Blockchain as an Emerging and Disruptive Technology for Container Shipping Logistics: Bridging the Gap between Transformative Potential and Industry Adoption

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Abstract

Blockchain has emerged as one of the most promising technologies for transforming container shipping logistics because of its potential to enhance transparency, traceability, automation, interoperability, and trusted information sharing across maritime supply chains. Despite being widely recognised as both an emerging and disruptive technology, its adoption and industry-wide impact have remained considerably slower than anticipated. This study systematically reviews the literature to examine why blockchain is considered an emerging and disruptive technology, identify the factors responsible for the gap between its transformative potential and actual implementation, and explore future directions for enabling wider adoption. A systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) Statement, with evidence synthesised from 86 peer-reviewed studies published between 2008 and 2026 using thematic analysis. The review reveals that blockchain's limited disruptive impact is primarily constrained by governance challenges, trust deficits, organisational resistance, regulatory and legal constraints, confidentiality concerns, and interoperability limitations rather than technological shortcomings. The findings further demonstrate that governance neutrality, consortium-based collaboration, privacy-preserving technologies, interoperability standards, regulatory alignment, organisational readiness, and ecosystem-wide collaboration are essential for realising blockchain's disruptive potential. This study provides a comprehensive synthesis of current knowledge and offers a research agenda to support the broader adoption and sustainable digital transformation of container shipping logistics.

Keywords: Blockchain; Emerging Technology; Disruptive Technology; Container Shipping Logistics; Systematic Literature Review; Digital Transformation

1. Introduction

Container shipping logistics forms the backbone of global trade by facilitating the movement of goods across complex international supply chains. The industry connects shipping lines, ports, customs authorities, freight forwarders, terminal operators, logistics providers, and regulatory agencies to enable the efficient movement of cargo across national and international boundaries. As global trade continues to expand in both volume and complexity, the maritime industry is undergoing extensive digital transformation to improve operational efficiency, supply chain visibility, information sharing, resilience, and service delivery [62, 73, 85]. Despite these digitalisation efforts, container shipping logistics continues to experience fragmented information systems, paper-intensive documentation processes, limited interoperability, duplicated administrative activities, and persistent trust challenges among participating organisations [12, 40, 71, 76]. These longstanding limitations have increased the demand for digital technologies capable of fundamentally transforming how information is exchanged, verified, and governed across maritime logistics ecosystems.

Among the technologies driving digital transformation, blockchain has emerged as one of the most widely discussed innovations within both academia and industry. Initially developed to support cryptocurrencies, blockchain has evolved into a general-purpose distributed ledger technology capable of securely recording, validating, and sharing transactions across decentralised networks without relying on a single trusted intermediary [44, 39, 82, 79]. Its core capabilities, including decentralisation, immutability, transparency, consensus mechanisms, smart contracts, and cryptographic security, have attracted significant attention across multiple sectors, including finance, healthcare, manufacturing, government services, and supply chain management [25, 79, 82,26, 35, 23]. Within container shipping logistics, blockchain has been promoted as a technology capable of improving cargo traceability, enhancing information transparency, automating business processes, reducing fraud, strengthening interoperability, simplifying documentation, and improving collaboration among geographically distributed stakeholders [18,19, 82, 52,38].

Beyond these technological capabilities, blockchain is increasingly recognised as both an **emerging technology** and a **disruptive technology**. Emerging technologies are generally characterised by novelty, rapid technological evolution, high levels of scientific and market uncertainty, evolving standards, and the potential to generate significant economic and societal transformation [20,21; 11]. Disruptive technologies, in contrast, fundamentally reshape existing industries by introducing new business models, redefining value creation, reducing dependence on traditional intermediaries, enabling new forms of governance, and transforming organisational relationships (66, 65, 48). Blockchain exhibits many of these defining characteristics through its decentralised architecture, distributed governance mechanisms, programmable smart contracts, and ability to establish trust among organisations that may not fully trust one another [79, 2, 9]. Consequently, blockchain has been widely presented as a technology with the potential to fundamentally transform container shipping logistics by replacing fragmented, paper-based, and intermediary-dependent processes with trusted, interoperable, and digitally connected ecosystems.

Despite these expectations, the anticipated industry-wide transformation has not materialised. Although blockchain has been the subject of substantial academic research, industrial investment, pilot projects, and collaborative initiatives, its adoption across container shipping logistics remains considerably lower than originally anticipated [54, 46, 6]. Several large-scale blockchain initiatives have demonstrated technical feasibility, yet many have struggled to achieve sustainable ecosystem-wide adoption, while others have been discontinued despite considerable technological success (22, 41, 32, 33, 51; 38,72]. This apparent contradiction presents an important paradox. If blockchain possesses the defining characteristics of both emerging and disruptive technology and demonstrates considerable transformative potential, why has it not fundamentally transformed container shipping logistics?

Existing research has contributed significantly to understanding blockchain adoption from technological, organisational, governance, legal, and operational perspectives. Numerous studies have investigated blockchain architecture, smart contracts, interoperability, privacy mechanisms, governance models, organisational readiness, regulatory challenges, trust formation, and implementation barriers [31, 7,73,75]. Collectively, these studies provide valuable insights into the factors influencing blockchain adoption within maritime logistics. However, the existing body of knowledge remains fragmented. Much of the literature examines individual technological capabilities or isolated adoption challenges, while relatively limited attention has been devoted to explaining how these factors collectively account for the persistent gap between blockchain's recognised transformative potential and its comparatively limited industry adoption. Consequently, although the literature clearly demonstrates that blockchain possesses substantial disruptive capabilities, it provides only limited integrated understanding of why these capabilities have not yet translated into widespread industry transformation.

This review addresses this gap by critically synthesising the existing literature to explain why blockchain, despite being widely recognised as an emerging and disruptive technology, has not yet realised its transformative potential within container shipping logistics. Rather than simply cataloguing adoption challenges, this paper examines the relationship between blockchain's disruptive characteristics, its anticipated transformative capabilities, and the technological, organisational, governance, regulatory, interoperability, and confidentiality factors that collectively influence industry adoption. By integrating these diverse perspectives, the review provides a comprehensive explanation of the disconnect between blockchain's transformative potential and its current level of implementation while identifying future directions capable of supporting wider industry adoption and realising blockchain's disruptive potential.

Accordingly, this study addresses the following research questions:

RQ1: Why is blockchain considered an emerging and disruptive technology in container shipping logistics?

RQ2: What factors explain the gap between blockchain's transformative potential and its actual adoption of industry?

RQ3: What future directions could enable blockchain to realise its disruptive potential in container shipping logistics?

2. Methodology

This study employed a Systematic Literature Review (SLR) to synthesise existing knowledge on blockchain as an emerging and disruptive technology in container shipping logistics and to explain the gap between its recognised transformative potential and its actual industry adoption. A systematic literature review was selected because it provides a transparent, rigorous, and reproducible approach for identifying, evaluating, and synthesising evidence from existing studies. The review methodology was guided by the systematic review procedures proposed by [78]. This systematic literature review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) Statement to ensure methodological transparency, completeness, and reproducibility. This systematic literature review was not prospectively registered in a review registry such as PROSPERO or the Open Science Framework (OSF), and no formal review protocol was prepared. The overall review process adopted in this study is illustrated in Figure 1.

Figure 1. Systematic Literature Review Methodology Adopted in This Study

The literature search was conducted between May and June 2026 across eleven scientific databases comprising Scopus, Web of Science, IEEE Xplore, ACM Digital Library, ScienceDirect, SpringerLink, Taylor & Francis Online, Emerald Insight, ProQuest, EBSCOhost, and Google Scholar. Google Scholar was used primarily to identify recently published studies and to perform backward and forward citation tracking. The review considered publications published between January 2008 and June 2026, reflecting the emergence of blockchain technology and the evolution of its application within container shipping logistics.

