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Evolution or involution? A systematic literature review of organisations' blockchain adoption factors

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ABSTRACT

To understand the slow adoption of blockchain technology by organisations, we conduct a systematic literature review of adoption factors using a mixed-methods approach. Using thematic analysis, 880 factors are identified and grouped into 29 themes, which offer a comprehensive overview of the literature. Using statistical analysis, the identified factors are dissected into technological (T), organisational (O), and environmental (E) dimensions (the TOE framework). Themes are further classified as barriers (B), enablers (En), and ambiguous (A) to describe a firm's readiness for blockchain adoption (the BEnA framework). We emphasise the multidimensionality of adoption factors across the TOE dimensions and the conditionality of adoption enablers across the BEnA dimensions. Analysis of research trends shows that recent blockchain adoption literature has focused on elaborating upon existing research themes (involution) rather than on developing new themes (evolution). Based on our analyses, we propose future research directions, including scrutinising the interdependence and multidimensionality of blockchain adoption factors, further examining factors with conditional or unclear effects on adoption, and broadening the contextual, temporal, and theoretical aspects of blockchain adoption research.

1. Introduction

Blockchain technology has garnered extensive attention from both the media and academia (Perdana et al., 2021) due to the potential business benefits it offers in replacing intermediaries (Tan and Saraniemi, 2023), promoting trust (Yadav et al., 2021), and reducing transaction costs (Pereira et al., 2019). Previous research has explored potential and actual applications of blockchain in various industries, including finance (Garg et al., 2021), supply chain management (Chang et al., 2019), healthcare (Balasubramanian et al., 2021) and energy (Hojckova et al., 2020). However, adoption of blockchain technology across industries remains limited (Dehghani et al., 2022; Litan, 2022). Only 2 % of digital leaders worldwide reported large-scale adoption of blockchain technology in their companies, with 8 % reporting small-scale adoption, whereas other contemporary technologies have seen wider adoption: cloud computing (92 %), big data (62 %), and AI (36 %) (Harvey Nash, 2023).

It is proposed that gradual adoption is typical of transformative technologies, whose value requires time to fully unfold (Iansiti and Lakhani, 2017; Toufaily et al., 2021). Research also suggests that lower rates of blockchain adoption result from its benefits being overstated (Ølnes et al., 2017; Taplin, 2023). Several studies have conceptually or empirically explored the barriers and enablers of blockchain adoption (Balzarova et al., 2022; Li et al., 2023; Liyanaarachchi et al., 2024; Singh et al., 2023), providing arguments for why, despite its benefits, organisations struggle with adoption (Sternberg et al., 2021). These studies are either context- or theory-specific, focusing on particular industries or factors pertinent to the selected theoretical lenses, such as the Technology Acceptance Model (Kamble et al., 2019) or the Diffusion of Innovation Theory (Agi and Jha, 2022). As a result, findings are sometimes contradictory. For example, although top management support is often argued to positively impact blockchain adoption (Kamble et al., 2021), several empirical studies have not confirmed this relationship (e.g., Nayal et al., 2023; Wong et al., 2020a). The reason provided is that top management may not be aware of the advantages of blockchain, such as enhanced traceability and information sharing. A significant barrier to blockchain adoption in the supply chain is similarly identified as a lack of technology awareness (Mathivathanan et al., 2021). Contradicting that finding, Cozzio et al. (2023) find that food suppliers are aware of the benefits of blockchain in enhancing consumer trust but remain hesitant due to a lack of intra-organisational support for interdepartmental efforts and concerns about data sharing. Beyond those

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studies emphasising technological or organisational factors as the most prominent drivers of blockchain initiatives, others highlight environmental factors such as government readiness (Balasubramanian et al., 2021) and external pressures (Agi and Jha, 2022). To reconcile existing findings and provide a coherent overview, our first objective is to comprehensively review organisations' blockchain adoption factors identified in the literature, thereby answering the following question.

RQ1. *What are the influencing factors of blockchain adoption by organisations?*

As researchers focus on identifying adoption factors and examining their prominence and interdependencies, some start to ask 'what is next?' (e.g., Choi and Siqin, 2022). Venkatesh et al. (2007) find significant progress in technology adoption research but criticise an excessive focus on replication and minor 'tweaking' of existing models that impede progress in understanding technology adoption. Understanding how existing research has developed over time can reveal patterns in the evolution of themes, whether these themes have been exhaustively conceptualised, extensively utilised, or intensively elaborated in blockchain adoption research. Such understanding allows us to evaluate existing blockchain adoption research and to direct future research. Hence, our second research question is:

RQ2. *How has the research on blockchain adoption developed over time?*

To answer the two research questions, we conduct a Systematic Literature Review (SLR) based on three major research databases up to 2022. Our final sample comprises 75 papers, from which 880 blockchain adoption factors are identified. These factors are aggregated into 29 common themes using qualitative thematic analysis. Quantitative tools are then employed to examine how these themes align with each dimension of the Technology-Organisation-Environment (TOE) framework. We further develop a novel framework, termed Barrier-Enabler-Ambiguous (BEnA), to capture the extent to which the themes act as enablers, barriers, or have an ambiguous role in blockchain adoption. In addition, we propose a developmental perspective to critically evaluate the literature. Inspired by philosopher Immanuel Kant (1970) and anthropologist Clifford Geertz (1963), we utilise the concepts of 'evolution' and 'involution' to distinguish between two patterns of literature development: outward progression (i.e., unveiling new themes) and inward progression (i.e., elaborating on existing themes). Our analysis finds that recent development in the literature on blockchain adoption is better characterised as 'involution'.

Our paper attempts to make four important contributions. First, to the best of our knowledge, this is the first comprehensive review of blockchain adoption by organisations. Previous reviews are limited to specific industries or sectors, thus restricting their generalisability (e.g., Choi and Siqin, 2022; Hastig and Sodhi, 2020; Vu et al., 2023).

Second, we provide a nuanced understanding of the identified themes by extending and combining the TOE and BEnA frameworks. Many studies (e.g., Kouhizadeh et al., 2021; Orji et al., 2020) have applied the TOE framework to categorise blockchain adoption factors into one of the technological, organisational, or environmental dimensions. Moving beyond this binary approach, we allow for fractional degrees of TOE for each factor and theme. This underscores the multidimensionality of technology adoption factors (Tornatzky and Fleischer, 1990). Further, we introduce the BEnA framework to unpack the driving and hindering aspects of the themes, many of which involve factors whose impacts on blockchain adoption are found to be unclear or conditional. Integrating the TOE and BEnA frameworks provides a novel perspective that deepens our understanding of themes and their interconnectedness and how these themes influence blockchain adoption.

Third, our paper provides a 'developmental' review instead of a static snapshot of the literature (e.g., Hastig and Sodhi, 2020). The chronological analysis enables us to gain an in-depth insight into how the literature develops over time (Majdouline et al., 2022; Yun et al., 2019). We uncover an involutionary pattern in blockchain adoption research and demonstrate how research efforts are influenced by the popularity of themes, leaving some aspects of blockchain adoption less explored. Specifically, as our results show, no new themes emerged in recent years, and novel factors are increasingly used to elaborate on existing themes. This pattern indicates that the literature has reached a saturation point in generating new themes. Building on our analyses, we propose a research agenda to direct future studies towards a more thorough exploration of themes in this saturated knowledge area.

Fourth, most literature reviews are either quantitative (e.g., bibliometrics or citation network analysis) or qualitative (e.g., thematic analysis). A notable exception is reviews combining computational methods and content analysis (see Antons et al., 2023 for a review). Our mixed-methods paper contributes to this approach. We apply qualitative thematic analysis to synthesise themes of adoption factors and implement a novel quantitative approach to measure the proximity of themes to the TOE and BEnA dimensions. The mixed-methods toolbox in this paper is applicable to other literature reviews.

Following the introduction, Section 2 describes our methodology. Section 3 summarises the themes of blockchain adoption factors to address RQ1. Section 4 investigates how these themes develop over time to address RQ2. Future research directions are discussed in Section 5 based on the identified patterns and trends of the literature. Section 6 concludes.

2. Blockchain in organisations

Blockchain technology gained widespread attention with the launch of Bitcoin in 2008 and Ethereum in 2015. Ethereum introduced smart contracts, offering more flexible and programmable capabilities that spurred interest in blockchain beyond cryptocurrencies (Catalini, 2017). By providing a decentralised, transparent, cryptographically tamper-proof, and programmable system of ledgers for storing, verifying, and exchanging various types of data through a peer-to-peer network of partners, blockchain potentially enables organisations to operate and trade securely with lower contractual hazards (Murray et al., 2021) and transaction costs (Pereira et al., 2019). Researchers and practitioners have thus investigated how blockchain can empower organisations in the business landscape. As shown in Fig. 1, blockchain-related publications surged exponentially after 2016.

Research efforts over the past decade have led to many literature reviews. While earlier literature primarily explored technical features and design choices of blockchain, recent reviews have focused on the potential or actual effects of blockchain technology to provide business values (Constantinides et al., 2018; Rossi et al., 2019). A central theme of the recent trend is the overview of prospective applications of blockchain technology across various fields (Tandon et al., 2021). Typical examples include Konstantinidis et al. (2018), Grover et al. (2018), Alkhudary et al. (2020), and Brookbanks and Parry (2024),

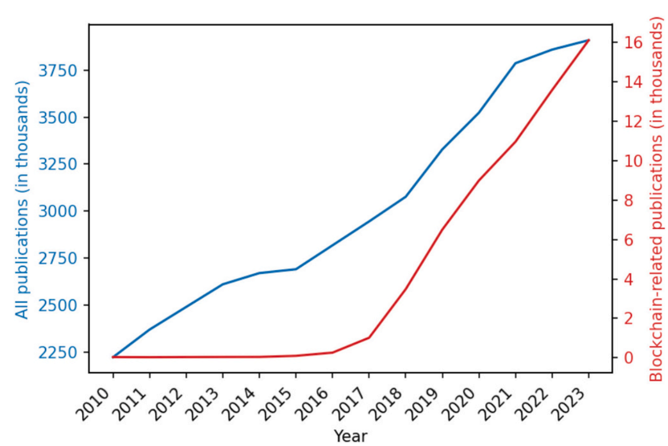

Fig. 1. Blockchain-related publications.
Data Source: Scopus.

highlighting prevalent domains for blockchain use in public and private sectors, such as cross-border transactions, data storage, identity management, and traceability of products in supply chains. The scope of these discussions continues to expand with new or refined application domains, including patent management (Denter et al., 2023), construction contract management (Zhang et al., 2023), regulatory compliance (Tuladhar et al., 2024), digital advertising (Stallone et al., 2024), Six Sigma (Najafi et al., 2024), lean automation (Jackson et al., 2023), tokenisation of assets (Zhang et al., 2024), decentralised autonomous organisations (Bonnet and Teuteberg, 2024), and linking the metaverse with healthcare products and marketing (Hajian et al., 2024).

