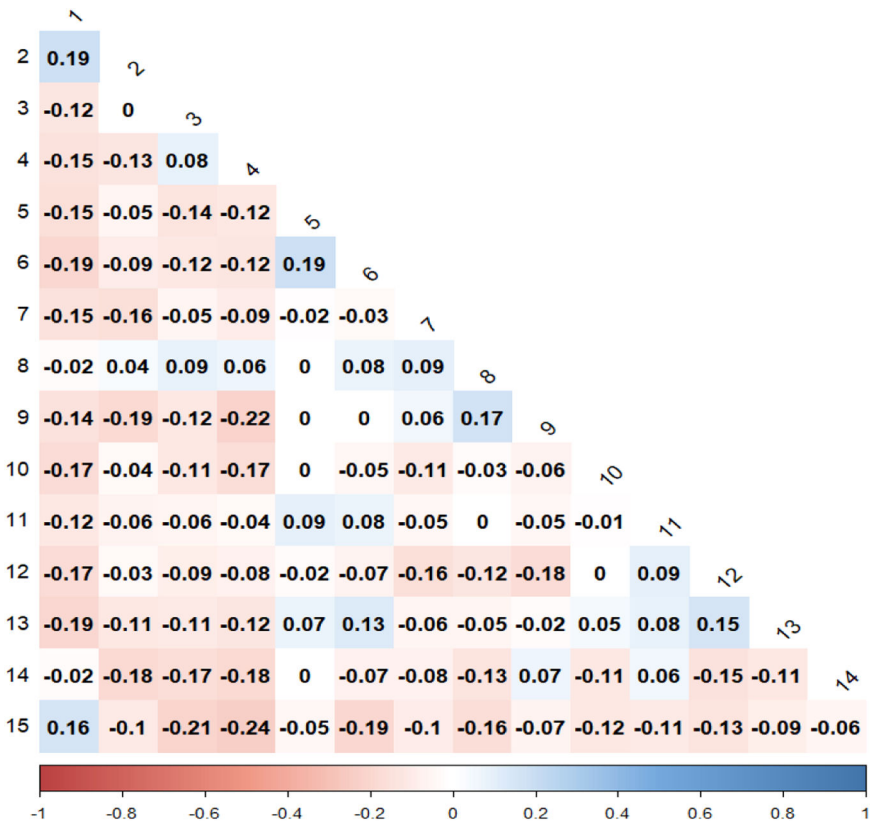

Fig. 5. Correlations among topics.

transactions, primarily using cryptocurrencies (Sharma et al., 2022; Zohar, 2017). Blockchain advances security features to ensure financial operations are stable and controlled, for example, blockchain has made data management efficient and secure in the Banking and Financial sector (BFSI) (Mishra & Kaushik, 2023).

Scenario 2: Datatopia "Aspiring creativity" (Control-connected)

The second scenario, "Datatopia 'Aspiring Creativity'", depicts a state where technology is well-regulated, society is interconnected, and goals are aligned. This connection between society and technology leads to the innovative use of blockchain. Three topics are mapped in this quadrant: Transaction and mining (Topic 5), Smart Contracts (Topic 6), and Data Privacy (Topic 8). Blockchain is reshaping the way financial transactions and mining procedures by making it more connected to the world. By automating contractual obligations and providing transparency and security in transactions, blockchain has made significant progress in smart contracts. Hence, blockchain can provide data privacy and ensure control and trust in the digital world (Tan & Saraniemi, 2023).

Scenario 3: Digital Wild West "State of the Nature" (Amok-conflicted)

The third scenario, the "Digital Wild West 'State of Nature," depicts a scenario where technology is uncontrolled and in conflict with society and its goals. In this scenario, the technology spirals out of control, and society's only recourse is to react. The quadrant discusses four distinct topics: International Law and Economy (Topic 14), Emerging Sustainable Technology (Topic 3), Audit and Accounting (Topic 7) and Governance (Topic 13). Blockchain offers alternative frameworks for legal and economic sectors within the International Law and Economy (Antonyan & Aminov, 2019; Hughes, 2021). Additionally, it emphasizes the use of sustainable technologies which thus leads to new challenges for society (Karmakar & Shukla, 2023). Blockchain improves precision and efficiency in auditing and accounting to ensure effective governance.