The search strategy combined keywords using Boolean operators (AND and OR). Representative search terms included blockchain, distributed ledger technology, container shipping, maritime logistics, shipping logistics, supply chain, emerging technology, disruptive technology, digital transformation, trust, governance, interoperability, confidentiality, privacy, adoption, implementation, and smart contracts. Additional backward and forward citation searches were conducted to identify relevant studies that were not retrieved during the initial database search.

Publications were eligible for inclusion if they were peer-reviewed journal articles or conference papers published in English that examined blockchain within container shipping logistics, maritime logistics, maritime supply chains, or closely related logistics domains. Eligible studies investigated one or more aspects of blockchain's emerging characteristics, disruptive potential, governance, trust, interoperability, confidentiality, regulatory environment, organisational adoption, implementation challenges, or future research directions. Publications focusing exclusively on cryptocurrencies, blockchain performance benchmarking without organisational implications, dissertations, editorials, book chapters, duplicate records, grey literature, or studies unrelated to maritime or logistics applications were excluded.

Study selection was undertaken in two sequential stages. During the first stage, the titles and abstracts of all retrieved records were screened against the predefined eligibility criteria. Publications considered potentially relevant proceeded to full-text review during the second stage. The screening and eligibility assessment were performed independently by the authors. Any differences in study selection were resolved through discussion until consensus was reached. No automation tools were used during the screening process.

The database search initially identified 150 publications. After removing duplicate records, the remaining publications were screened using their titles and abstracts to determine their relevance to the research questions. Studies satisfying the initial screening criteria subsequently underwent full-text assessment against the predefined eligibility criteria. Publications that lacked direct relevance to blockchain adoption within container shipping logistics or did not contribute to the objectives of the review were excluded. Following the screening and eligibility assessment, 86 studies satisfied all inclusion criteria and were retained for the final review. The complete study selection process is presented in Figure 2.

Figure 2. PRISMA 2020 Flow Diagram of the Study Selection Process

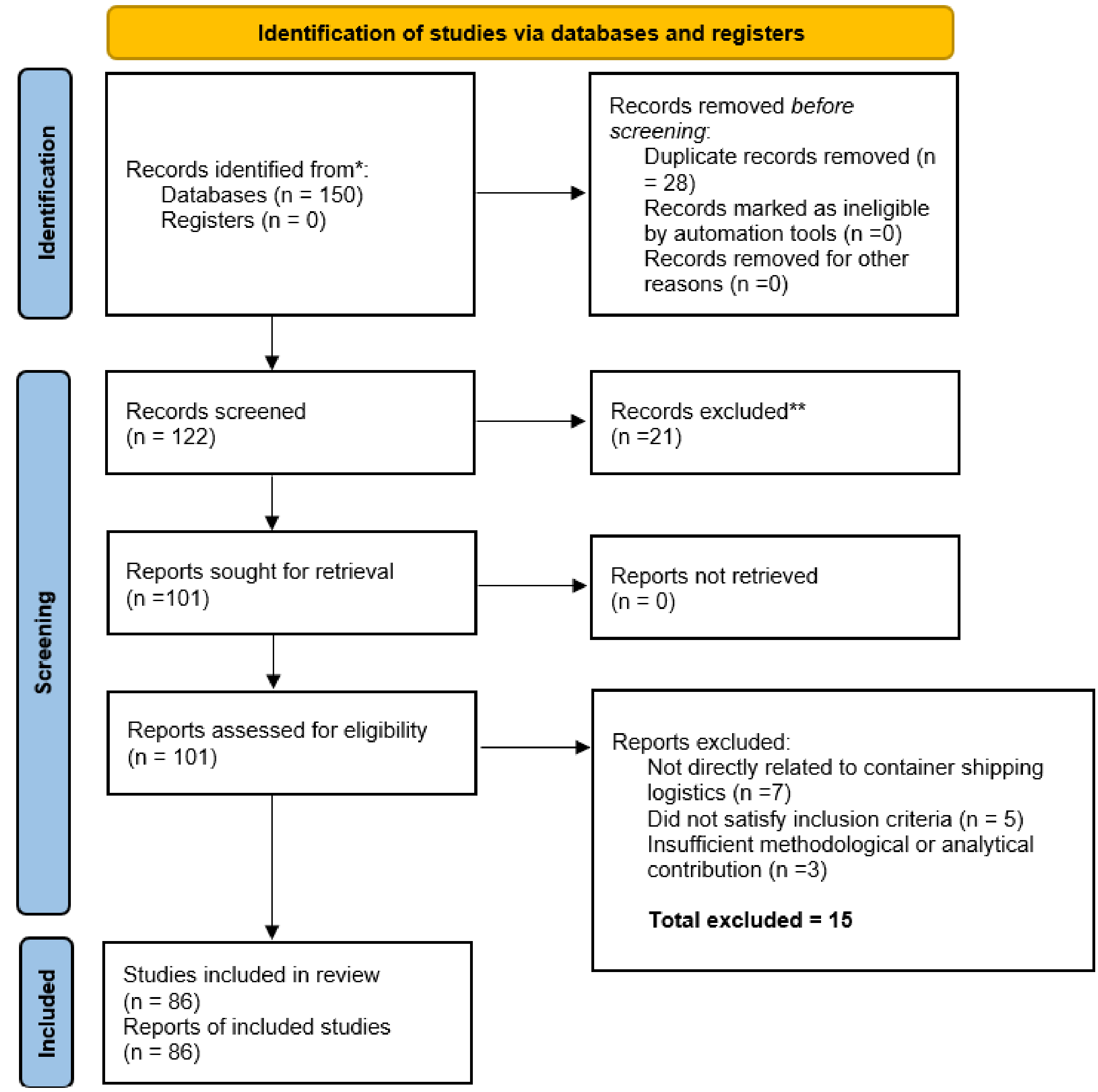


Figure 2 illustrates the PRISMA 2020 study selection process, summarising the identification, screening, eligibility assessment, and final inclusion of studies considered in this systematic literature review.
To ensure methodological quality, all included studies were independently assessed by the authors before being included in the final synthesis. Each publication was evaluated against predefined quality criteria,

including relevance to the research questions, methodological rigour, clarity of findings, and contribution to understanding blockchain adoption within container shipping logistics. Any differences in quality assessment were resolved through discussion until agreement was reached. No automation tools were used during the quality assessment process.

Data extraction was undertaken independently by the authors using a structured Microsoft Excel extraction matrix developed specifically for this review. Prior to extraction, the data collection form was piloted using a small sample of studies and refined to ensure consistency. Any differences in extracted information were discussed and resolved by consensus. For each included publication, bibliographic information, research context, research objectives, methodological approach, blockchain characteristics, reported benefits, governance mechanisms, organisational challenges, interoperability issues, confidentiality concerns, regulatory considerations, and future research recommendations were systematically recorded. This structured process enhanced consistency, transparency, and traceability throughout the review.

The extracted evidence was analysed using thematic synthesis. Initially, recurring concepts were identified through inductive coding across the selected studies. Similar concepts were subsequently grouped into higher-order themes representing blockchain as an emerging technology, blockchain as a disruptive technology, the factors explaining the gap between transformative potential and industry adoption, mechanisms for bridging this gap, and future research directions. These themes directly informed the structure of the review and enabled the synthesis to address each of the three research questions systematically.

Although every effort was made to ensure methodological rigour, certain limitations should be acknowledged. The review was restricted to English-language peer-reviewed publications published between January 2008 and June 2026. Furthermore, because blockchain technologies, governance models, and regulatory frameworks continue to evolve rapidly, additional evidence may emerge after the review period. Nevertheless, the systematic review provides a comprehensive, transparent, and methodologically robust synthesis of the current state of knowledge regarding blockchain as an emerging and disruptive technology within container shipping logistics.