In addition to use cases, another key theme in these reviews is economic, environmental, and social implications of blockchain. The economic aspect emphasises operational efficiency in information management, business innovation, and collaboration flows within and between organisations (e.g., Ali et al., 2020; Ancillai et al., 2023; Agrawal et al., 2023; Peng et al., 2023). Environmentally, it involves, for instance, trade-offs between substantial energy consumption and roles in waste management (e.g., Parmentola et al., 2022; Kayikci et al., 2024). Social potential is increasingly recognised, particularly regarding gender equality (Di Vaio et al., 2023), trust (Batwa and Norrman, 2021), and anti-corruption benefits of blockchain implementation (Trequattrini et al., 2024).

Nevertheless, blockchain adoption has not significantly grown in organisations despite its potential and positive effects (Dehghani et al., 2022; Kayikci et al., 2022). Adoption decisions are endogenous and influenced by various outcome variables and key antecedents. These antecedents also affect the final outcomes of blockchain adoption. For example, organisations' capacity to manage change effectively influences both their decision-making and the desired outcomes of utilising blockchain (Tiron-Tudor et al., 2021). Consequently, a growing number of SLRs have emerged to focus on the antecedents of organisations' blockchain adoption or consider both antecedents and outcomes simultaneously (e.g., Saheb and Mamaghani, 2021; Surucu-Balci et al., 2024). However, these SLRs often target specific sectors, such as finance (Fosso Wamba et al., 2020), supply chain (Vu et al., 2023), and tourism (Acikgoz et al., 2024) or specific antecedents like scalability (Khan et al., 2021) and change management (Tiron-Tudor et al., 2021). A comprehensive review of antecedents of organisations' blockchain adoption is lacking. Our SLR aims to fill this gap.

3. Methodology

To ensure rigour, the review follows the recommended three-stage SLR process of Tranfield et al. (2003) and Denyer and Tranfield (2009), illustrated in Fig. 2. In the planning stage, a review panel was established, an exploratory review was conducted, and the search strategy and selection criteria were set. The review panel (Step 1-1) comprised a panel leader (the first author) and three members (the co-authors) who were involved in various stages of the SLR. The panel aims to minimise possible retrieval, selection, and expectancy biases of the review, ensuring methodological rigour and outcome reliability

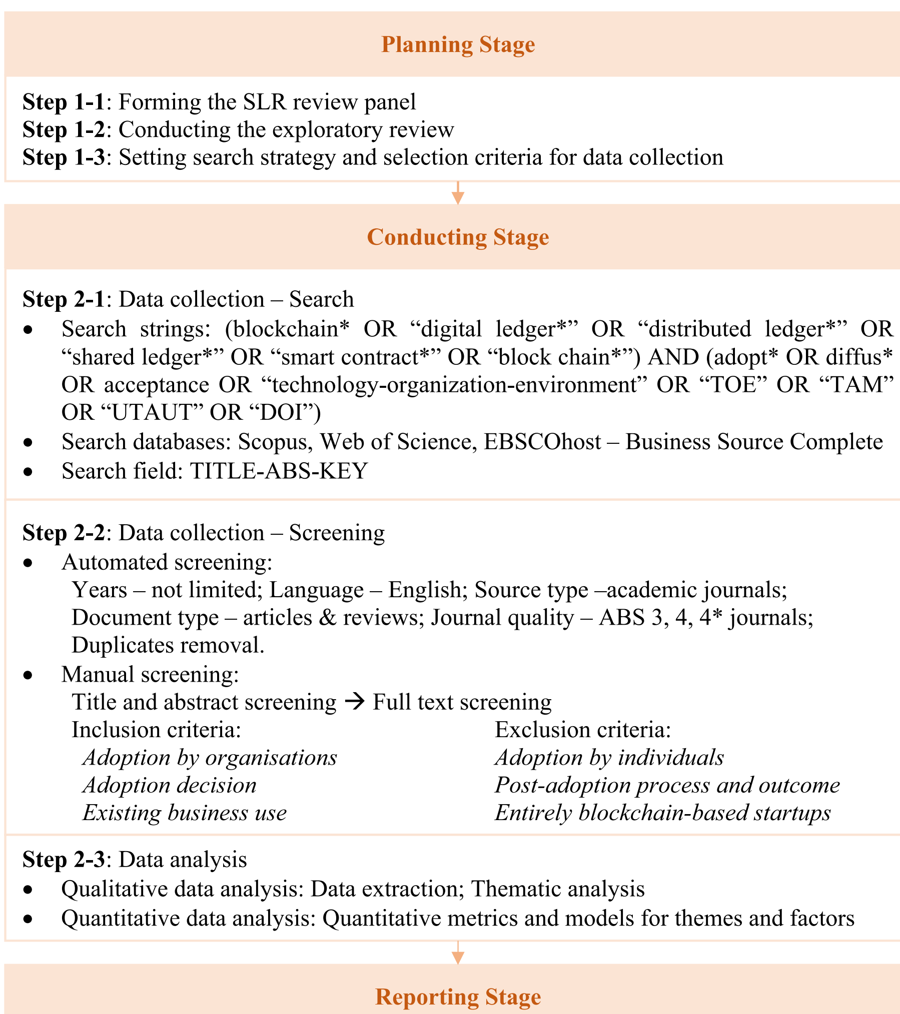

Fig. 2. An overview of the SLR process.

(Tranfield et al., 2003; Castañer and Oliveira, 2020). Prior to the formal systematic review, we conducted an exploratory review (Step 1-2) to help establish the search strategy and selection criteria for data collection during the formal review (Step 1-3). In the conducting stage, we collected data through a comprehensive search (Step 2-1) and a meticulous screening (Step 2-2), followed by data analysis (Step 2-3). Findings were presented in the reporting stage, following a similar structure to empirical research, utilising papers as data (Denyer and Tranfield, 2009).

The panel leader managed the SLR design and implementation of each step of the process. All members approved the search strategy and selection criteria. The screening process was triangulated between the leader and two members. The leader was responsible for the initial identification of factors and themes, and for mapping them across the TOE and BEnA frameworks, informed by the literature. These factors and themes, as well as their mapping into frameworks, were vetted, refined, and synthesised by panel members through regular meetings until the review panel reached a consensus, as explained in the following sections. All steps, from protocols and data collection to coding, mapping, and synthesis, were transparently documented and communicated among all reviewers.

3.1. Data collection

In Step 2-1, we used search strings that included all relevant blockchain adoption keywords, as shown in Fig. 2, which covers a broader scope than previous reviews (e.g., Vu et al., 2021). Our search was conducted through three major literature databases, Scopus, Web of Science (WoS), and EBSCOhost's Business Source Complete (BSC), following previous systematic reviews published in leading management journals (e.g., Lu et al., 2018; Vu et al., 2021). The search field was limited to the title, abstract, and keywords (TITLE-ABS-KEY) (e.g., Lu et al., 2018; Creevey et al., 2022; Tan et al., 2022).

In Step 2-2, we filtered the papers through a combination of automated screening (years, language, source type, and document type) and manual screening (e.g., content relevance). We do not restrict the year range to minimise retrieval bias (Castañer and Oliveira, 2020; Creevey et al., 2022). The language was limited to 'English', following the conventions of SLRs (Follmer and Jones, 2018). The source type was limited to 'journal' or 'academic journal', as peer-reviewed knowledge sources (Battisti et al., 2021). The document type was restricted to 'article' and 'review', excluding conference proceedings, book series, trade publications, editorials, notes, letters, and other non-refereed publications (Lu et al., 2018; Mahmud et al., 2022). To ensure the quality of research included in our review, we limited our selection to papers published in the ABS 2021 journal list and ranked 3-star or above (Academic Journal Guide, 2021), following previous review studies (Mallett et al., 2019; Battisti et al., 2021). The focus on top-tier journals is a common practice for reliably capturing high-quality scholarly debates and research trends in systematic reviews (Radaelli and Sitton-Kent, 2016; Atewologun et al., 2017). Using journal quality rather than paper rating can avoid the subjectivity of authors' judgements (Kirkman et al., 2006; Foss et al., 2010; Radaelli and Sitton-Kent, 2016). Duplicates among the three databases were then removed by matching their DOIs.

The manual screening process involved two phases of evaluation to filter papers in accordance with the general practice established in SLRs (Creevey et al., 2022). The first phase hinged on the papers' titles and abstracts, followed by the second phase based on the papers' full texts. The panel leader and two panel members conducted the assessment using a systematic review software, Covidence, to facilitate collaboration among members (Kellermeyer et al., 2018). The leader and one member independently evaluated the content relevance of each paper, and a third member served as the conflict resolver. As outlined in the assessment criteria of Fig. 2, the focus is on blockchain adoption by *organisations*, not individual users, as in cryptocurrency trading. Moreover, we are only interested in organisations adopting blockchain for their current business rather than startups entirely built on blockchain. Finally, our focus is on the antecedents of blockchain adoption, not its outcome.

Yet, we also used 'implementation' and 'application' as synonyms of 'adoption', so there are three search strings: baseline ('adoption'), expanded 1 (baseline plus 'OR implementation'), and expanded 2 (baseline plus 'OR application'). This ensured the comprehensiveness of our search against the potential ambiguity in the usage of 'adoption' in the literature. Including 'implementation' and applying the screening process eventually led to adding eight additional papers, while only one additional paper was included when 'application' was added to the search term. Finally, 75 papers were retained for data analysis. Fig. 3 summarises the number of papers that go through each selection step.

The final sample of 75 papers includes publications from 21 journals. Most of the journals are ABS 3-star outlets (n = 15, 71.43 %). The OPS&TECH field (Operations and Technology Management) has the highest number of journals (n = 9, 42.85 %) and includes the largest number of papers (n = 40, 53.33 %). The journal *International Journal of Production Economics* in the OPS&TECH field has the largest number of papers (n = 11, 14.67 %). Other notable journals in our sample are the *Annals of Operations Research* (n = 10, 13.33 %) and the *International Journal of Production Economics* (n = 8, 10.67 %). See Table A.1 in Appendix A for the full list of journals, their ABS rankings, fields, and the number of papers per journal included in our review. We also examined the top ten authors, their citation metrics, and research focus, following recent bibliographic analyses (Kumar et al., 2022; Sharma et al., 2024). We computed the authors' *sample-specific* h-index and total citations. Accordingly, we identified Joseph Sarkis (h-index = 5; total citations = 3193), Samuel Fosso Wamba (h-index = 4; total citations = 538), and Mahtab Kouhizadeh (h-index = 3; total citations = 2784) as the top three influential authors of blockchain adoption research. Their research mainly focuses on barriers to blockchain adoption in sustainable supply chain management. See Table A.2 in Appendix A for the list of the top ten authors and their research focus.