Scenario 4: Sorcerer's Apprentice "Ruled by Machines": Amok-connected

The fourth scenario, "Sorcerer's Apprentice 'Ruled by Machines,'" describes a situation where technology is uncontrolled while society is interconnected, and goals are aligned. This quadrant refers to a state where blockchain has become a fundamental societal need. The topics mapped to this quadrant are Supply Chain and Technology (Topic 1), Adoption of Blockchain (Topic 9), and Challenges in Adoption (Topic 15). This represents that academic literature primarily explores the adoption of blockchain across various industries, its role in driving societal changes and the challenges. For example, blockchain significantly improves supply chain transparency, efficiency, and traceability (Chittipaka et al., 2023).

Discussion

The analysis of 2360 articles reflects emerging trends in the field of blockchain. The STM analysis identified 15 distinct topics, such as privacy protection, the changing work landscape, blockchain's involvement in intellectual property, and finance. The 15 topics were mapped to four futuristic scenarios by combining the Datatopia model (Gartner, 2014) and the eWOM model (King et al., 2014) leading to the development of the DBlock framework (Fig. 9). Further, literature review was done to find research gaps, such as identifying the role of blockchain toward sustainability, adoption challenges, potential risks in industries like hospitality, and concerns related to security. Based on the eWOM model (King et al., 2014), we identified three layers of knowledge available on the blockchain for each quadrant. First, we evaluated the available knowledge under the heading "What do we know." Second, the