3. Results

3.1 Blockchain as an Emerging and Disruptive Technology

The accelerating pace of digital transformation has stimulated considerable interest in technologies capable of fundamentally reshaping industries, business models, and organisational ecosystems. Among these technologies, blockchain has attracted significant academic and industrial attention because of its ability to decentralise information management, establish distributed trust, automate business processes, and facilitate secure collaboration among independent organisations. Since its emergence, blockchain has evolved beyond its original application in cryptocurrencies to become a general-purpose digital infrastructure supporting a wide range of industrial, governmental, financial, and supply chain applications. Consequently, blockchain has increasingly been recognised as both an emerging technology and a disruptive technology. Understanding these two perspectives provides an important theoretical foundation for explaining why blockchain has been expected to transform container shipping logistics and why this transformation has progressed more slowly than anticipated.

3.1.1 Emerging Technologies

Emerging technologies represent innovations that are still evolving technically, commercially, and institutionally while demonstrating significant potential to transform industries and society [44, 15, 70].

Unlike mature technologies, emerging technologies are characterised by technological novelty, rapid development, high levels of scientific and market uncertainty, evolving standards, limited institutional maturity, and considerable innovation potential [44, 15,70]. These characteristics often make it difficult for organisations to predict long-term technological trajectories, investment outcomes, governance requirements, and industry-wide adoption patterns [15]. Consequently, emerging technologies typically experience prolonged periods of experimentation, pilot implementation, and gradual ecosystem development before achieving widespread industrial acceptance [15, 20]**.**

Blockchain exhibits each of these defining characteristics. Although blockchain has progressed considerably since its introduction in 2008, its technological architecture, governance models, interoperability standards, scalability mechanisms, privacy-enhancing techniques, and industrial applications continue to evolve rapidly (11; Tiwari et al., 2024; 49). New blockchain platforms, consensus mechanisms, smart contract architectures, privacy-preserving protocols, and interoperability solutions continue to emerge, reflecting the technology's ongoing evolution rather than technological maturity (79; Tiwari et al., 2024; 57). Simultaneously, organisations continue to experiment with alternative deployment models, including public, private, consortium, and hybrid blockchain architectures, while regulatory frameworks and industry standards remain under continuous development (11; Tiwari et al., 2024; 9). This combination of technological evolution, institutional uncertainty, and expanding application domains demonstrates that blockchain continues to satisfy the defining characteristics of an emerging technology (20, 47, 37).

Furthermore, blockchain exhibits considerable innovation potential because it introduces fundamentally new approaches to information management, digital trust, decentralised governance, and inter-organisational collaboration [59, 87, 79, 9]. Rather than merely digitising existing business processes, blockchain enables organisations to redesign how transactions are validated, recorded, governed, and shared across distributed ecosystems (79,9, 47, 49]. This transformative capability extends beyond technological innovation to include organisational innovation, governance innovation, and business model innovation, further reinforcing blockchain's position as one of the most influential emerging technologies associated with the Fourth Industrial Revolution [87, 37].

3.1.2 Disruptive Technologies

While emerging technologies introduce novel capabilities, disruptive technologies fundamentally transform existing industries by changing how value is created, delivered, and captured [30, 65, 74]. Christensen's Disruptive Innovation Theory explains that disruptive technologies often challenge established business models by introducing alternative approaches that initially appear less attractive than existing solutions but subsequently reshape industries through continuous technological improvement and expanding ecosystem adoption [68, 30, 14]. Rather than simply improving operational efficiency, disruptive technologies redefine industry structures, alter competitive dynamics, eliminate traditional intermediaries, create new digital ecosystems, and establish entirely new forms of value creation [65, 74, 14].

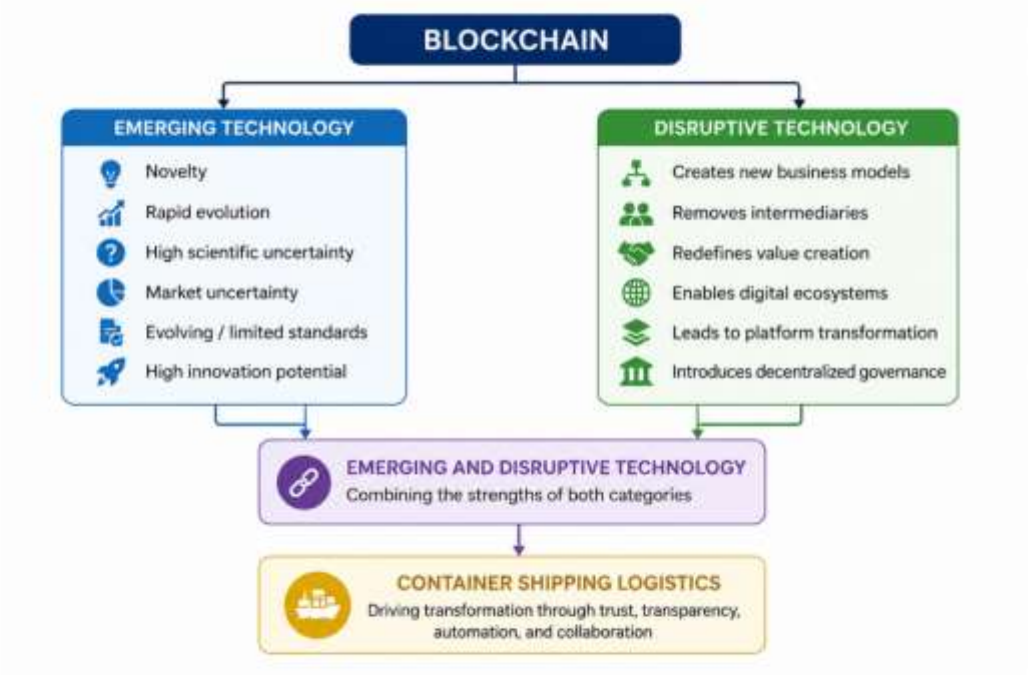
Blockchain demonstrates many of these disruptive characteristics. Traditional inter-organisational transactions often rely upon trusted intermediaries to validate information, coordinate activities, enforce contractual obligations, and maintain transaction records [24, 69]. Blockchain fundamentally alters this arrangement by enabling decentralised consensus, distributed record keeping, programmable smart contracts, and shared digital infrastructures that allow independent organisations to collaborate without depending upon a single central authority [8, 19]. Consequetly, blockchain introduces new governance arrangements, transforms organisational relationships, and enables collaborative digital ecosystems that operate according to collectively agreed rules rather than institutional dominance [69, 8,6].

Blockchain also supports the emergence of entirely new business models by enabling tokenised assets, decentralised finance, programmable digital contracts, digital identity management, trusted information sharing, and cross-organisational automation [14, 5, 74]. These capabilities extend beyond technological efficiency improvements and instead redefine how organisations create value, exchange information, coordinate supply chain activities, and establish trust across organisational boundaries [65, 69, 24, 6]. Such characteristics position blockchain as a technology capable of disrupting existing institutional arrangements rather than merely improving traditional information systems [19,54].

3.1.3 Why Blockchain Fits Both Categories

Although emerging and disruptive technologies are frequently discussed independently, blockchain demonstrates the defining characteristics of both categories simultaneously [20, 37]. As an emerging technology, blockchain continues to evolve through ongoing technological innovation, expanding industrial applications, evolving governance models, and increasing regulatory development [77, 59, 9]. At the same time, blockchain demonstrates disruptive characteristics by introducing decentralised governance structures, reducing reliance on traditional intermediaries, enabling programmable business processes, supporting collaborative digital ecosystems, and fundamentally redefining mechanisms for establishing trust among organisations [87, 59, 79].

Figure 3. Blockchain as an Emerging and Disruptive Technology in Container Shipping Logistics.



The combination of these characteristics distinguishes blockchain from many other digital technologies. Rather than representing a single technological innovation, blockchain combines distributed computing, cryptography, consensus mechanisms, smart contracts, and decentralised governance within an integrated digital infrastructure capable of supporting entirely new forms of inter-organisational collaboration [35; 86, 8, 17]. Consequently, blockchain has been widely recognised as possessing significant transformative potential across industries requiring trusted information exchange, shared governance, and collaborative decision-making [37, 80, 73, 9].