3.2. Data analysis

To fully explore the information within the data, we developed a mixed-methods approach that incorporates both qualitative data coding and quantitative data analysis (Step 2-3).

Identification of themes

We extracted content details for each paper (e.g., research questions, adoption factors, theoretical perspectives, research methodology, key findings, etc.), from which we obtained 880 factors of blockchain adoption. We then applied thematic analysis to aggregate these factors into 29 common themes to answer RQ1. To ensure reliability, we adopted the procedures proposed by Nowell et al. (2017). In our case, this method consists of three iterative phases and two guiding principles to inductively synthesise the factors into themes. In phase 1, we familiarised ourselves with the 880 adoption factors in the contexts of the papers. In phase 2, to avoid arbitrariness, we formed an initial list of themes established in the literature, such as *capability*, *compatibility*, and *complexity*. In phase 3, we aggregated all factors into an initial list of themes. Phases 2 and 3 followed two principles. The first principle is that each theme has a unique emphasis. We allowed for overlapping between theme definitions, but no theme is a subset of another. Overlapping is inevitable because these existing themes are developed and used in different papers by different authors. The second principle is that each factor can be categorised into one theme (one-to-one) or multiple themes (one-to-many). In the latter case, we considered all relevant themes to be equally relevant because there is no universally accepted way of determining the relevance weights. For example, the factor 'business process reengineering' (Choi and Siqin, 2022) highlights the necessary organisational change management for integrating existing business processes with a blockchain system; hence, the factor belongs

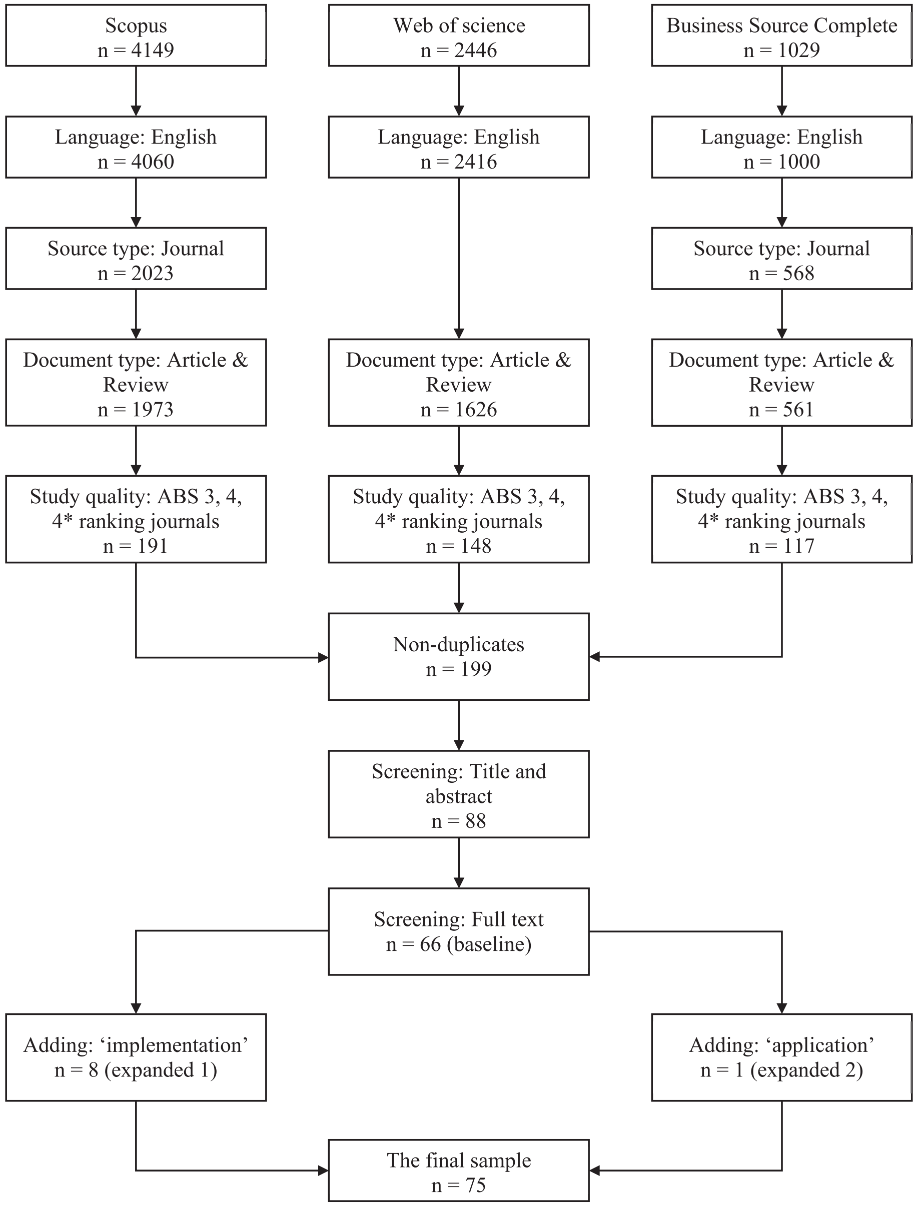

Fig. 3. The number of papers included in the search and screening process.

to both *capability* and *compatibility*. The initial list of extracted factors and their aggregation into themes was undertaken by the panel leader, which was then cross-checked and refined in an iterative process with two panel members. The final list of themes was discussed, adjusted, and approved by all reviewers through several meetings until the review panel reached a consensus. The finalised themes and their definitions are presented in the result section.

Analysis of themes

First, we classified factors into the technology, organisation, or environment dimensions, in accordance with the TOE framework (Baker, 2012; Tornatzky and Fleischer, 1990). Second, we identified if each factor acts as an enabler or a barrier to blockchain adoption. Where the literature could not clearly identify a factor as an enabler or barrier, we labelled it as ambiguous. We term this analysis as the barrier-enabler-ambiguous (BEnA) framework. Utilising factors dimensions, we quantified the extent to which each theme aligns with the technology, organisation, or environment dimensions (TOE ratios) and the extent to which each theme acts as an enabler or a barrier to blockchain adoption (BEnA ratios). The details of these ratio measurements are provided in Section A of the Supplementary Material. We combined TOE and BEnA frameworks to provide a multi-dimensional understanding of the identified themes. Mapping factors to relevant dimensions of TOE and BEnA frameworks was initially performed by the panel leader and then vetted and refined iteratively by two panel members. The final categorisation was discussed and approved by all panel members. Further, analyses of the theme and synthesis of the two frameworks were conducted through various review panel meetings.

Analysis of trends

To answer RQ2, we quantitatively analysed the development of themes and factors in the literature in two ways. First, using *papers* as the unit of analysis, we examined the dispersion of factors along the TOE and BEnA dimensions across years (see Section A of the Supplementary Material for computation formula). This shows how attention to these factors changes chronologically. Second, using *themes* as the unit of analysis, we calculated the number of unique factors per theme and traced the emergence of new themes over time. This allows us to determine whether more factors are used to elaborate existing themes (i.e., involution) or whether new themes are introduced in the literature (i.

e., evolution). We further examined the correlation between the development of factors and the popularity of themes to reveal potential research directions. The results of all analyses are reported in the next sections.

4. Results: themes

Using qualitative thematic analysis, we identified 880 factors, which are aggregated into 29 common themes (the full list of factors is provided in Section D of the Supplementary Material). The general criteria of theme aggregation are to maintain definition clarity, to ensure theme distinction, and to balance theme scopes. Large themes containing broad or mixed information in their definitions necessitate break-up into smaller, more clearly defined ones. Conversely, themes that are too narrow often represent special cases of broader themes and are merged into larger themes where appropriate. To examine the extent of overlap between themes, we quantified the co-occurrence of themes using a correlation matrix and found that most co-occurrences are either weak or statistically insignificant (p-values > 0.05) (see Section B of the Supplementary Material), suggesting that the identified themes are adequately distinctive. The following bullet points present the definitions of these themes (in alphabetic order), along with representative examples of factors and references. This comprehensive list answers RQ1.