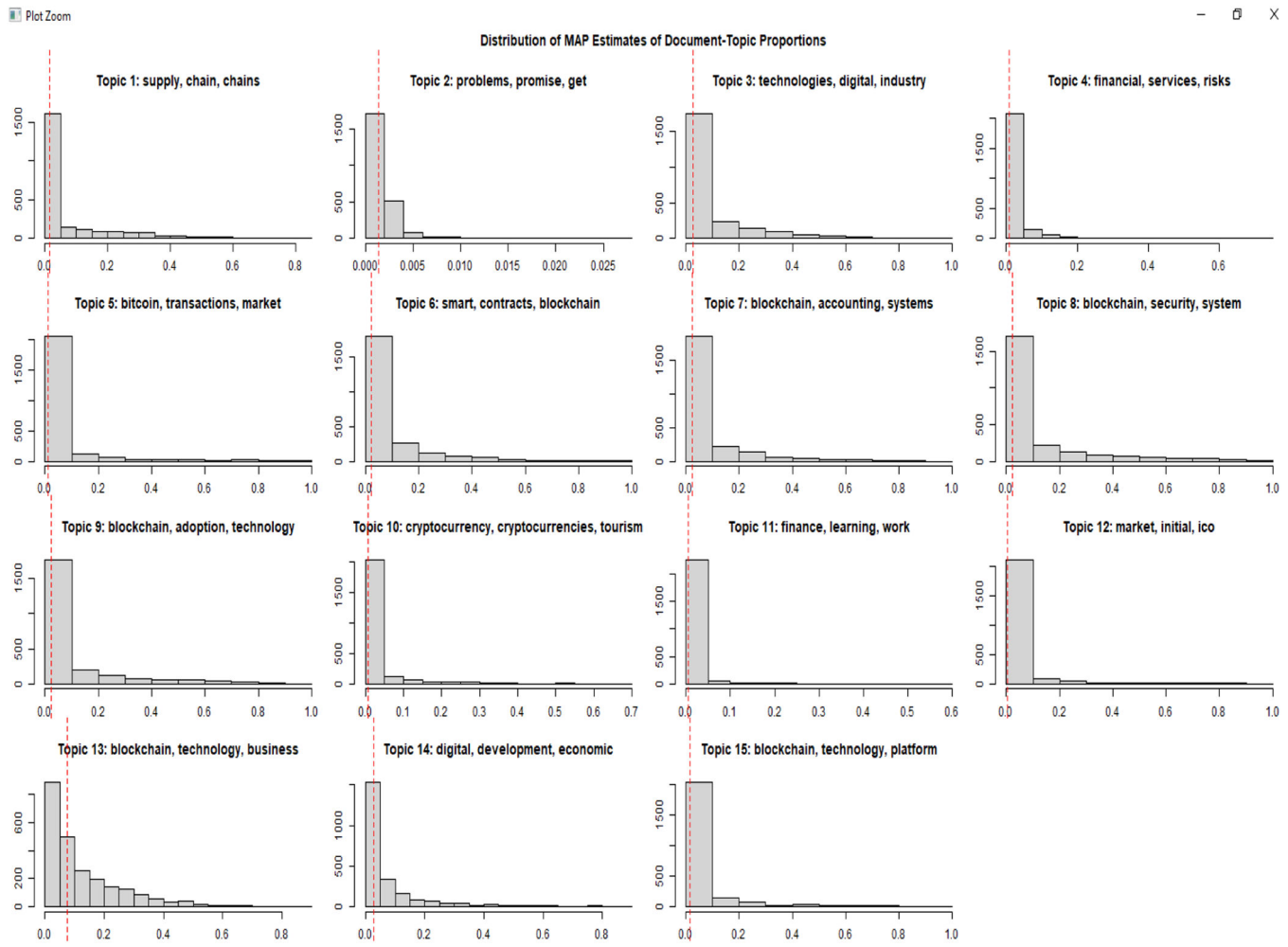

Fig. 6. Topic proportions within documents.

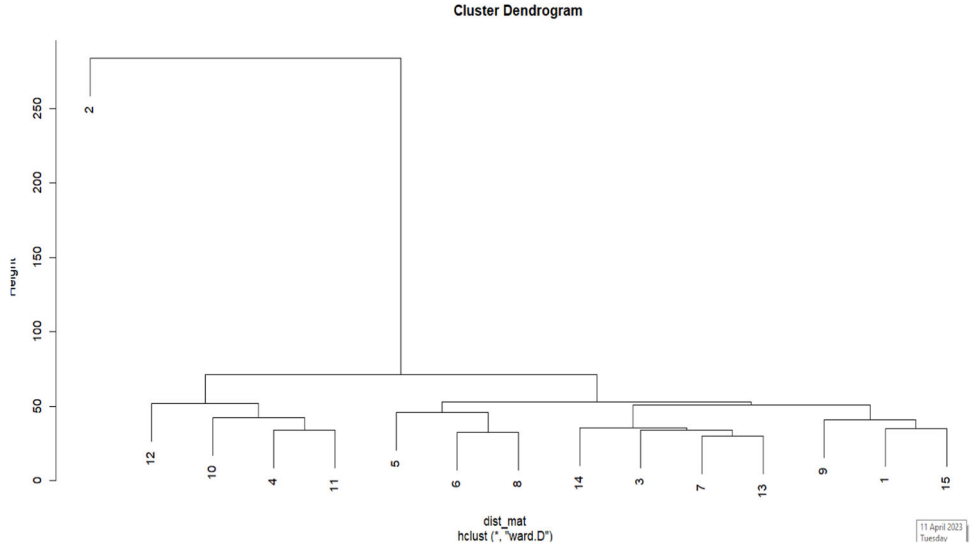

Fig. 7. Dendrogram.

literature review led to the identification of characteristics of blockchain, which were mapped to each quadrant. Third, the emerging research questions from the literature were mapped under the heading "What do we need to know" providing a holistic view of emerging scenarios (Fig. 9).

		Society	
		Conflicted	**Connected**
Technology	**Control**	**Scenario 1: Society, Inc. "Whatever"** Topic 12 (Initial coin offering) Topic 10 (Payments using crypto) Topic 4 (BFSI) Topic 11 (Cyber security)	**Scenario 2: Datatopia "Aspiring Creativity"** Topic 5 (Transaction and mining) Topic 6 (Smart Contracts) Topic 8 (Data Privacy)
	Amok	**Scenario 3: Digital Wild West "State of the Nature"** Topic 14 (International law and economy) Topic 3 (Emerging sustainable technology) Topic 7 (Accounting and audit) Topic 13 (Governance)	**Scenario 4: Sorcerer's Apprentice "Ruled by Machines"** Topic 9 (Adoption of Blockchain) Topic 1 (Supply chain and technology) Topic 15 (Challenges in adoption)

Fig. 8. Datatopia Model with STM topics.