Table 1. Comparative Characteristics of Emerging Technologies, Disruptive Technologies, and Blockchain.

Characteristic	Emerging Technology	Disruptive Technology	Blockchain
Technological novelty	√		√
Rapid evolution	√		√
Scientific uncertainty	√		√
Market uncertainty	√		√
High innovation potential	√		√
New business models		√	√
Decentralisation		√	√
Removes intermediaries		√	√
Platform transformation		√	√
Governance innovation		√	√

For container shipping logistics, this dual identity is particularly significant. Industry's dependence on multiple independent organisations, fragmented information systems, extensive documentation requirements, and complex cross-border coordination creates an environment in which both emerging technological capabilities and disruptive governance innovations appear especially relevant [71, 32, 61]. Consequently, blockchain has frequently been presented as a technology capable of transforming not only operational processes but also the institutional relationships that underpin global maritime logistics [19, 50, 43].

3.1.4 Transformative Potential of Blockchain in Container Shipping Logistics

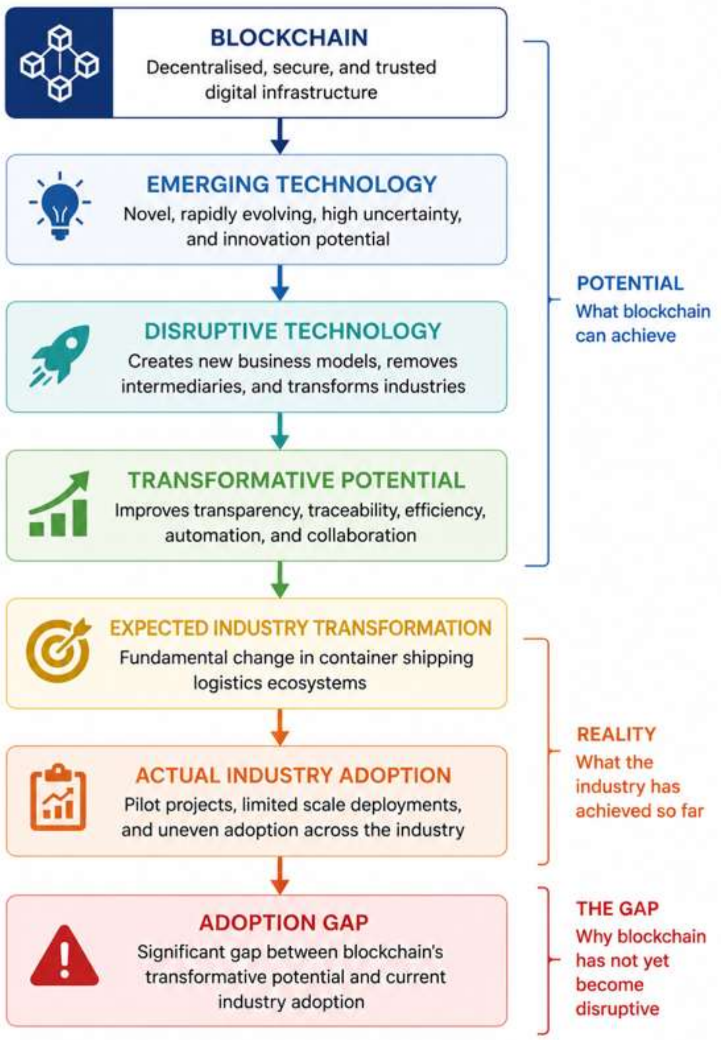
Container shipping logistics has long been characterised by fragmented information systems, extensive paper-based documentation, limited interoperability, duplicated administrative activities, and complex coordination among multiple independent stakeholders [42,19,54]. These characteristics have encouraged researchers and industry practitioners to view blockchain as a technology capable of fundamentally transforming maritime logistics through secure, transparent, and decentralised information sharing [19, 16].

Literature consistently identifies numerous capabilities through which blockchain may transform container shipping logistics. Immutable distributed ledgers improve transparency and transaction traceability by providing trusted records that cannot be altered without consensus [19, 27]. Smart contracts automate contractual processes, customs procedures, cargo release, payment verification, and compliance activities, thereby reducing administrative effort and processing delays [36]. Shared digital ledgers improve information consistency among ports, shipping lines, freight forwarders, customs authorities, and terminal operators while reducing duplication of documentation and improving interoperability across heterogeneous information systems (19, 53, 34). Similarly, blockchain has been recognised as an important enabler of digital bills of landing, port digitalisation initiatives, customs integration, fraud prevention, automated compliance verification, operational cost reduction, and enhanced supply chain sustainability through improved resource utilisation and reduced paper consumption [16, 36].

Beyond operational improvements, blockchain offers the potential to transform how trust is established within container shipping logistics. Traditional supply chain coordination frequently depends upon institutional trust, contractual enforcement, and central intermediaries to verify information and coordinate transactions [36]. Blockchain instead introduces technologically supported trust through distributed consensus, cryptographic verification, immutable transaction histories, and shared governance mechanisms that allow organisations to collaborate within trusted digital ecosystems [1, 45]. Consequently, blockchain has been widely regarded as a technology capable of simultaneously improving transparency, accountability, operational efficiency, and collaborative decision-making across maritime supply chains [1, 53].

Taking together, these technological capabilities explain why blockchain has been widely recognised as one of the most promising emerging and disruptive technologies for container shipping logistics. Literature consistently presents blockchain as possessing the technical, organisational, and governance capabilities required to transform maritime logistics into a more transparent, interoperable, efficient, and trusted digital ecosystem (19, 53]. However, despite these widely recognised capabilities and expectations, widespread industry disruption has not occurred [19, 53,54]. Understanding why this gap persists is therefore essential for explaining blockchain's current adoption trajectory within container shipping logistics. This paradox provides the foundation for the next section, which examines the factors that have constrained blockchain's transformative impact despite its considerable disruptive potential.

Figure 4. Blockchain's Transformative Potential and the Industry Adoption Gap.



3.2. Why Has Blockchain Not Yet Become Disruptive?

The preceding section demonstrated that blockchain possesses the defining characteristics of both an emerging technology and a disruptive technology. Its decentralised architecture, distributed governance, immutable record keeping, programmable smart contracts, and ability to facilitate trusted collaboration across organisational boundaries have positioned blockchain as a technology capable of fundamentally transforming container shipping logistics [36,43]. Collectively, these characteristics suggest that blockchain should have accelerated digital transformation by replacing fragmented information systems, reducing dependence on intermediaries, improving transparency, and enabling collaborative digital ecosystems [19, 73].

Despite these capabilities, blockchain has not yet produced the level of disruption originally anticipated [19, 54]. Although numerous pilot projects, proof-of-concept implementations, and consortium initiatives have demonstrated blockchain's technical feasibility, widespread adoption across the maritime industry remains limited [36, 10]. This contrast between technological capability and industrial reality represents one of the most significant paradoxes within contemporary blockchain research [10, 75]. The evidence suggests that blockchain's limited disruptive impact cannot be attributed solely to technological shortcomings [50, 53, 61, 36]. Instead, the literature consistently indicates that organisational, governance, institutional, legal, and ecosystem factors collectively constrain blockchain's ability to realise its transformative potential. Consequently, understanding blockchain adoption requires moving beyond technological capabilities towards explaining the conditions under which disruptive technologies become successfully embedded within complex inter-organisational ecosystems.

Rather than treating these factors as isolated adoption barriers, this review interprets them as interconnected explanations for the persistent gap between blockchain's recognised disruptive potential and its comparatively limited industry adoption [73, 54]. The following sections synthesise the literature to explain how governance arrangements, trust relationships, organisational readiness, regulatory environments, confidentiality requirements, and interoperability collectively influence blockchain adoption within container shipping logistics.