- **Accessibility** refers to organisations' access to the necessary environmental infrastructure for blockchain implementation. Examples include IT infrastructure (Saberi et al., 2019), good interfaces (Bai et al., 2021), the absence of blockchain infrastructure (Govindan, 2022), and limited information about infrastructure (Mangla et al., 2022).
- **Adaptability** is the need for organisations to sustain themselves in a changing environment (Bai and Sarkis, 2020). Examples include stronger risk management (Sodhi et al., 2022), improved resiliency of the system (Sharma et al., 2021), and mitigated disruption risks (Narwane et al., 2023).
- **Capability** refers to organisations' objective competencies in adopting a blockchain system (Hastig and Sodhi, 2020). Examples include technical capability (Agi and Jha, 2022), financial resources (Liang et al., 2021), and human capital (Ahi et al., 2022).
- **Collectivity** refers to four core organisational activities in blockchain adoption: collaboration, coordination, cooperation, and communication, reflecting a collective approach within or between organisations (Castañer and Oliveira, 2020; Majchrzak et al., 2015). Examples include employee resistance to change (Ali et al., 2021), top management support (Kamble et al., 2021), goal alignment (Hastig and Sodhi, 2020), cooperation commitment (Kurpjuweit et al., 2021), and cooperation to adopt common supply chain objectives (Agi and Jha, 2022).
- **Compatibility** is the degree to which blockchain innovations are suitable or can integrate with existing systems and processes within organisations (Orji et al., 2020). Examples include integration with legacy systems (Rana et al., 2022), lack of organisational culture for changing (Govindan, 2022), lack of new organisational policies for using blockchain technology (Kouhizadeh et al., 2021), and lack of technology vision in the organisation (Sodhi et al., 2022).
- **Competitivity** is the strategic interdependence among competitors during blockchain adoption, where competitors influence an organisation's understanding and intention to adopt blockchain (Orji et al., 2020). Examples include inter-vendor competition (Cho et al., 2021), mimetic pressures (Hew et al., 2020), competitive pressure (Kamble et al., 2021), and competition intensity between platforms (Li et al., 2021).
- **Complexity** is the perceived difficulty in understanding and using blockchain innovations (Kamble et al., 2021). Examples include perceived ease of use (Turhan and Akman, 2022), complexity in set up or use (Mathivathanan et al., 2021), and increased IT handling complexity (Sternberg et al., 2021).
- **Connectivity** refers to the real-time availability of data among involved stakeholders in a blockchain system (Samad et al., 2023; Yadav et al., 2021) and additionally, includes timely information capture (Huang et al., 2022) and supply chain disconnections (Wang et al., 2019).
- **Efficiency** refers to the ability of a blockchain system to enhance the cost-effectiveness of various processes and transactions for organisations (Sodhi et al., 2022). Examples include transaction speed (Bai et al., 2021), cost reduction (Sharma et al., 2021), and efficient decision-making (Karakas et al., 2021).
- **Feasibility** refers to the practicality and viability of adopting innovation in a specific context, particularly based on the cost-benefit analysis (Huang et al., 2022). Examples include adoption cost (Cho et al., 2021), training cost (Sodhi et al., 2022), sufficiency of internal control mechanisms (Ali et al., 2021), and assessment of blockchain's business value (Ostern et al., 2022).
- **Flexibility** refers to the ease of changing records on a blockchain system, related to blockchain's immutable nature (Rana et al., 2022). Examples include lack of contract mutability (Drummer and Neumann, 2020) and further immutability challenges of blockchain technology (Kouhizadeh et al., 2021).
- **Interoperability** refers to the ability of different systems to exchange and make use of information. It may involve different blockchains, as well as other information systems in organisations (Kurpjuweit et al., 2021). Examples include standardisation of blockchain systems (Dutta et al., 2020), establishing rules and standards for interoperability (Agi and Jha, 2022), and diverging blockchain standards and protocols (Drummer and Neumann, 2020).
- **Legality** refers to the legislation that organisations must consider in blockchain adoption (Hastig and Sodhi, 2020; Xu et al., 2022). Examples include lack of legal security (Govindan, 2022), no legal solution in case of contract breach (Drummer and Neumann, 2020), and legal issues for smart contracts (Rana et al., 2022).
- **Legitimacy** refers to an organisation's tendency to conform to rules and norms established primarily by suppliers, clients, and industry associations during blockchain adoption decision processes (Hew et al., 2020). Examples include customer requirements, trading partner pressure (Wamba et al., 2020), industry-wide initiatives (Agi and Jha, 2022), and normative pressures (Hew et al., 2020).
- **Maturity** refers to the phased features of blockchain innovations, which can be represented by its position in a technology life cycle (Govindan, 2022). Examples include 'infantile challenges' of blockchain (Dwivedi et al., 2023), lack of technological development (Mangla et al., 2022), and immature technology (Toufaily et al., 2021).
- **Novelty** refers to blockchain innovations' distinctive qualities compared to alternative technologies (Falcone et al., 2021). Examples include relative advantage (Hew et al., 2020), smart contract (Samad et al., 2023), decentralisation (Yousefi and Tosarkani, 2022), and cryptographic and tamper-proof qualities (Sharma et al., 2021).
- **Policy** refers to the rules and norms set by the government, which are typically supportive of organisations' adoption of blockchain technology (Mangla et al., 2022). Examples include strong support for start-ups from government bodies (Balasubramanian et al., 2021), lack of governmental commitment (Mangla et al., 2022), and government policy and support (Orji et al., 2020).
- **Popularity** refers to the acceptance rate of suppliers, clients, and competitors towards blockchain technology (Bai et al., 2021). Examples include participation degree (Bai and Sarkis, 2020), user resistance (Kurpjuweit et al., 2021), stakeholder acceptance (Hastig and Sodhi, 2020), and network effect (Sharma et al., 2021).
- **Privacy** is the system's ability to safeguard user identity and control over personal or commercially sensitive data (Toufaily et al., 2021). Examples include immutability and encryption (Yousefi and

Tosarkani, 2022), loss of private keys (Liu et al., 2021), and privacy leakage (Zhao et al., 2019).

- **Regulatory** refers to the regulations made by the government, which are typically restrictive, and that organisations must follow during blockchain adoption (Agi and Jha, 2022). Examples include lack of government regulations (Sharma et al., 2021), lack of regulatory standards and experience (Liu et al., 2021), and regulatory compliance (Rana et al., 2022).
- **Reliability** refers to the likelihood of a blockchain system to work smoothly without system faults or errors (Bai and Sarkis, 2020). Examples include occasional errors (Liu et al., 2021) and inaccurate inputs (Vu et al., 2021).
- **Scalability** refers to the effectiveness of a blockchain system for organisations as the system grows (Sodhi et al., 2022). Examples include throughput capacity (Bai and Sarkis, 2020), storage capacity and scalability (Dwivedi et al., 2023; Zhao et al., 2019), and longer latency time (Sharma et al., 2021).
- **Security** refers to the system's ability to protect data from getting into the wrong hands through a breach, leak, or cyber-attack (Kurpjuweit et al., 2021; Rana et al., 2022). Examples include malicious attacks (Liu et al., 2021), hacking (Wang et al., 2019) and security risks of public blockchains (Drummer and Neumann, 2020).
- **Subjectivity** refers to the influence of personal beliefs, perceptions, or feelings, rather than facts, on adoption decisions. Examples include hesitancy (Saberi et al., 2019), personal innovativeness (Falcone et al., 2021), and varying opinions among decision-makers (Bai and Sarkis, 2020).
- **Sustainability** refers to the (un)sustainable prospects that blockchain technology enables for the environment and society (Yousefi and Tosarkani, 2022). Examples include job creation (Bai et al., 2021), lower carbon footprint (Yousefi and Tosarkani, 2022), and ethical issues (Rana et al., 2022).
- **Traceability** refers to the quality of a blockchain system to discover information about where, when, and how products are produced and exchanged (Sharma et al., 2021). Examples include tracking product components (Bai and Sarkis, 2020), proving provenance (Yousefi and Tosarkani, 2022), and monitoring of agro-practices and processes (Yadav et al., 2021).
- **Transparency** refers to the quality of a blockchain system to operate in a way that makes it easy to see what actions are performed (Karakas et al., 2021). Examples include visibility (Samad et al., 2023) and enhanced food chain transparency (Vu et al., 2021).
- **Trust** refers to the spirit in which a trusted party, whether between individuals or individuals and blockchain technology, will fulfil its obligations as expected by the trusting party (Falcone et al., 2021).

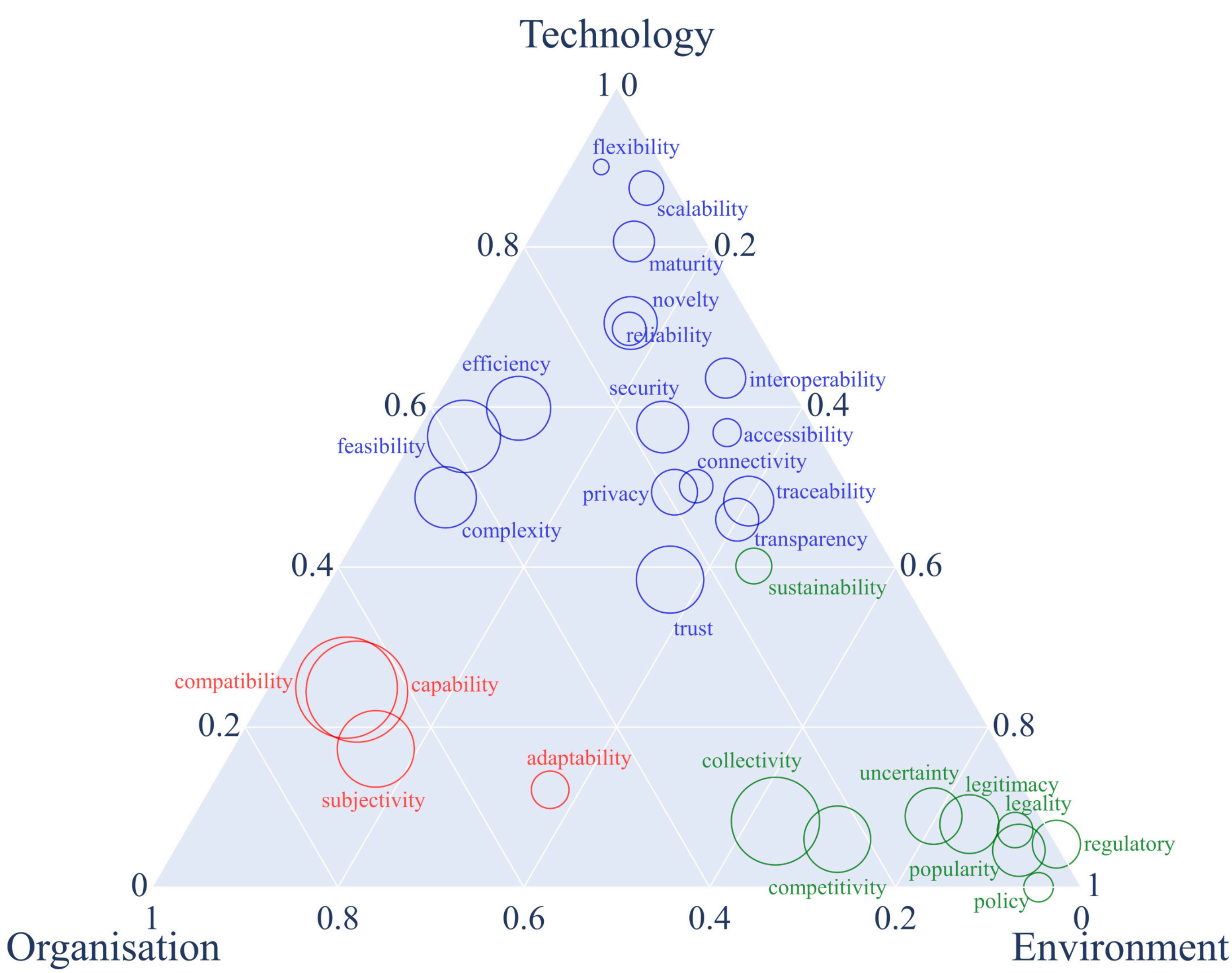

Fig. 4. The TOE composition of themes.
Notes: Blue = Technology-oriented, Red = Organisation-oriented; Green = Environment-oriented. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Examples include trustworthiness (Bai et al., 2021), trust towards blockchain (Sharma et al., 2021), inter-organisational trust (Choi and Siqin, 2022), partnership trust (Huang et al., 2022), and enhanced trust (Sternberg et al., 2021).

- **Uncertainty** encompasses various risks related to blockchain adoption from market regulators and players in the environment (Chowdhury et al., 2023). Examples include market turbulence (Orji et al., 2020), regulatory uncertainty (Dutta et al., 2020), uncertain government policies (Govindan, 2022), and legal and contractual uncertainty (Sharma et al., 2021).