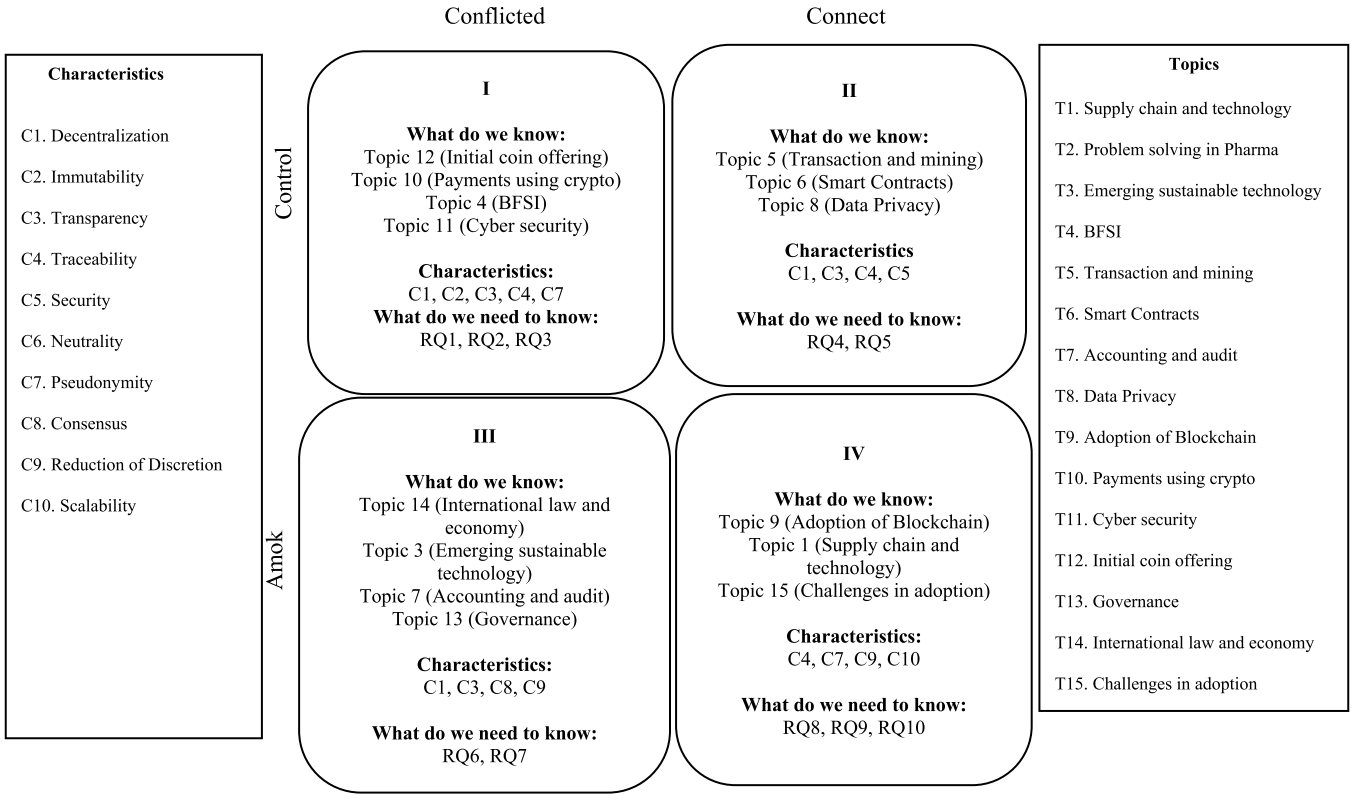

Fig. 9. DBlock framework.

Quadrant 1: control-conflicted

What do we know?

Recently, blockchain technology has transformed how the money is raised, payments are made and online transactions. Initial Coin Offerings (ICOs) are a new way for small companies to get money by selling their own digital coins for other well-known digital currencies like bitcoin (Nakamoto, 2008). This method skips the old way of getting money through banks or investors (Chen & Bellavitis, 2020; Tapscott & Tapscott, 2016). Also, paying with cryptocurrencies makes sending money worldwide faster, easier, and safer without needing regular banks (Chen & Bellavitis, 2020; Sharma et al., 2022). In banking and insurance, adding blockchain means making financial dealings more secure, open, and efficient (Tian, 2017; Warkentin & Orgeron, 2020). The way blockchain is built helps make online transactions and data storage very secure because of its key features like being spread out over many places, complex to change, and well-encrypted (Hajian et al., 2023; Tanwar et al., 2020; Yue et al., 2016). This shows how blockchain significantly impacts how money is handled and keeps information safe online.