Table 2. Literature-Based Explanations for the Gap Between Blockchain's Transformative Potential and Industry Adoption.

Explanation	Influence on Industry Adoption
Governance challenges	Reduce stakeholder confidence and participation.
Trust deficits	Limit collaboration among competing organisations.
Organisational resistance	Slow implementation and technology acceptance.
Regulatory and legal constraints	Create uncertainty regarding compliance and cross-border deployment.
Confidentiality and commercial sensitivity	Restrict willingness to share commercially sensitive information.
Interoperability challenges	Prevent seamless integration across maritime information systems.

3.2.1 Governance Challenges

Governance emerges consistently throughout literature as one of the most influential determinants of blockchain adoption within container shipping logistics [33, 73, 54]. Unlike conventional information systems that are managed by a single organisation, blockchain platforms require multiple independent organisations to participate within shared governance arrangements [33,66]. Consequently, blockchain adoption depends not only on technological capability but also on the establishment of governance structures that are perceived as legitimate, transparent, equitable, and collectively accountable [51, 66] The literature therefore suggests that governance should not be viewed as an operational consideration but rather as the institutional foundation upon which successful blockchain ecosystems are established.

A recurring concern involves consortium governance and the distribution of decision-making authorities among participating organisations [33, 66]. Container shipping logistics operates within highly interconnected ecosystems comprising shipping lines, ports, customs authorities, freight forwarders, terminal operators, regulators, and technology providers, each possessing distinct objectives and varying degrees of influence [33; 73,69]. When governance structures become concentrated within a small number of dominant organisations, concerns regarding decision-making fairness, strategic control, and unequal influence emerge [29; 66]. Such governance asymmetry reduces confidence in collaborative blockchain initiatives and discourages broader ecosystem participation [29, 51]

The TradeLens initiative illustrates these governance challenges. Although TradeLens demonstrated the technical feasibility of blockchain-enabled maritime logistics, widespread industry participation remained limited because many organisations perceived the platform's governance structure as favouring particular commercial interests (33, 51, 13). Concerns regarding platform neutrality, ownership concentration, and decision-making authority reduced stakeholder confidence despite the platform's considerable technological capabilities [33, 51, 29]. Consequently, the literature suggests that blockchain disruption depends as much upon governance legitimacy as upon technological innovation, indicating that governance arrangements constitute a critical explanation for the gap between blockchain's disruptive potential and its actual industry adoption (29; 54; Elmay et al., 2022).

3.2.2 Trust Deficits

Blockchain is frequently described as a technology capable of establishing trust within distributed environments (58, 18). However, the literature consistently demonstrates that technological trust does not automatically translate into organisational trust (Yavaprabhas et al., 2022; 58). Container shipping logistics operates within a competitive environment where organisations must simultaneously collaborate operationally while competing commercially [33, 73]. This coexistence of cooperation and competition creates complex trust relationships that technological solutions alone cannot fully resolve [19].

Inter-organisational trust influences organisations' willingness to exchange information, participate in collaborative platforms, and accept shared governance arrangements [66]. Although blockchain provides immutable transaction records and cryptographic verification, organisations remain reluctant to participate when they perceive risks relating to competitive disadvantages, unequal governance, or strategic information disclosure [83]. Consequently, blockchain's technical mechanisms reduce transactional uncertainty but do not eliminate institutional, relational, or strategic trust concerns [83].

The literature therefore indicates that blockchain adoption depends upon both technological trust and organisational trust. Trust must be established not only through distributed consensus and immutable records but also through governance neutrality, equitable participation, institutional transparency, and collaborative decision-making [66, 33]. These findings suggest that trust deficits explain why blockchain's disruptive potential has not yet translated into sustained industry-wide adoption [33, 54].

3.2.3 Organisational Resistance

Technological disruption frequently requires organisational transformation [28]. The literature consistently reports that container shipping organisations continue to rely upon mature operational practices, legacy information systems, established governance procedures, and long-standing business relationships that have evolved over several decades [33,10]. Consequently, blockchain adoption requires considerably more than technological implementation; it demands substantial organisational change [28, 54].

Many organisations remain cautious regarding blockchain because implementation often involves significant financial investment, organisational restructuring, employee training, systems integration, and business process redesign [69]. Uncertainty surrounding return on investment further discourages large-scale deployment, particularly where technological benefits remain difficult to quantify during the early stages of implementation [19]. These concerns are reinforced by the relatively conservative nature of the maritime industry, where operational reliability frequently takes precedence over technological experimentation [18, 10].

Rather than representing resistance to blockchain itself, the literature suggests that organisational resistance reflects broader concerns regarding technological transition, institutional readiness, and change management [28]. Consequently, organisational readiness represents an important explanation for the disparity between blockchain's recognised capabilities and its comparatively limited adoption [28, 54].

3.2.4 Regulatory and Legal Constraints

Container shipping logistics operates across multiple legal jurisdictions, international conventions, customs regulations, and national governance frameworks [19]. Consequently, blockchain adoption extends beyond technological implementation to include legal recognition, regulatory compliance, data governance, and institutional accountability [19].

The literature identifies considerable uncertainty regarding the legal status of blockchain transactions, digital documentation, smart contracts, electronic bills of lading, cross-border information sharing, and digital evidence [19, 36]. Differences between national regulatory frameworks further complicate blockchain deployment because organisations frequently operate across jurisdictions with differing legal requirements [43]. This regulatory fragmentation reduces organisational confidence and delays investment in blockchain-enabled logistics platforms.

Furthermore, uncertainty regarding data ownership, legal responsibility, liability allocation, and compliance obligations continues to limit collaborative blockchain deployment [19]. These regulatory considerations demonstrate that blockchain disruption depends not only upon technological maturity but also upon the evolution of legal and institutional environments capable of supporting decentralised digital ecosystems [19, 53].

3.2.5 Confidentiality and Commercial Sensitivity

Although blockchain improves transparency and information integrity, container shipping logistics operates within commercially competitive environments where organisations remain reluctant to disclose sensitive operational information [36]. Consequently, transparency and confidentiality must be carefully balanced rather than treated as mutually exclusive objectives [19, 16].

The literature consistently reports that concerns regarding commercially sensitive information remain among the most significant factors influencing blockchain adoption [19,36]. Shipping schedules, pricing arrangements, customer relationships, cargo information, contractual agreements, and operational performance data frequently represent commercially valuable assets that organisations are unwilling to expose within shared digital platforms [50]. Even within permissioned blockchain environments, organisations continue to express concerns regarding information visibility, competitive intelligence, and data governance [36].

These findings suggest that blockchain disruption depends upon governance mechanisms capable of balancing transparency with commercial confidentiality [36]. Consequently, privacy-preserving technologies, selective information disclosure, role-based access control, and carefully designed governance policies become essential components of successful blockchain ecosystems rather than optional technological enhancements [33].