4.1. TOE analysis of themes

Based on TOE ratios of each theme, we can position the themes in a ternary plot (Fig. 4) against the technology (T), organisation (O), and environment (E) dimensions. For instance, the T-ratio of a theme indicates the proportion of its underlying factors that are technology-related. In the ternary plot, the theme's T, O, or E ratios measure the theme's proximity to the three vertices. The size of a circle represents the total number of factors belonging to each theme, while the colour of a circle represents the theme's dominant dimension—based on the dominant T/O/E ratio.

The ternary plot (Fig. 4) reveals important patterns in the distribution of themes across the TOE dimensions. First, as the largest cluster, the T-family has the widest dispersion, contrasting with the more concentrated O- and *E*-family themes. This shows that T-family themes are intertwined with organisational and/or environmental dimensions (Kewell et al., 2017). Notably, *trust*, despite being a T-family theme (T/O/E-ratios: 0.38, 0.25, 0.37), is close to the ternary centre with a balanced set of TOE attributes. Blockchain technology, often described as a 'trust machine' or a 'trustless system' (Sodhi et al., 2022), facilitates distributed trust via unique consensus and verification algorithms, which are obviously a T-dimension attribute. Distrust by top management in blockchain's ability to function correctly can be a barrier against adoption (Kamble et al., 2019), which exemplifies the O-dimension attribute of trust. Additionally, there is a growing emphasis on fostering trustful relationships among participating firms (an E-dimension attribute), forming the foundation for long-term investments (Sternberg et al., 2021). The interconnectedness of the trust theme makes it one of the most challenging issues in blockchain adoption (Queiroz et al., 2021). Similarly, *privacy*, a T-family theme encompassing visibility versus privacy dilemma (Sternberg et al., 2021), privacy leakage and technical schemes (Zhao et al., 2019), and information disclosure issues (Govindan, 2022), is usually addressed through organisational and environmental mechanisms. For example, recent studies emphasise managing data governance (O-dimension) and establishing standards for shared responsibility within a blockchain-based platform ecosystem in inter-organisational settings (*E*-dimension) (Sternberg et al., 2021).

Second, O-family themes are more concentrated, reflecting the connectedness of underlying intra-organisational factors. For instance, Farnoush et al. (2022) suggest that firms with long-term financial well-being show a higher intention to adopt blockchain (*capability*), while recent studies emphasise the alignment between organisational conditions and blockchain technology (*compatibility*) such as organisational culture (Ahi et al., 2022) and organisational strategy (Govindan, 2022). Arguably, *capability* and *compatibility* are closely related themes as, according to the resource-based view, both reflect the resources available within an organisation (Wamba and Queiroz, 2022). One outlier of the O-family themes is *adaptability*, which leans more towards the E-family. This theme encompasses factors external to the organisation, such as improved system resiliency (Sharma et al., 2021), the level of inter-organisational policy adaptability to change (Bai et al., 2021), and various supply chain risks (Narwane et al., 2023).

Third, E-family themes are mainly distributed close to the E-vertex. Exceptions are two O-leaning themes (*competitivity* and *collectivity*) and a T-leaning theme (*sustainability*). Both *competitivity* and *collectivity* are themes with organisational attributes. Competitiveness acquisition is a critical consideration in adopting blockchain to explore first-mover advantage and a positive image effect (Liang et al., 2021). Firms also tend to imitate the adoption strategies of other successful firms, often their competitors, to mitigate uncertainty in a competitive environment (Hew et al., 2020). However, if competition intensifies, firms may have a reduced budget for blockchain adoption (Cho et al., 2021). Moreover, organisations also consider the risk of losing competitiveness after the adoption. For instance, shared business information within an inter-organisational blockchain system may be exploited by competitors (Dutta et al., 2020). *Collectivity* (collaboration, coordination, cooperation, and communication) is crucial for achieving alignment either within organisations (e.g., management-level commitment and employee resistance) or between organisations (e.g., partner commitment and industry stakeholder resistance) for blockchain adoption (Guan et al., 2023; Sternberg et al., 2021). To foster core inter-organisational alignments, proposed organisational capabilities include cognitive capital (i.e., shared vision among partners), relational capital (i.e., social networks), and incentive mechanisms (Choi and Siqin, 2022; Galati, 2022). As an outlier towards the T-dimension, the *sustainability* theme involves factors such as energy efficiency (Bai et al., 2021), lower carbon footprint (Yousefi and Tosarkani, 2022), and stakeholder awareness of sustainability (Saberi et al., 2019; Sternberg et al., 2021), which are linked with technological aspects of blockchain.

In summary, this analysis emphasises the multi-dimensionality of blockchain adoption factors. Most themes exhibit a mix of T-, O-, and E-dimensional attributes, especially the T-family themes. Intra- and inter-organisational interdependence plays a crucial role in O- and E-family themes. It suggests that a binary approach may not be accurate in understanding the TOE attributes of adoption factors. Our multi-dimensional analysis is an extension of the TOE framework and provides a more nuanced review.

4.2. BEnA analysis of themes

The TOE analysis describes the *contexts* in which factors affect the adoption decision (Tornatzky and Fleischer, 1990), but it does not inform the *directions* in which these factors affect the decision. To address this omission, we categorise factors into 'barriers' (B) or 'enablers' (En) to blockchain adoption (e.g., Karakas et al., 2021; Vu et al., 2021). However, the categorisation is not always clear. To be logically complete, we also add an 'ambiguous' (A) category. The 'A' category encompasses three cases: *contingent* factors, where game theoretical or mathematical models assess optimal adoption decisions contingent on variables like cost and competition (Fan et al., 2022); *indeterminate* factors, with unclear or inconclusive effects on adoption, such as psychological influences or unreported statistical significance in control variables (Falcone et al., 2021; Sternberg et al., 2021); and *insignificant* factors, which lack statistical significance, for instance, firm age and size's impact on blockchain adoption in manufacturing (Hew et al., 2020). The BEnA framework provides an analysis of readiness for blockchain adoption by categorising themes based on the signs of their effects. Fig. 5 illustrates how themes are positioned in the BEnA dimensions. The size of each circle indicates the number of factors of each theme, and the colour denotes if the theme belongs to the T-, O-, or *E*-family. A couple of patterns emerge in the ternary plot.

Weak enablers and barriers (farther from the B or En vertex) tend to have more ambiguous (closer to the A vertex) impacts on blockchain adoption. In drawing two regression lines from the B vertex and the En vertex, the slopes of the two regression lines imply that, on average, weak enablers (steeper slope) tend to be more ambiguous than weak barriers (flatter slope), which can explain the challenges against blockchain adoption in practice; enablers are conditional (e.g., *competitivity*), but barriers are more definitive (e.g., *collectivity*). The motivation to adopt blockchain for competitiveness is linked to other

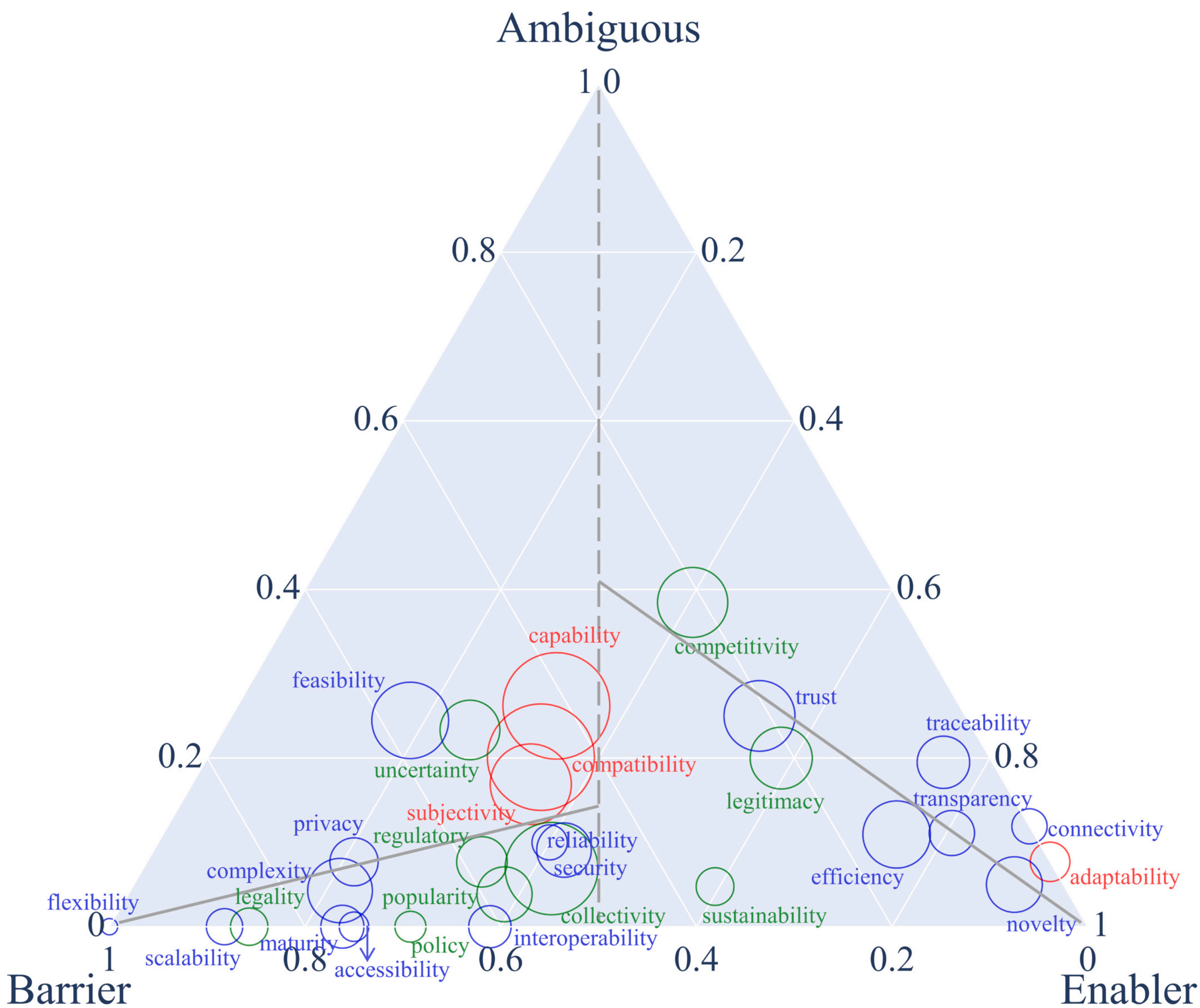

Fig. 5. The BEnA composition of themes.
Notes: Blue = Technology-oriented, Red = Organisation-oriented, Green = Environment-oriented. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

competitive considerations, such as competition intensity (Li et al., 2021), the degree of product disclosure (Song et al., 2023), and pricing power in the market (Zhang et al., 2022). These factors often have threshold values that further inform adoption decisions, which make *competitivity* an enabler of blockchain adoption, conditional on other considerations. In contrast, factors within *collectivity* are primarily barriers, and are more definitive. Examples include conflicts of interest (Kurpjuweit et al., 2021), resistance from current economic winners (Wang et al., 2019), and problems in collaboration, communication, and coordination within the supply chain (Saberi et al., 2019).