Characteristics of blockchain

The Control-Conflicted quadrant emphasizes blockchain's characteristics such as decentralization, decentralization, immutability, transparency and traceability. Decentralization (C1), enhances system resilience and security against attacks; Data Immutability (C2) ensures the integrity and authenticity of data, preventing fraud and tampering; Transparency (C3) makes all transactions visible to all participants, enabling collaboration and trust; Traceability (C4) helps in identification of historical payments and transactions; Pseudonymity (C7) could lead to potential risk of lack of truct.

What do we need to know?

Based on the mapping of topics and characteristics of blockchain in each quadrant literature review led to identification of emerging research questions. Regulatory framework, enhanced data privacy, and security are crucial in the world of technology, where technology is controlled but faces conflict with society (Xiao et al., 2020), thus leading to the following emerging research questions:

RQ1: What are the benefits of enhancing payment systems using cryptocurrencies with blockchain technology? (Charles et al., 2023)
RQ2: What frameworks need to be developed to deal with privacy and security issues emerging due to the pseudonymity of blockchain? (Yue et al., 2016)
RQ3: What strategic development is needed in blockchain technology in specific sectors that are vulnerable to breaches such as finance/BFSI? (Chenthara et al., 2020)

RQ1 focuses on identifying the benefits of using blockchain for recording historical payment transactions. Future research could pursue qualitative studies to identify the benefits in crypto based transactions due to the adoption of blockchain. Similarly, RQ2 guides future researchers toward developing a framework to deal with privacy and security issues emerging from blockchain applications in the industry. Future research can develop risk measurement metrics for the same, such as risk registers and heat maps that could be mapped to blockchain. Blockchain companies should also note the frauds happening in the currencies. For example, Ripple Labs sold XRP tokens to institutional investors without registering with the Securities and Exchange Commission, for which it was penalized $125 million (Dolmetsch, 2024). RQ3 highlights the importance of cyber frauds in area of banking and finance. Future research could explore the development of advanced privacy-preserving protocols within the blockchain, such as zero-knowledge proofs, homomorphic encryption, and confidential transactions, which can enhance privacy without sacrificing transparency.

Quadrant 2: control-connected

What do we know?

Blockchain has significantly improved how financial transactions are performed and contracts are handled, ensuring that personal information is secure over the Internet (Christodoulou et al., 2024). Mining is a crucial activity in blockchain as it validates transactions and provides secure networks; this is performed using complex algorithms. Also, mining provides new digital currency units, adding to the security, functional, and secured issuance of new tokens (Tanwar et al., 2020). Blockchain supports smart contracts that allow the agreements between the parties to be carried out automatically without intermediaries resulting in enhanced transparency, efficiency, and security (Yue et al., 2016). Further, encryption and distributed ledger prevents unauthorized access and data breaches while storing data leading to data privacy (Hajian et al., 2023). These innovative enhancements in blockchain significantly improve financial transactions, security, and contract management.

Characteristics of blockchain

Within the Control-Connected quadrant, decentralization (C1) and transparency (C3) play vital roles in automating and securing smart contracts (i.e., digital agreements). Traceability (C4) ensures that the transactions made are traceable. Security qualities of blockchain (C5) and neutrality (C6) features allow for maintaining transaction integrity.

What do we need to know?

The topics mapping to quadrant second reflects financial transactions and privacy concern. Based on mapping of relevant blockchain characteristics emerging questions were identified from the literature. Smart contracts automate the execution of agreement without any involvement of third party at the same time keeping transactions private. This leads to following emerging questions to explore:

RQ4: How to ensure neutrality in smart contracts to work optimally, being efficient, transparent, and tamper-proof? (Leng et al., 2022; Wang et al., 2019)
RQ5: How can we ensure the privacy of user's data to enhance trust among potential users to adopt blockchain technology? (Sharma et al., 2022; Xu et al., 2023)

RQ4 aims to identify issues related to smart contracts. Future research could optimize smart contract codes to ensure efficiency and security. Researchers can explore best practices for coding in smart contract languages like solidity, aiming to reduce vulnerabilities, minimize gas costs, and enhance execution speed. Studies could also evaluate the use of formal verification techniques to ensure the correctness and security of smart contracts. RQ5 focuses on user privacy and trust. Future research could focus on designing and evaluating educational campaigns that aim to demystify blockchain technology for the general public, such as online courses, workshops, webinars, and social media content that explain blockchain's benefits, use cases, and how it can help users.

Quadrant 3: amok-conflicted

What do we know?