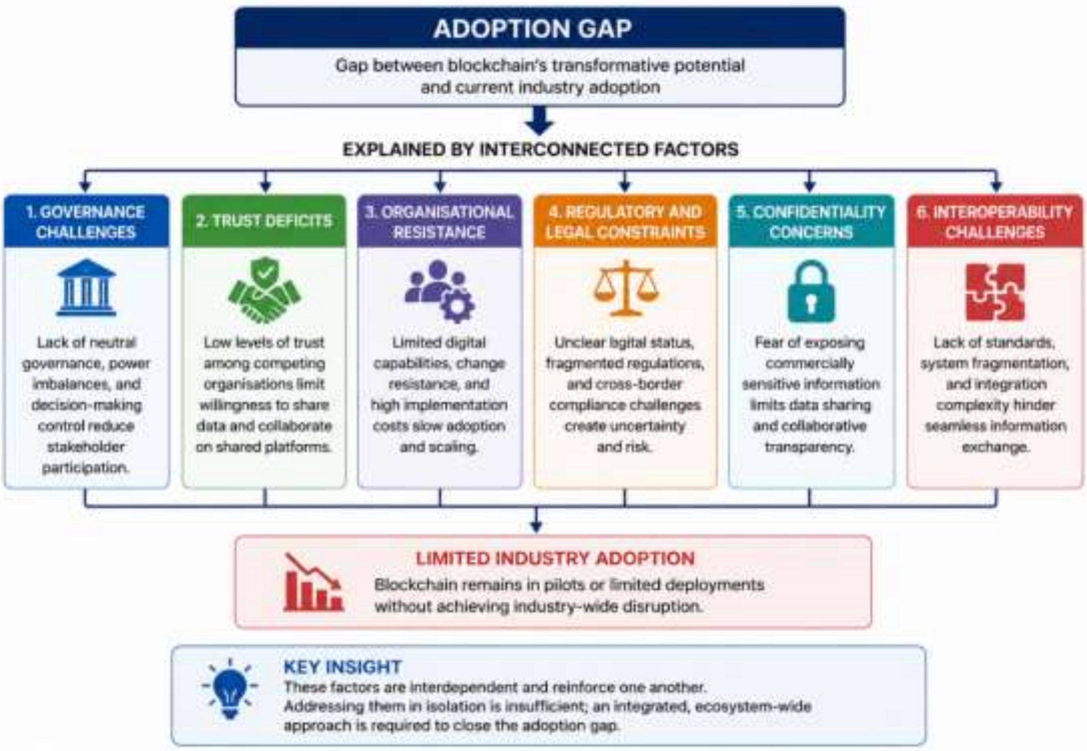
3.2.6 Interoperability Challenges

Interoperability represents another important explanation for blockchain's limited disruptive impact [50, 69]. Container shipping logistics comprises numerous heterogeneous information systems developed independently by ports, shipping lines, customs authorities, freight forwarders, logistics providers, and regulatory agencies [50, 33]. Consequently, blockchain cannot operate effectively in isolation but must integrate seamlessly with existing digital infrastructures [50, 33].

Literature consistently identifies interoperability as a prerequisite for industry-wide blockchain adoption [53]. Differences in data formats, communication protocols, information standards, legacy enterprise systems, and organisational workflows continue to complicate blockchain integration across maritime ecosystems [36]. Although international initiatives have promoted common standards and digital documentation frameworks, inconsistent implementation continues to limit seamless information exchange [36].

These findings indicate that blockchain disruption depends not only upon the capabilities of blockchain platforms themselves but also upon their ability to integrate with existing organisational systems and broader digital ecosystems [33]. Consequently, interoperability should be understood as an ecosystem capability that enables blockchain to realise its transformative potential rather than merely as a technical requirement.

Figure 3. Factors Explaining the Gap Between Blockchain's Transformative Potential and Industry Adoption.



3.3 Bridging the Gap Between Transformative Potential and Industry Adoption

The preceding section demonstrated that blockchain's limited disruptive impact cannot be attributed solely to technological limitations. Instead, the literature consistently indicates that governance arrangements, organisational readiness, institutional environments, interoperability, confidentiality requirements, and ecosystem collaboration collectively influence the extent to which blockchain can realise its transformative potential [67, 73, 54, 19]. These findings suggest that widespread blockchain adoption requires considerably more than technological deployment [67]. Rather, successful disruption depends upon the simultaneous alignment of technological innovation, governance structures, regulatory frameworks, organisational capabilities, and collaborative industry ecosystems [67, 33, 19]. Consequently, bridging the gap between blockchain's recognised transformative potential and its comparatively limited industry adoption requires an integrated approach that addresses these interdependent dimensions simultaneously.

3.3.1 Governance Neutrality

Literature consistently identifies governance neutrality as one of the most important prerequisites for successful blockchain ecosystems [58,66, 33]. Collaborative blockchain platforms depend upon the willingness of multiple independent organisations to participate within shared governance structures (66, 33, 73). Consequently, governance arrangements must ensure transparency, accountability, fairness, and balanced decision-making to encourage long-term ecosystem participation [66, 33]. Neutral governance structures reduce concerns regarding institutional dominance, unequal influence, and strategic control, thereby increasing stakeholder confidence in collaborative blockchain initiatives [66, 33]. Rather than concentrating authority within individual organisations, future blockchain ecosystems should adopt governance models that distribute decision-making responsibilities among participating stakeholders while ensuring collectively agreed operational rules and dispute resolution mechanisms [66, 33, 60].

3.3.2 Consortium-Based Governance Models

Literature increasingly advocates consortium blockchain architectures as an effective governance approach for container shipping logistics [64, 66, 18]. Consortium models combine the security and decentralisation of blockchain with controlled participation, allowing trusted organisations to collaborate while maintaining appropriate governance oversight [64, 66, 33]. Shared ownership of blockchain infrastructure encourages collective responsibility, reduces dependence on dominant platform operators, and promotes equitable participation across maritime ecosystems [66, 33]. By distributing governance responsibilities among shipping lines, ports, customs authorities, terminal operators, freight forwarders, regulators, and other stakeholders, consortium governance provides a practical foundation for establishing sustainable digital ecosystems capable of supporting long-term blockchain adoption [73; 33; 67].

3.3.3 Privacy-Preserving Technologies

While transparency represents one of blockchain's principal advantages, the literature consistently demonstrates that transparency must be balanced against commercial confidentiality [67, 56, 19]. Future blockchain ecosystems therefore require advanced privacy-preserving technologies capable of protecting commercially sensitive information without compromising data integrity or collaborative trust (33, 56). Technologies such as Zero-Knowledge Proofs, confidential computing, secure multi-party computation, selective disclosure mechanisms, private data collections, and role-based access control provide promising approaches for achieving this balance [73, 33]. By enabling transaction verification without exposing confidential business information, these technologies strengthen organisational confidence while preserving blockchain's integrity, accountability, and transparency [64, 18].

3.3.4 Standardisation and Interoperability

Industry-wide blockchain adoption depends upon common technical standards capable of supporting seamless information exchange across heterogeneous digital environments [33, 69]. Literature consistently emphasises that interoperability should extend beyond technical integration to include semantic consistency, governance compatibility, and regulatory alignment [33, 19]. Industry initiatives such as the Digital Container Shipping Association (DCSA), GS1 standards, and Digital Bills of Lading provide important foundations for improving interoperability across container shipping logistics [33,60]. Wider adoption of these standards would facilitate consistent information exchange, simplify systems integration, reduce implementation complexity, and improve cross-organisational collaboration throughout global maritime supply chains [33; 60].

3.3.5 Regulatory and Institutional Alignment

Technological innovation alone cannot transform highly regulated industries such as container shipping logistics [73, 19, 10]. The literature consistently demonstrates that blockchain adoption requires regulatory frameworks capable of recognising digital documentation, validating smart contracts, clarifying data ownership, and supporting cross-border information exchange [33, 19, 60]. Regulatory harmonisation across jurisdictions would increase organisational confidence while reducing legal uncertainty associated with blockchain deployment [19, 10, 60]. Furthermore, collaboration between governments, regulators, international maritime organisations, and industry stakeholders is essential for establishing governance frameworks that support innovation while ensuring compliance with existing legal and operational requirements [19, 60].

3.3.6 Organisational Readiness

Successful blockchain adoption requires organisations to develop the capabilities necessary to integrate emerging technologies into existing operational environments [28, 67, 60]. The literature identifies organisational readiness as a multidimensional capability encompassing digital skills, leadership commitment, technological infrastructure, financial investment, organisational culture, and effective change management [28, 69, 56]. Rather than viewing blockchain implementation as a purely technological initiative, organisations should adopt comprehensive transformation strategies that prepare employees, redesign business processes, strengthen digital capabilities, and encourage collaborative innovation [28, 73]. Such organisational readiness increases the likelihood that blockchain initiatives will progress beyond pilot implementations towards sustainable industry adoption [67,54, 28].