Upon combining TOE analysis, it becomes evident that across all families, more themes are on the barrier side, and fewer themes are on the enabler side. The average proportions of barriers (i.e., B-ratios) in the T-, O-, and E-family themes are 47 %, 34 %, and 50 %, respectively. The smaller B-ratio of O-family themes suggests that the main challenges to blockchain adoption come from the environment and the technology. These barriers are potentially beyond the control of organisational decision-makers, exacerbating the challenges of blockchain adoption. Blockchain grapples with inherent tensions on a technological level, such as *traceability* vs *efficiency* (Sternberg et al., 2021), *transparency* vs *privacy* (Vu et al., 2021), immutability (related to *security*) vs *flexibility* (Govindan, 2022). External legal issues, like the absence of a legal framework (Xu et al., 2022) and varying laws across countries (Vu et al., 2021), expose organisations adopting blockchain to legal compliance risks. Similarly, the absence of supportive government policies (Kouhizadeh et al., 2021) and regulatory standards (Wong et al., 2020a) further contribute to these risks.

In summary, our findings reveal that the effects of adoption barriers, which mostly pertain to technology (e.g., technical tensions) or environmental aspects (e.g., legal and regulatory compliance), are more unequivocal. In contrast, the impacts of enablers (e.g., inter-organisational dependence and organisational readiness) tend to be conditional.

5. Results: trends

The analyses of themes summarise the state of the art, but how has the literature developed to this state (RQ2)? Answering this question can illuminate the future research directions. A developmental perspective is required in order to discern trends in research (Ferrigno et al., 2024; Yan et al., 2019), and in taking a temporal review of the papers, we distinguish two types of development: evolution and involution.

The term 'involution' was first coined by the philosopher Immanuel Kant in 1970 (Kant, 1970; Wang and Hui, 2021). Anthropologist Clifford Geertz later used 'involution' to describe a phenomenon in which '*agriculture could not be extended outward, and labor could only be constantly devoted to the limited production of rice*' (Geertz, 1963, pp. 80–81). In this context, agricultural development reached a point of inward over-elaboration, with population growth failing to increase productivity (White, 1983). Inspired by this tradition, we use the terms 'evolution' and 'involution' to describe outward and inward progressions in research, respectively. Evolution refers to the emergence of new themes, whereas involution describes the elaboration of existing themes through the incorporation of novel factors into a given theme. Evolution provides breakthroughs, though too rapid evolution results in a lack of detailed understanding of the phenomenon. When the literature 'involutes', researchers focus on a deep investigation of discipline or subject. Involution carries the risk of excessive elaboration, leading to publications that increase in complexity but fail to embrace broader, inter- or trans-disciplinary thinking necessary for novelty (de Jong et al., 2016; Gooding et al., 2023).

5.1. *Trend analysis of themes*

We measure the extent of evolution by the number of new themes identified per quarter by extant research and involution by the number of identified factors per theme per quarter, normalised by the number of papers. Fig. 6 suggests a significantly positive trend in the number of factors per theme, yet no new themes emerged after 2020Q1. This indicates an early period of evolution as researchers examine the novel blockchain space. An involutionary trend in later blockchain adoption research followed, suggesting that the literature quite rapidly reached a saturation point or limit in generating new themes. Note that the number of factors per theme is calculated for each paper individually and then averaged. Each paper should not have duplicate factors, which ensures the factors' uniqueness per theme. While duplicates might occur across papers, such instances only reinforce our proposition of inward-looking literature; duplication provides even less novelty than involution.

To better capture the trends in the literature, we report the proportions (averaged over papers) of factors belonging to TOE and BEnA dimensions in Table 1.

In the TOE dimensions, researchers' attention shifts to the E-family

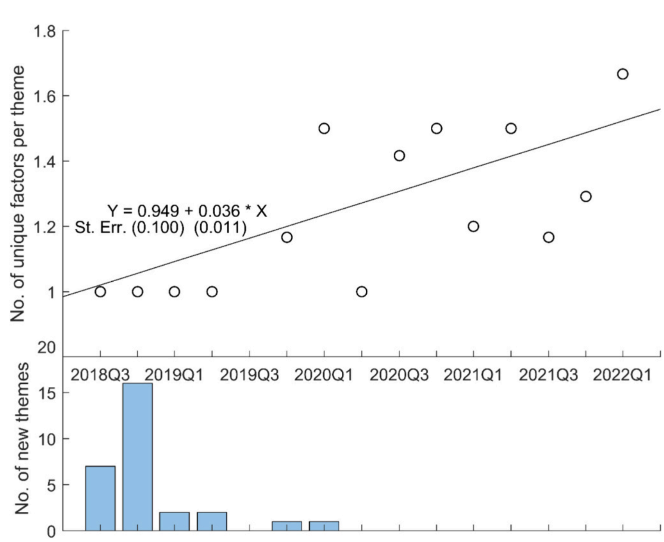

Fig. 6. The trend of the number of factors per theme and the number of new themes.

Table 1
The average proportions of TOE/BEnA dimensions over time.

Year	T	O	E	B	En	A
2018	0.34	0.36	0.30	0.56	0.29	0.14
2019	0.42	0.29	0.29	0.41	0.45	0.15
2020	0.29	0.40	0.31	0.23	0.44	0.33
2021	0.30	0.34	0.36	0.33	0.40	0.27
2022	0.32	0.27	0.41	0.40	0.47	0.14

factors in later years. Neither the T-ratio nor the O-ratio exhibits a clear trend from 2018 to 2022, while the E-ratio expands substantially from 30 % to 41 %. This implies that environmental factors (e.g., coordination complexity and regulatory uncertainty) have recently received greater attention from researchers examining blockchain adoption. This trend in research emerges because blockchain is a technology built on collaboration between networked participants, without which the technical benefits disappear (Patil et al., 2023). Other important E-family themes include support and regulation (e.g., *regulatory*, *legality*, and *policy*) from the government, which have thus far lagged behind business practice.

In the BEnA dimensions, researcher attention has gradually shifted from barriers to enablers over time. As shown in Table 1, the En-ratio has risen significantly from 29 % to 47 %. This implies a shift in research focus from explaining 'why not adopt' (barrier factors) to addressing 'why and how to adopt' (enabler factors). This trend in research reflects a changing attitude in business practice, as empirical findings are mostly based on interviews and surveys of practitioners. As environmental conditions such as related policies and regulations mature, more organisations are expected to adopt blockchain solutions to explore the potential benefits (Hojckova et al., 2020; Orji et al., 2020).

5.2. *'Directed' research change*

The previous subsection demonstrated how factors and themes of research in blockchain adoption have developed over time. Building on the identified trends, this subsection attempts to further explore the overarching relationship among the research trends.

To establish the relationship, we quantify two constructs: (i) the research intensity of a theme is measured by the proportion of *factors* that have elaborated the theme; (ii) the research extensity of a theme is measured by the proportion of *papers* that have investigated the theme. The scatter plot in Fig. 7 demonstrates a statistically significant and positive relationship between research extensity and intensity of themes (p-value < 0.05), suggesting that themes with wider research attention (extensity) are likely to have more factors (intensity). Put differently, the direction of blockchain adoption research is influenced by the popularity of the theme. For example, the most discussed themes (*compatibility* and *capability*) encompass 15 times more factors than the least discussed themes (*flexibility* and *accessibility*).

This 'directed' research change has an important implication for blockchain adoption research. We demonstrate that there is a significant imbalance in the level of elaboration among the identified themes, which appears to be driven by their popularity. If an extensively investigated theme tends to be more intensively explored, then popular themes will grow faster than other themes. Themes may grow to a point where they are destined to break down into smaller new themes, leading to an evolution. We witnessed this evolutionary development in the earlier years before 2020. For example, initially, the three themes *regulatory*, *legality*, and *policy* belonged to a single aggregate dimension, as they all related to *authority*. As an increasing number of researchers focused on this theme and identified contributing factors, distinct foci emerged, based on the general principle of theme identification stated in Section 4. *Regulatory factors* are restrictive rules set by the government (Sharma et al., 2021), differing from *legality* factors, which are restrictive rules set by the legislature (Xu et al., 2022). The former consists of temporary rules, while the latter comprises permanent regulations.

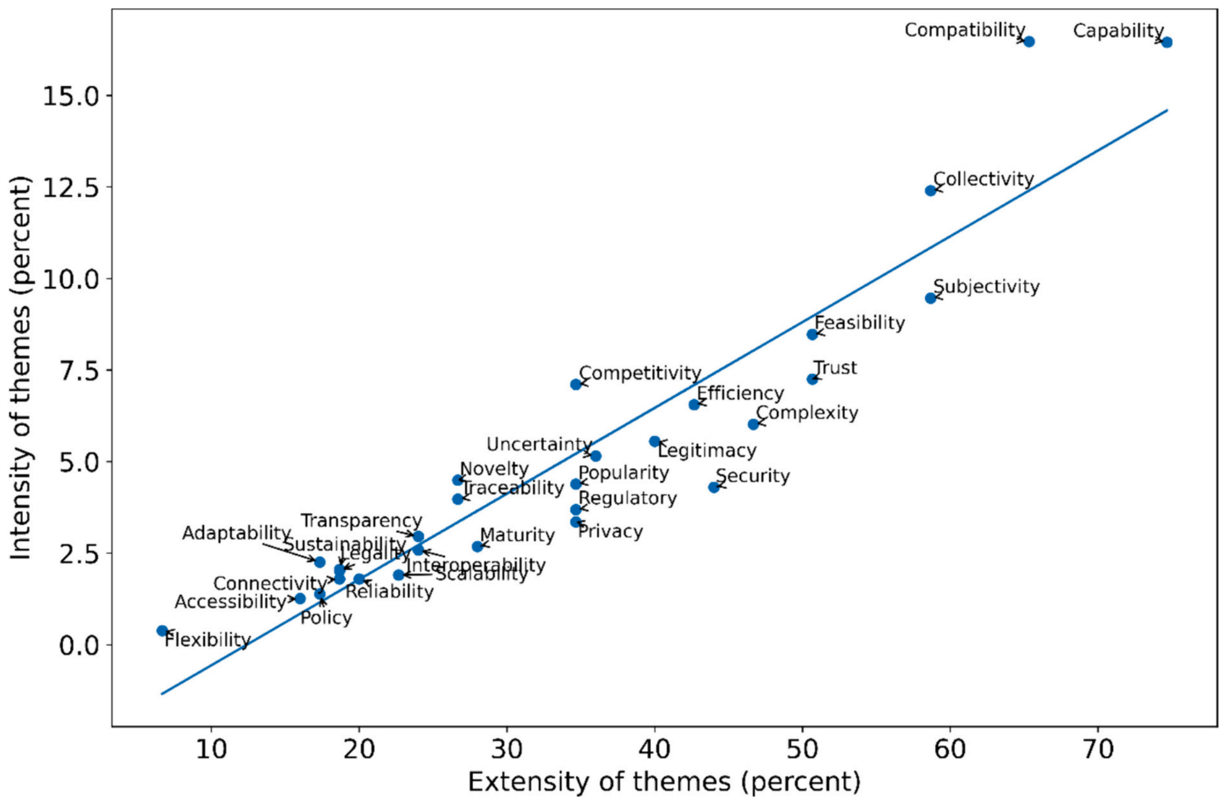

Fig. 7. The relationship between intensity and extensity of themes.