Blockchain is impacting the functioning of international law and economy. Thus, it is necessary to reassess the current law and make potential amendments to accommodate the decentralized nature of transactions (Warkentin & Orgeron, 2020). Blockchain encourages sustainability by tracking carbon footprints and verifying emissions for organizations (Sharma et al., 2022). For example, it provides clear and effective ways for trading renewable energy and efficient supply chain management (Chittipaka et al., 2023). Blockchain has changed how traditional accounting and auditing are performed through its unchangeable record-keeping systems (Gauthier & Brender, 2021). This enables quick verification, leading to a reduction in fraud (Tanwar et al., 2020). Additionally, blockchain presents innovative ways to organize businesses using decentralized governance models (Ziolkowski et al., 2020). These decentralized models use distributed are distinct from the traditional centralized approach, shifting towards distributed nodes (Yue et al., 2016). Thus, blockchain significantly influences the reassessment of legal, economic, governance, and environment.

Characteristics of blockchain

The quadrant Amok-Conflicted reflects the Decentralization (C1), Transparency (C3), Consensus (C8), Reduction of discretion (C9) and Scalability (C10) features. The consensus feature of blockchain is very visible in protecting digital assets and storing value at the global level, thus impacting international law and the economy. Decentralization and transparency provide accountability in auditing and governance. Traceability (C4) supports sustainability in upcoming technological innovation. For example, impact tokens such as Cardano (ADA), Tezos (XTZ), and BitGreen (BITG) contribute to UN SDGs Goals (Uzsoki & Guerdat, 2019).

What do we need to know?

As blockchain technology is significantly impacting international law and economics and due to its contribution to sustainable technologies, it is crucial to explore the impacts in the future. The study is essential to understand when technology grows out of control in the world and society is in conflict; these research questions can be explored:

RQ6: How does blockchain enable changes in international legal and economic frameworks due to its decentralized nature? (Antonyan & Aminov, 2019)
RQ7: How do we overcome sustainability issues by integrating blockchain technology to provide seamless integration? (Tanwar et al., 2020; Yue et al., 2016)

RQ6 focuses on using blockchain technology as an enabler in international legal and economic frameworks. Future studies can analyze how decentralized autonomous organizations (DAOs) and other blockchain-based governance structures challenge traditional hierarchical systems and propose models for international adaptation. Researchers can study the development of international regulatory frameworks for blockchain by analyzing existing efforts by bodies like the G20, OECD, or the European Union and proposing new frameworks that accommodate blockchain's decentralized and borderless nature. With the application of blockchain on a global scale, scalability issues will arise. Researchers can study existing protocols like Polkadot, Cosmos, and Atomic Swaps to identify areas of improvement. Future studies could focus on sharding techniques, where the blockchain is divided into smaller, manageable parts, or "shards," that process transactions in parallel. Researchers can explore sharding implementation in various blockchain networks and assess its impact on scalability and security. RQ7 focuses on sustainability using blockchain. Future studies can track carbon emissions from transactions and monitor them using blockchain to verify and reduce them (Tanwar et al., 2020; Uzsoki & Guerdat, 2019).

Quadrant 4: Amok-connected

What do we know?

Although blockchain adoption provides significant advantages (Liang et al., 2021), it also presents hurdles like scalability, unclear regulations, and pseudonymity (Tan & Saraniemi, 2023; Warkentin & Orgeron, 2020). In the supply chain sector, blockchain has enhanced the capability to trade products from the source and increase efficiency and openness by making sure that end to end, i.e., producer to the consumer, the journey of the product can be securely and accurately monitored (Jain et al., 2020; Tian, 2017). However, issues due to scalability, interoperability, and shortage of skilled professionals in blockchain remain a cause of concern (Tanwar et al., 2020; Yue et al., 2016). Integrating blockchain technology with existing systems is a complex task, reflecting challenges in adoption (Liang et al., 2021).

Characteristics of blockchain

The Amok-Connected quadrant concentrates on Traceability (C4), Pseudonymity (C7), Reduction of discretion (C9) and Scalability (C10). Traceability (C4) is a significant aspect of the supply chain sector because it provides visibility and history of transactions. Reduction of discretion (C9) ensures fast transactions. Pseudonymity (C7) and Scalability (C7) highlight technical challenges in wider adoption.

What do we need to know?