3.3.7 Ecosystem Collaboration and Shared Value Creation

Blockchain derives much of its value from network participation rather than individual organisational implementation [33, 73]. Consequently, the literature consistently argues that successful blockchain ecosystems require collaboration among all participants within container shipping logistics [33, 73]. Shared incentives, equitable value distribution, collaborative governance, and mutually beneficial participation models encourage organisations to contribute actively to blockchain ecosystems while reducing concerns regarding competitive disadvantage [58,33]. Establishing collaborative partnerships among shipping lines, ports, customs authorities, freight forwarders, logistics providers, technology vendors, regulators, and international standards organisations therefore represents an essential requirement for achieving sustainable blockchain adoption [73,19]. By fostering ecosystem-wide collaboration, blockchain can evolve from isolated technological deployments into integrated digital infrastructures capable of supporting industry-wide transformation [33, 73, 10].

3.3.8 Towards Realising Blockchain's Disruptive Potential

Collectively, the literature suggests that realising blockchain's disruptive potential requires a fundamental shift from technology-centred implementation towards ecosystem-centred transformation [67,33, 73]. Rather than viewing blockchain as a standalone technological solution, successful implementation depends upon the coordinated alignment of governance neutrality, consortium participation, privacy-preserving technologies, interoperability standards, regulatory frameworks, organisational readiness, and collaborative industry ecosystems [33, 66, 60, 28, 19]. These interdependent dimensions reinforce one another, creating the institutional conditions necessary for blockchain to evolve from an emerging technology with considerable promise into a genuinely disruptive technology capable of transforming container shipping logistics **[19**, **54**, 1**0**, **69]**. Bridging this gap therefore requires a holistic approach in which technological innovation is supported by governance innovation, organisational transformation, regulatory evolution, and ecosystem-wide collaboration.

3.4 Future Research Directions

The preceding sections demonstrated that blockchain possesses the defining characteristics of both emerging and disruptive technology, yet its transformative impact within container shipping logistics remains constrained by technological, organisational, governance, regulatory, and ecosystem-related challenges. While literature proposes several mechanisms for bridging this gap, the rapid evolution of digital technologies presents new opportunities for extending blockchain capabilities beyond their current state. Consequently, future research should move beyond addressing existing adoption challenges and instead investigate how emerging technologies, advanced governance models, and evolving digital ecosystems can collectively enhance blockchain's disruptive potential. Developing such knowledge will be essential for supporting the next generation of trusted, intelligent, interoperable, and resilient maritime logistics ecosystems.

3.4.1 Artificial Intelligence and Blockchain Integration

Artificial Intelligence (AI) represents one of the most promising technologies for extending blockchain capabilities beyond secure transaction management towards intelligent decision support and autonomous operational management [3, 69, 63]. Future research should investigate how AI and blockchain can be integrated to improve predictive analytics, intelligent contract execution, anomaly detection, fraud prevention, cargo optimisation, demand forecasting, and automated compliance monitoring. AI-enabled blockchain platforms could significantly enhance operational efficiency by combining blockchain's trusted data infrastructure with AI's ability to analyse complex datasets and support adaptive decision-making [3,4, 84, 55]. Furthermore, research should explore governance frameworks capable of ensuring transparency, accountability, and explainability within AI-driven blockchain ecosystems.

3.4.2 Quantum-Safe Blockchain

Advances in quantum computing present both opportunities and challenges for blockchain technology. Although current blockchain systems rely heavily on cryptographic algorithms that remain computationally secure under classical computing environments, future quantum computers may significantly weaken existing cryptographic protections. Consequently, future research should investigate quantum-resistant cryptographic algorithms, post-quantum digital signatures, secure consensus mechanisms, and migration strategies capable of protecting blockchain infrastructures against emerging quantum threats. Developing quantum-safe blockchain architectures will become increasingly important for safeguarding long-term maritime information security and preserving trust within future digital supply chain ecosystems.

3.4.3 Cross-Chain Interoperability

The continued emergence of multiple blockchain platforms has created fragmented blockchain ecosystems that frequently operate independently. Future research should therefore prioritise cross-chain interoperability mechanisms capable of enabling secure communication and trusted information exchange between heterogeneous blockchain networks. Such interoperability will be particularly important within container shipping logistics, where multiple organisations may adopt different blockchain platforms based on operational requirements, governance preferences, or regulatory obligations. Research should investigate standardised interoperability protocols, blockchain bridges, decentralised identity management, and cross-chain governance models capable of supporting seamless collaboration across distributed maritime ecosystems.

3.4.4 Smart Ports and Intelligent Maritime Infrastructure

The digital transformation of ports provides significant opportunities for expanding blockchain-enabled logistics ecosystems. Future research should investigate how blockchain can support Smart Port initiatives through secure information sharing, automated cargo handling, digital port operations, intelligent asset management, and integrated maritime information platforms. Integrating blockchain with Internet of Things (IoT) technologies, intelligent sensors, automated terminal systems, and port community systems could improve operational visibility while strengthening trust among multiple port stakeholders. Such integration may significantly enhance the efficiency, resilience, and sustainability of future maritime logistics operations.

3.4.5 Digital Twins for Maritime Logistics

Digital Twin technology offers considerable opportunities for enhancing blockchain-enabled supply chain management through virtual representations of physical assets, logistics processes, and operational environments. Future research should investigate how blockchain can provide trusted data sources for Digital Twins while ensuring data integrity, provenance, and traceability throughout the lifecycle of maritime operations. Integrating blockchain with Digital Twins may support predictive maintenance, real-time cargo monitoring, simulation-based decision-making, operational optimisation, and risk management across complex maritime logistics ecosystems.

3.4.6 Autonomous Shipping and Maritime Automation

Autonomous shipping technologies continue to transform maritime operations through increased automation, intelligent navigation, autonomous vessels, and digitally connected logistics networks. Future research should examine how blockchain can support trusted communication, autonomous contract execution, secure machine-to-machine transactions, decentralised coordination, and real-time operational governance within autonomous maritime environments. Such research will become increasingly important as autonomous shipping systems evolve towards greater operational independence and require trusted digital infrastructures capable of supporting secure inter-organisational collaboration.

3.4.7 Environmental, Social, and Governance (ESG) Integration

Growing emphasis on Environmental, Social, and Governance (ESG) reporting presents new opportunities for blockchain-enabled sustainability management. Future research should investigate how blockchain can improve the transparency, traceability, and verification of environmental performance, carbon emissions, sustainable sourcing, regulatory compliance, and corporate governance reporting throughout maritime supply chains. Blockchain-enabled ESG reporting may improve stakeholder confidence while supporting international sustainability initiatives and strengthening organisational accountability across global logistics ecosystems.

3.4.8 Central Bank Digital Currencies and Blockchain Ecosystems

The increasing development of Central Bank Digital Currencies (CBDCs) presents opportunities for integrating trusted digital payment mechanisms into blockchain-enabled maritime logistics platforms. Future research should investigate how CBDCs can support secure international trade settlement, automated customs payments, programmable financial transactions, and cross-border commercial activities within blockchain ecosystems. Such integration may reduce transaction costs, improve payment transparency, accelerate international trade processes, and strengthen financial interoperability across global container shipping networks.

3.4.9 From Pilot Projects to Industrial Deployment

Despite numerous successful pilot projects and proof-of-concept implementations, relatively limited evidence exists regarding long-term industrial deployment of blockchain within container shipping logistics. Future research should therefore prioritise large-scale industrial validation capable of evaluating blockchain performance under realistic operational conditions involving multiple organisations, jurisdictions, and international supply chains. Longitudinal studies examining governance evolution, stakeholder participation, organisational transformation, scalability, operational performance, and ecosystem sustainability would provide valuable evidence regarding blockchain's ability to transition from experimental technology to operational infrastructure capable of supporting industry-wide digital transformation.