Beyond these restrictive rules, supportive *policies* have also been implemented by policymakers to foster blockchain adoption (Orji et al., 2020).

6. Future research agenda

Drawing on evidence from preceding analyses, we discuss three directions to advance blockchain adoption research (Table 2).

6.1. Scrutinising interdependence and multi-dimensionality aspects of blockchain adoption

The first direction is to study themes that demonstrate significant interdependence across TOE dimensions, as identified in our TOE analysis. These types of themes cannot be well studied within one single dimension, so multiple views are needed to study themes that involve multiple stakeholders. Notably, themes such as *trust*, *privacy*, *sustainability*, and *collectivity* demonstrate significant multi-dimensionality and interdependence. *Trust* plays a pervasive role across all TOE dimensions. While the role of trust as a key determinant for adoption decisions has been increasingly recognised (e.g., Gan and Lau, 2024; Wong et al., 2020a), less attention has been given to the trust-building process. Moreover, although blockchain shifts the mode of trust towards trust in technology, the perceived trustworthiness of organisational partners and technology providers remains instrumental (Lumineau et al., 2023), at least in the early stages of adoption. Additionally, while blockchain reduces reliance on a central authority, regulatory certainty and safeguards still play a role in fostering trust (Orji et al., 2020). Exploring the interplay between these aspects, the mechanisms of trust formation, and their changing significance over time is a promising research area. Similarly, reconciling tensions between *privacy* concerns, system transparency, and competitive considerations in adopting blockchain technology warrants further investigation across technological, organisational, and environmental levels. Investigating the diverse factors influencing blockchain adoption across multiple *sustainability* dimensions, including environmental, economic, and social aspects, presents another promising research area.

Furthermore, *collectivity* involves significant inter-organisational dynamics to foster blockchain adoption. While existing literature emphasises the challenges of inter-organisational alignments (e.g., Kouhizadeh et al., 2021), the process of establishing these alignments in adoption decisions remains unclear. For instance, Galati (2022) notes that relational capital is necessary but not sufficient for adopting blockchain in supply networks. This calls for a deeper understanding of how competitive considerations impact co-optative dynamics in blockchain network formation (Galati, 2022), how centralised leadership empowers joint implementation of blockchain while balancing the necessity for decentralised governance among organisations (Guo and Zhou, 2023; Naef et al., 2022), and how interoperability between different blockchain networks impacts collective adoption in multi-stakeholder situations (Dutta et al., 2020).

6.2. Examining conditional or unclear drivers of blockchain adoption

The second direction is to further examine themes that are unclear or conditional—the 'A' dimension of the BEnA framework—to better understand their roles. Factors that are theoretically relevant but empirically rejected (e.g., top management support, performance expectancy, firm size) or indeterminate (e.g., hesitancy, regret aversion, organisational readiness) warrant deeper examination to confirm the plausibility and the generalisability of their effects on blockchain adoption. For instance, firm size is found to have no effect on halal manufacturers' intention to participate in blockchain-based traceability systems (Hew et al., 2020). However, subsequent research in the context of the Chinese supply chain reveals that firm size does play a significant role, with large organisations demonstrating higher readiness compared to smaller firms (Shahzad et al., 2024). For the *contingent* factors theoretically discussed in analytical models (e.g., competition intensity, organisation sector,

Table 2
Key avenues for future research.

Research directions	Key research areas
Research direction 1: *Scrutinising interdependence and multi-dimensionality aspects of blockchain adoption*	**Trust** • Exploring the trust-building process in organisations' blockchain adoption decisions and the interplay of technological, organisational, and institutional aspects of trust • Examining how the relative importance of technological trust, inter-organisational trust, and institutional trust evolve during the blockchain adoption process • Examining whether and how technological, inter-organisational, and institutional aspects of trust complement or substitute each other at different stages of blockchain adoption **Privacy** • Examining the tension between heterogenous organisations' privacy concerns and maintaining information transparency in blockchain networks • Exploring how cross-border blockchain networks between organisations address privacy and data protection laws in different jurisdictions • Examining how blockchain facilitates secure and private data sharing between organisations without compromising competitive advantages **Sustainability** • Exploring the diverse factors shaping blockchain adoption across multiple sustainability goals, contextualised within specific environmental (e.g., renewable energy trading, carbon credits), economic (e.g., supply chain finance, assets tokenisation), and social (e.g., humanitarian operations management, ethical supply chains) dimensions • Examining the impact of stakeholder awareness and sustainability inclination on blockchain adoption decisions • Examining the impact of sustainability standards, corporate accountability requirements, and policy initiatives on blockchain adoption decisions **Collectivity** • Studying the competition versus cooperation tension and inter-organisational alignments in forming blockchain networks • Studying the tension between a need for centralised leadership while maintaining the decentralised operation • Studying how the interoperability between different blockchain networks affects its collective adoption in multi-stakeholder situations
Research direction 2: *Examining conditional or unclear drivers of blockchain adoption*	**Competitivity** • Empirically examining the role of contingent factors suggested in analytical models such as competition intensity, consumer sensitivity to blockchain, information disclosure policy, and their moderation or mediation effects on blockchain adoption • Empirically examining how competitive considerations for blockchain adoption vary across market structures with different competition intensities • Empirically examining the variation in competitive strategies, such as entry deterrence, for blockchain adoption between incumbent firms and potential entrants **Capability** • Empirically examining contextual nuances that influence the statistical significance of factors like firm size, age, and sector • Empirically examining how organisational cultures and leadership styles of top management influence blockchain adoption decisions across organisations
Research direction 3: *Expanding contextual, temporal, and theoretical investigation of blockchain adoption*	**Context expansion** • Investigating how blockchain adoption differs across countries with diverse cultural and institutional settings, including collectivistic versus individualistic cultures, as well as well-established versus less developed institutional safeguards • Conducting a comparative analysis of blockchain adoption across sectors with varying concerns about privacy, legal compliance, security, etc. • Employing a longitudinal approach to study organisations' blockchain adoption decisions, capturing the evolution of barriers/enablers and their shifts in prominence and impact throughout the technology adoption cycle **Theoretical perspectives expansion** • Integrating current technology adoption theories to comprehensively understand various aspects (symbolic, functional, behavioural, institutional, etc.) of blockchain adoption • Employing theories that address the tensions and multidimensional nature of blockchain adoption, such as complexity theory, sociomateriality, and paradox theory, to offer novel perspectives on organisations' blockchain adoption • Developing theories to address the *causal complexity* inherent in blockchain adoption, which involves the interdependence of multiple conditions, multiple pathways to a given outcome, and indefinite causal relations, from a configurational perspective. Qualitative Comparative Analysis (QCA) can serve as a valuable tool for building such theoretical propositions

information disclosure policy), future empirical studies can verify the theoretical propositions and understand how these factors are moderated by other variables. Further empirical investigation is necessary to understand the varying competitive considerations across market structures, including different competition intensities and distinctions between incumbent firms and potential entrants. *Competitivity* and *capability* stand out as the two themes with the highest ambiguity ratios in our analysis. Contingent factors like price, cost, consumer sensitivity to blockchain, and competition intensity are notable ambiguous factors of *competitivity*. *Capability* involves broader aspects of ambiguous factors, such as insignificant factors like firm size, age, and top management support, contingent factors like sector, and indeterminate factors like organisational readiness.

6.3. Expanding contextual, temporal, and theoretical investigation of blockchain adoption

The cycle of evolution and involution is inherent to scientific inquiry. Based on our analysis, it appears that blockchain adoption research is in a period of involution, marked by a saturated set of themes. We propose two avenues to invigorate research with fresh perspectives on these themes, which could potentially spur a new evolutionary phase in blockchain adoption research. The first avenue is context expansion, spanning not only ‘space’ (cross-sectional) but also ‘time’ (longitudinal) dimensions. While many studies investigate or survey blockchain adoption factors in a cross-sectional setting, there is a consensus that future research should adopt a more longitudinal approach to capture dynamics across the technology adoption process (e.g., Hew et al., 2020; Kamble et al., 2019; Wong et al., 2020b). Currently, our sample identifies only one longitudinal case study by Sternberg et al. (2021), offering an in-depth understanding of supply chain organisations' struggles with blockchain adoption. Broader and further longitudinal studies are essential to understand the evolution of barriers/drivers and their shifts in prominence and relationships (Kouhizadeh et al., 2021). The second avenue involves expanding theoretical perspectives. In our sample, five underpinning theories account for more than half of those used in the blockchain adoption literature, i.e., Game Theory, Technology Acceptance Model, TOE framework, Unified Theory of Acceptance and Use of Technology, and Diffusion of Innovations Theory (see Section C of Supplementary Material). These established theories are effective in explaining themes from a single disciplinary perspective. However, further investigation into the interdependence aspects of themes, such as industry leadership and trust-building, could better fit into different theoretical frameworks that recognise the trans-disciplinary nature of blockchain technology adoption (Chandler and Kirsch, 2018; Mačiulienė and Skaržauskienė, 2021). Future research should further develop theories to address the inherent *causal complexity* in blockchain adoption, which involves the interdependence of multiple conditions, multiple pathways to a given outcome, and indefinite causal relations, from a configurational perspective (Misangyi et al., 2017).