Blockchain plays an important role in reducing carbon footprints, tackling the skilled professional shortage, and redefining governance through a decentralized model (Ziolkowski et al., 2020), suitable for a world where technology is both amok and connected, paving the way for innovative organizational structures and sustainability efforts (Cozzio et al., 2023). Thus, the following research questions emerge:

RQ8: How can the adoption of blockchain be increased? (Charles et al., 2023)
RQ9: What measures can be implemented to address the shortage of skilled professionals in the blockchain? (Tanwar et al., 2020)
RQ10: How can an organization overcome the implementation challenges of blockchain? (Chen & Bellavitis, 2020)

RQ8 aims to increase the adoption of blockchain. Researchers can focus on specific industries, such as energy, supply chain, or agriculture, to evaluate the gaps that can be overcome by the usage of blockchain. Another approach could be developing case studies on companies or regions where blockchain has been integrated successfully. RQ9 focuses on identifying measures that can be implemented to address the shortage of skilled professionals in the blockchain sector. Researchers can investigate the effectiveness of existing blockchain education and certification programs for this. Studies could explore how these programs can be scaled or improved to meet industry needs, including collaborations between universities and industry. Also, future research may examine strategies that companies use to retain blockchain professionals, such as competitive salaries, career development opportunities, and workplace culture. RQ10 highlights the challenges in the adoption of blockchain. Future research may conduct in-depth case studies of organizations that have adopted decentralized governance models using blockchain, leading to insights into how these models change decision-making processes, power distribution, and organizational efficiency.

Implication

Theoretical implication

Blockchain is an emerging technology with vast areas of application. By integrating the output of STM in the Datatopia framework (Gartner, 2014) and eWOM framework (King et al., 2014), the DBlock model is developed, providing a comprehensive understanding of the possible scenario existing for blockchain. The DBlock model outlines the four scenarios reflecting the emerging blockchain themes and research questions.

This study is a novel attempt to synthesize academic developments to develop future plausible scenarios using the Datatopia model (Gartner, 2014). The literature review and STM analysis helped identify blockchain characteristics and research gaps. The study uses large language models to describe the existing knowledge and synthesize it to predict emerging research questions. The study advances the academic literature in the following three ways. *First*, the study extends the knowledge of blockchain technology by synthesizing the academic literature and identifying emerging themes. *Second*, the study also identifies promising research questions that must be addressed. For example, an interesting emerging theme scenario is when technology is amok, society, and goals are conflicting, and sustainability is a challenge. Blockchain can aid in resolving environmental concerns and encompass social and economic dimensions of sustainability (Chen et al., 2024; Cozzio et al., 2023). This comprehensive approach to sustainability aligns seamlessly with the United Nations' Sustainable Development Goals, underscoring the integral relationship between our global ecosystem and technological advancements (Bai et al., 2022). *Third*, emerging from the current trends and research gaps identified in blockchain research, one promising area of research is the integration of blockchain with other emerging technologies such as the Internet of Things (IoT), generative Artificial Intelligence, and quantum computing. This convergence is poised to lead to smarter and more adaptable smart contracts (Lansiti & Lakhani, 2017; Leng et al., 2022; Wang et al., 2019), and it presents both challenges and opportunities in the era of quantum computing's influence on cryptographic standards. Future research can look into developing and standardizing cross-chain communication protocols that enable interoperability between different blockchain networks, allowing seamless data and asset transfers as fake news or misinformation is challenging (Mishra et al., 2024).

Practical & policy implication

The study identifies the prominent research themes and emerging scenarios in the field of blockchain that are valuable for practitioners

and policymakers. Blockchain is vital in fundraising, as it offers initial coins and manages payments using cryptocurrencies. Industry needs to substantially improve security measures, allowing entities to maintain control and stability within their systems. Blockchain uses smart contract technologies to redefine the method of financial transactions leading to a more connected world (Leng et al., 2022; Wang et al., 2019). Therefore, blockchain can act as a technology for self-protection and reducing corruption (Sarker et al., 2021). The financial industry can develop blockchain-based applications for accounting and auditing to improve efficiency and accuracy (Gauthier & Brender, 2021). Managers must incorporate blockchain in the payment systems to generate a more transparent and efficient system reflecting the flow of money. Blockchain plays a significant role in healthcare by personalizing medical care; however, data security is a challenge. Managers should focus on identifying methods that offer secure data management and give patients more control over their health records (Chenthara et al., 2020). Further, Blockchain technology is revolutionizing supply chain management and paving the way for greater environmental sustainability and operational efficiency (Tian, 2017; Treiblmaier & Garaus, 2023; Vu et al., 2023). Managers should use blockchain to enhance sustainable development goals through its ability to introduce transparency, reliability, and traceability across diverse sectors (Bai et al., 2022). This impact is particularly significant in the seafood industry, where its role in ensuring traceable and sustainable supply chains (Cordova & Aguirre, 2022) can reduce challenges such as illegal fishing and product mislabeling.