3.4.10 Research Agenda for Realising Blockchain's Disruptive Potential

Collectively, these research directions demonstrate that the future of blockchain extends beyond improving existing technological capabilities. Instead, future investigations should focus on developing intelligent, interoperable, secure, sustainable, and governance-driven blockchain ecosystems capable of supporting next-generation maritime logistics. Integrating blockchain with emerging technologies, strengthening regulatory and governance frameworks, advancing interoperability standards, and promoting ecosystem-wide collaboration will be essential for enabling blockchain to evolve from a promising emerging technology into a genuinely disruptive technology capable of transforming container shipping logistics. Accordingly, the future research agenda should prioritise ecosystem transformation rather than technological refinement alone.

Figure 4. Roadmap for Realising Blockchain's Disruptive Potential in Container Shipping Logistics.

4. Discussions

The findings of this review demonstrate that blockchain possesses the defining characteristics of both an emerging technology and a disruptive technology. As an emerging technology, blockchain continues to evolve through rapid technological innovation, expanding industrial applications, developing governance models, and evolving regulatory frameworks. Simultaneously, blockchain demonstrates disruptive characteristics by introducing decentralised trust, distributed governance, programmable business processes, secure information sharing, and new approaches to inter-organisational collaboration. Collectively, these characteristics explain why blockchain has attracted considerable attention as one of the most promising technologies for transforming container shipping logistics.

The literature consistently demonstrates that blockchain possesses substantial transformative potential within maritime logistics. Distributed ledgers, smart contracts, interoperable information exchange, digital documentation, automation, cryptographic security, and decentralised governance collectively provide capabilities capable of improving transparency, traceability, operational efficiency, regulatory compliance, and collaborative decision-making. These capabilities suggest that blockchain should fundamentally transform container shipping logistics by replacing fragmented information systems and paper-based administrative processes with trusted digital ecosystems. Consequently, expectations regarding blockchain's disruptive potential have been both technically justified and widely supported throughout the existing literature.

However, the review also demonstrates that technological capability alone is insufficient to generate industry-wide disruption. Despite significant technological advances and numerous successful pilot implementations, blockchain has not yet produced the level of transformation originally anticipated. This apparent contradiction represents the central paradox examined throughout this review. Rather than reflecting deficiencies in blockchain itself, the evidence indicates that disruption has been constrained by a combination of governance, organisational, institutional, legal, interoperability, and confidentiality considerations that collectively influence adoption across complex maritime ecosystems.

An important finding emerging from this review is that these factors should not be interpreted as isolated barriers to technology adoption. Instead, they represent interconnected ecosystem conditions that determine whether blockchain's disruptive capabilities can be successfully translated into sustainable industry transformation. Governance legitimacy influences stakeholder trust; trust affects organisational participation; organisational readiness shapes implementation capability; interoperability enables ecosystem integration; regulatory alignment establishes institutional confidence; and confidentiality mechanisms determine organisations' willingness to exchange commercially sensitive information. These dimensions therefore operate collectively rather than independently, reinforcing the view that blockchain adoption represents an ecosystem transformation challenge rather than a purely technological implementation problem.

This interpretation extends existing blockchain literature by shifting the discussion from technology-centred adoption towards ecosystem-centred transformation. Much of the current literature evaluates blockchain according to its technical characteristics, including decentralisation, immutability, consensus mechanisms, and smart contracts. While these capabilities remain fundamental, this review suggests that blockchain's disruptive impact depends equally upon governance innovation, institutional coordination, organisational readiness, regulatory evolution, and collaborative ecosystem development. Consequently, successful blockchain adoption requires simultaneous technological and institutional transformation rather than technological innovation in isolation.

The review further demonstrates that blockchain's emerging and disruptive characteristics are closely interconnected. Emerging technologies frequently experience prolonged periods of uncertainty before achieving widespread industrial maturity, while disruptive technologies require broader ecosystem adaptation before their transformative capabilities become fully realised. Blockchain currently occupies this transitional stage. Its technological maturity has advanced considerably, yet governance models, interoperability standards, regulatory frameworks, and organisational capabilities continue to evolve. This explains why blockchain remains widely recognised as a transformative technology despite its comparatively limited large-scale implementation within container shipping logistics.

The future trajectory of blockchain will therefore depend upon the extent to which technological innovation is accompanied by governance innovation and ecosystem collaboration. Advances in Artificial Intelligence, quantum-resistant cryptography, cross-chain interoperability, Digital Twins, Smart Ports, autonomous shipping, Environmental, Social and Governance (ESG) reporting, Central Bank Digital Currencies, and industrial-scale blockchain deployment present significant opportunities for extending blockchain capabilities beyond their current state. However, these technological developments will only achieve widespread disruptive impact if supported by neutral governance structures, internationally recognised standards, regulatory harmonisation, organisational readiness, and sustained collaboration among maritime stakeholders.

Overall, this review demonstrates that blockchain has not failed to disrupt container shipping logistics because of technological inadequacy. Rather, its disruptive potential remains only partially realised because the institutional, organisational, governance, and ecosystem conditions necessary for large-scale transformation continue to evolve. Bridging this gap therefore requires a holistic approach in which technological innovation is integrated with governance, regulation, organisational transformation, interoperability, and collaborative ecosystem development. Under such conditions, blockchain possesses the capacity to progress from a promising emerging technology towards a mature disruptive technology capable of fundamentally transforming container shipping logistics.

5. Conclusion

Blockchain has emerged as one of the most influential technologies associated with the digital transformation of container shipping logistics. This review demonstrates that blockchain possesses the defining characteristics of both an emerging technology and a disruptive technology through its decentralised architecture, distributed governance, programmable smart contracts, immutable record keeping, and ability to establish trusted collaboration across organisational boundaries. These capabilities provide significant potential to transform container shipping logistics by improving transparency, traceability, interoperability, operational efficiency, and collaborative decision-making.

However, the findings of this review also demonstrate that technological capability alone is insufficient to achieve industry-wide disruption. Despite considerable technological progress and increasing industrial interest, blockchain has not yet realised its anticipated transformative impact within container shipping logistics. The literature consistently indicates that this adoption gap is shaped by the interaction of governance arrangements, inter-organisational trust, organisational readiness, regulatory and legal environments, confidentiality requirements, interoperability, and broader ecosystem collaboration. Consequently, blockchain should not be viewed as a purely technological innovation but as an ecosystem transformation that requires the coordinated evolution of technological, organisational, institutional, and governance capabilities.

By synthesising the existing body of knowledge, this review contributes a comprehensive explanation of the disconnect between blockchain's recognised transformative potential and its comparatively limited industry adoption. Rather than interpreting governance, trust, regulation, confidentiality, and interoperability as isolated adoption barriers, the review demonstrates that these factors collectively explain why blockchain has not yet become genuinely disruptive within container shipping logistics. This integrated perspective extends current understanding by repositioning blockchain adoption as an ecosystem-wide transformation challenge rather than solely a technological implementation problem.

The review further demonstrates that realising blockchain's disruptive potential will depend upon the continued convergence of technological innovation, governance neutrality, regulatory harmonisation, interoperability standards, organisational readiness, and collaborative ecosystem development. Emerging technologies such as Artificial Intelligence, quantum-resistant cryptography, Digital Twins, Smart Ports, autonomous shipping, and cross-chain interoperability present important opportunities for extending blockchain capabilities and accelerating digital transformation across maritime logistics. However, these technologies will only achieve their full disruptive impact when supported by trusted governance frameworks and coordinated industry participation.

In conclusion, blockchain possesses the technological capabilities required to transform container shipping logistics, yet its disruptive potential remains only partially realised because the surrounding organisational and institutional ecosystem has not evolved at the same pace as the technology itself. Bridging this gap requires moving beyond technology-centred implementation towards governance-driven, ecosystem-wide transformation. Achieving this transition will enable blockchain to progress from a promising emerging technology to a mature disruptive technology capable of fundamentally reshaping the future of container shipping logistics.

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