7. Conclusion and discussion

In this paper, we offer an in-depth, integrative review of blockchain adoption factors and extract the patterns and trends of the research through a developmental perspective. In the mixed-methods SLR, to answer RQ1, applying a thematic analysis, we identified 29 themes from 880 factors in organisations' blockchain adoption research. We mapped these themes across technology-organisation-environment (TOE) and barrier-enabler-ambiguous (BEnA) dimensions and quantified their proximity to each dimension. To answer RQ2, applying a quantitative approach, we analysed how these themes have been developed in the previous studies over time and uncovered recent research attention towards elaborating established themes rather than generating new themes—an involutionary pattern. Building on these findings, we discuss theoretical contributions and practical implications.

Our paper provides a comprehensive review of the research and adoption factors without being limited to a specific industry (c.f., Chang et al., 2019; Balasubramanian et al., 2021) or a subset of factors based on a specific theory (c.f., Agi and Jha, 2022; Kamble et al., 2019). The holistic overview reconciles contradictory findings and unifies fragmented evidence in existing research. Additionally, previous reviews often use a binary approach to examine blockchain adoption (e.g., Toufaily et al., 2021; Xu et al., 2022). In this review, by integrating research findings through multidimensional analyses, we highlight the interdependence of adoption factors among the technological, organisational, and environmental aspects.

The integration of the TOE and BEnA frameworks shows that adoption barriers are more frequently related to the technology (e.g., technology tensions such as *traceability* vs *efficiency* and *transparency* vs. *privacy*: Sternberg et al., 2021) or the environment (e.g., legal and regulatory compliance: Wong et al., 2020a). In contrast, the positive impact of enablers (e.g., inter-organisational trust and organisational readiness: Choi and Siqin, 2022) tends to be conditional on other parameters such as inter-organisational competition and collaboration (Li et al., 2021) and intra-organisational support for inter-departmental efforts (Cozzio et al., 2023). Overall, situating adoption themes across TOE and BEnA dimensions highlights the multidimensionality of blockchain adoption and reveals potentially overlooked dimensions. This analytical framework can be generalised to adoption of other disruptive technologies such as artificial intelligence, cloud computing, big data, etc.

Demonstrating the trends in the literature, we show that research on blockchain adoption after 2020 follows an involutionary pathway. These studies have focused on examining the established themes in blockchain adoption, such as *capability* and *compatibility*, often inflating them with novel (sometimes repetitive) factors, while leaving other themes (e.g., *flexibility* and *accessibility*) less explored. Our conjecture is that the current trend is temporary. Popular themes will reach a saturation point, and it will be then that we expect to see new themes developed and new theories applied to accommodate the new themes. Rene Descartes views such development as ‘a tree of knowledge’, where new knowledge springs from the old when old frameworks fail to solve new problems (Ariew, 1992). We propose three directions to advance knowledge development in blockchain research: scrutinising the interdependence and multi-dimensionality aspects of blockchain adoption, examining its conditional or unclear drivers, and broadening contextual, temporal, and theoretical investigation of blockchain adoption. We hope our research agenda spurs future studies to address critical gaps in understanding organisations' blockchain adoption.

The review also generates practical implications for different stakeholders in blockchain adoption. The comprehensive set of themes of blockchain adoption helps managers proactively mitigate risks associated with blockchain projects. We emphasise the importance of alignment (1) between technology attributes and organisational conditions such as culture, strategy, and infrastructure and (2) between different organisations in decision-making for successful adoption. Notably, 82 % of global executives have reported the lack of fair governance rules and clearly defined roles among collaborators as significant barriers to blockchain adoption (Deloitte, 2020). Our study supports this by highlighting the importance of inter-organisational aspects of blockchain adoption, particularly the *collectivity* (i.e., collaboration, coordination, cooperation, and communication among organisations), which stands in the middle of the enabler-barrier continuum (in Fig. 5), highlighting its pertinent challenges.

For blockchain service providers, this review offers general principles for developing blockchain-based applications and infrastructure. Addressing inherent tensions on a technological level, such as *traceability* vs *efficiency*, *transparency* vs *privacy*, *immutability* vs *flexibility*, and *security* vs *scalability*, requires innovative solutions or appropriate application scenarios to better transform blockchain's technical advantages into business value. Beyond technical improvements, trust is essential for promoting widespread blockchain adoption. The failure of Tradelens, a blockchain-based supply chain platform developed by IBM and Maersk, underscores the challenge of fostering trust and cooperation in a highly competitive industry (Holmstad, 2022).

For policymakers, our review identifies some themes with social values in blockchain adoption, such as *privacy*, *security*, and *sustainability*, so government interventions and regulatory legislations are entailed. The immutability of blockchain records, while beneficial for data integrity and security, conflicts with regulations requiring data to be alterable or removable, such as the EU's General Data Protection Regulation (GDPR). Additionally, cross-border blockchain applications with sustainability implications must navigate complex international regulations that vary significantly between jurisdictions. For instance, the Brooklyn Microgrid project, a peer-to-peer energy trading using blockchain, must comply with various local, state, and federal regulations regarding energy distribution and data privacy (Neal, 2022). These regulatory complexities can delay or even prevent the implementation of blockchain solutions, highlighting the need for policymakers' initiatives.

CRediT authorship contribution statement

Ying Zhang: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **M. Mahdi Tavalaei:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Resources. **Glenn Parry:** Writing – review & editing, Validation, Supervision, Resources, Funding acquisition, Data curation, Conceptualization, Methodology. **Peng Zhou:** Writing – review & editing, Visualization, Validation, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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Appendix A. Descriptive analysis of the final sample

Table A.1
Journal title, journal ABS ranking, journal field, and papers per journal included in our review.

Journal title	ABS	Field	Paper count	%
Int. Bus. Rev. (IBS)	3	IB&AREA	1	1.33
Inf. Manage. (IM)	3	INFO MAN	3	4.00
Inf. Technol. People (ITP)	3	INFO MAN	2	2.67
J. Manage. Inf. Syst. (JMIS)	4	INFO MAN	2	2.67
J. Inf. Technol. (JIT)	4	INFO MAN	1	1.33
Technol. Forecast. Soc. Change (TFSC)	3	INNOV	5	6.67
Ind. Mark. Manage. (IMR)	3	MKT	1	1.33
Comput. Ind. (CI)	3	OPS&TECH	2	2.67
IEEE Trans. Eng. Manage. (IEEE-TEM)	3	OPS&TECH	2	2.67
Int. J. Prod. Econ. (IJPE)	3	OPS&TECH	8	10.67
Int. J. Prod. Res. (IJPR)	3	OPS&TECH	11	14.67
Int. J. Oper. Prod. Manage. (IJOPM)	4	OPS&TECH	1	1.33
J. Bus. Logist. (JBL)	3	OPS&TECH	3	4.00
Prod. Plann. Control (PPC)	3	OPS&TECH	5	6.67
Prod. Oper. Manage. (POM)	4	OPS&TECH	2	2.67
Supply Chain Manage. (SCM)	3	OPS&TECH	6	8.00
Ann. Oper. Res. (AOR)	3	OR&MANSCI	10	13.33
Eur. J. Oper. Res. (EJOR)	4	OR&MANSCI	1	1.33
Manage. Sci. (MS)	4*	OR&MANSCI	1	1.33
Transp. Res. Part E (TRE)	3	SECTOR	6	8.00
Bus. Strategy Environ. (BSE)	3	SOC SCI	2	2.67

Notes: 1) Field is sourced from the ABS list (AJG2021). 2) IBS: International Business Review; IM: Information and Management; ITP: Information Technology and People; JMIS: Journal of Management Information Systems; JIT: Journal of Information Technology; TFSC: Technological Forecasting and Social Change; IMR: Industrial Marketing Management; CI: Computers in Industry; IEEE-TEM: IEEE Transactions on Engineering Management; IJPE: International Journal of Production Economics; IJPR: International Journal of Production Economics; IJOPM: International Journal of Operations and Production Management; JBL: Journal of Business Logistics; PPC: Production Planning and Control; POM: Production and Operations Management; SCM: Supply Chain Management; AOR: Annals of Operations Research; EJOR: European Journal of Operational Research; MS: Management Science; TRE: Transportation Research Part E: Logistics and Transportation Review; BSE: Business Strategy and the Environment. 3) IB&AREA: International Business and Area Studies; INFO MAN: Information Management; INNOV: Innovation and technology change management; MKT: Marketing; OPS&TECH: Operations and Technology Management; OR&MANSCI: Operations Research and Management Science; SECTOR: Sector Studies; SOC SCI: Social Sciences.
In the ABS journal ranking, 4* is higher than 4.

Table A.2
Top ten productive authors based on our sample.

Rank	Authors	h-Index	Total citations	Paper count	Year of first publication	Research focus
1	Sarkis, J	5	3193	5	2018	Adoption factors in sustainable supply chain management and circular economy
2	Fosso Wamba, S	4	538	4	2020	Barriers to blockchain adoption in operations, logistics, and supply chain digitalisation; mainly empirical studies using surveys
3	Kouhizadeh, M	3	2784	3	2018	Barriers to blockchain adoption in sustainable supply chain
4	Queiroz, M. M	3	512	3	2020	Barriers to blockchain adoption in operations and supply chain; mainly empirical papers using surveys

(*continued on next page*)

Table A.2 (*continued*)

Rank	Authors	h-Index	Total citations	Paper count	Year of first publication	Research focus
5	Ooi, K. B	3	377	3	2020	Blockchain adoption in Malaysia for operations management, mainly empirical papers using survey
6	Tan, G. W. H	3	377	3	2020	Adoption factors for operations management in Malaysia; mainly empirical papers using surveys
7	Wong, L. W	3	377	3	2020	Adoption factors for operations management in Malaysia; mainly empirical papers using surveys
8	Fan, Z. P	3	211	3	2020	Adoption factors in food supply chain and e-commerce platforms
9	Wu, X. Y	3	211	3	2020	Adoption factors in food supply chain and e-commerce platforms
10	Raut, R. D	3	102	3	2021	Adoption factors in India's food and agriculture sectors

Notes: 1) The h-index measures both the productivity and citation impact of a scholar's publications based on our sample. It is defined as the maximum value of h such that the author has h papers, each cited at least h times. For example, an h-index of 5 means the researcher has 5 papers in our sample, each cited at least 5 times. Paper count and Total citations refer to the author's total number of papers in our sample and corresponding citations as of 30th June 2024. Year of first publication is when the author's first paper in our sample was made available online. Research focus on blockchain adoption is identified through their papers included in our sample. 2) Data source: Crossref, an official Digital Object Identifier (DOI) registration agency of the International DOI Foundation. 3) Our sample includes 214 authors.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.techfore.2024.123710.

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