Blockchain is helpful for tracking products' carbon footprint, encouraging people to make eco-friendly choices, and supporting sustainable supply chains (Charles et al., 2023). In the renewable energy sector, blockchain enables direct energy trading among individuals, especially in solar and wind energy markets. However, evaluating these benefits against the environmental costs of blockchain operations, particularly those associated with energy-intensive public blockchains, is crucial.

Limitations and future research

This study has certain limitations. For example, the data was collected from Scopus, which is considered one of the largest sources of abstracts and citations of research (Donthu et al., 2021). However, this study did not compare Scopus with other databases, such as Web of Science and Google Scholar. It is recommended that scholars explore the present methodology using other databases and subject areas, including those relevant to blockchains and topics such as sustainability (Cozzio et al., 2023), cloud computing, and other emerging fields. The utilization of historical academic data for forecasting within the Datatopia model presents certain challenges due to the unprecedented pace of change in contemporary technological and societal environments. Additionally, the Datatopia model may not effectively represent the intricate and dynamic interplay between societal and technological advancements. Future studies should analyze other web-based articles to understand the growing discussion around blockchain using the ethnographic approach. In future research endeavors, exploring the potential of integrating blockchain with cutting-edge innovations such as generative (AI), quantum computing, and the Internet of Things (IoT) is crucial. This fusion of advanced technologies could result in remarkable applications and benefits.

Conclusion

The study presents a comprehensive analysis of academic research papers published in the field of blockchain. STM was applied to 2360 articles retrieved from the Scopus database, resulting in 15 topics being mapped to the four potential scenarios using the Datatopia model (Gartner, 2014). The findings highlight that blockchain has a transformative impact across diverse sectors, including finance, supply chain management, healthcare, and public governance. The first scenario presents a landscape where societal goals conflict, yet the technology is under control. Such a scenario presents a controlled and favorable usage of blockchain, such as application in banking, finance, and initial coin offerings. This quadrant represents emerging research questions, such as how the technology's decentralized, transparent, and secure nature can be used for better implications. The second scenario represents a situation where the world is connected, and technology is under control. It is an optimistic scenario where blockchain characteristics like immutability and consensus lead the future in mining and smart contracts. Yet data privacy remains a cause of concern. Thus, this quadrant presents two prominent emerging questions on how smart contracts can be efficiently utilized and how to bring trust in adopting blockchain. The third scenario represents a situation where technology runs amok and society is conflicted. This could be a threatening scenario. Here, we find the application of blockchain characteristics such as traceability and tightly coupled systems will take the lead in controlling the task. This quadrant represents the impact on international law and economy, sustainability, governance, and accounting. The quadrant leads to merging questions such as the scalability of blockchain and how blockchain can impact international legal and economic frameworks. The last scenario represents a situation where society runs amok, and technology is connected. This represents a transition phase of blockchain technology, which represents its adoption, challenges in adoption, and usage in the supply chain.

However, the study also identifies the challenges associated with blockchain adoption, such as regulatory uncertainties, sustainability concerns, and the emerging need for skilled professionals. Additionally, the study analyzes the literature to develop the DBlock framework by integrating STM results, the Datatopia model, and the eWOM framework to provide emerging research questions for future blockchain research. The results identify emerging research questions on sustainability, data privacy, smart contract optimization, and blockchain integration with advanced technologies like IoT, AI, and quantum computing.

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CRediT authorship contribution statement

Anuja Shukla: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Poornima Jirli:** Data curation. **Anubhav Mishra:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Alok Kumar Singh:** Writing – review & editing, Validation, Supervision.

Declaration of competing interest

We hereby declare that there are no conflicts of interest regarding the publication of this research paper. We affirm that the research was conducted with complete integrity and transparency, and no financial or personal relationships influenced the outcomes or interpretations presented in this work.

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