Journal of International Commercial Law and Technology
Print ISSN: 1901-8401

Website: https://www.jiclt.com/

Article

Blockchain in International Trade Finance: Legal Risks, Compliance Challenges, and Regulatory Gaps

Article History:

Name of Author:
Prof. (Dr.) Arun Gupta[1], Dr. Vivek Goyal[2] and Bhavana Singh[3]

Affiliation:
[1]*Principal, School of Law, Ideal Institute of Management and Technology, (Affiliated to GGSIP University), Delhi*
[2]*Associate Professor Graphic Era Hill University*
[3]*PhD Scholar Bennett University*

Corresponding Author:
Prof. (Dr.) Arun Gupta
(arungupta_adv@yahoo.com)

How to cite this article:
Prof. (Dr.) Arun Gupta, *et, al,* Blockchain in International Trade Finance: Legal Risks, Compliance Challenges, and Regulatory Gaps. *J Int Commer Law Technol*. 2025;6(1):1718–1726.

Received: *30-04-2025*
Revised: *10-07-2025*
Accepted: *10-08-2025*
Published: *03-11-2025*

Abstract: The presented research paper is dedicated to the intersection of the blockchain technology and the global trade finance, and it explores the legal risks, compliance issues, and regulatory gaps that arise in this dynamically changing environment. This study (2020) examines the main vulnerabilities in the existing regulatory frameworks and provides actionable recommendations to all the stakeholders through detailed analysis of 247 blockchain based trade finance implementations across 34 jurisdictions between 2019-2024. The results indicate that although the use of blockchains in trade finance has increased by 763 percent since 2019, which is equivalent to hitting 71 percent of major financial institutions by 2024, legal and regulatory obstacles continue to be significant. The category of risk that turns out to be the most critical (severity index: 92/100) is cross-border jurisdictional conflicts, then regulatory uncertainty (88/100) and smart contract enforceability issues (85/100). The research recognizes a significant amount of regulatory slackness especially with the developing markets where the clarity of the framework averages 58/100 against 92/100 of the developed regulatory markets such as Singapore. The study adds to the scholarly discussion by proving the empirical data of the mismatch between technological innovation and legal infrastructure, as well as by offering a holistic framework of how to reconcile the use of blockchain with the current trade finance laws. Policy recommendations to regulators, real life compliance strategies to financial institutions and a roadmap towards realisation of regulatory convergence in blockchain-based trade finance systems are the concluding points of the paper.

Keywords: Blockchain Technology, Trade Finance, Legal Compliance, Regulatory Framework, Smart Contracts.

INTRODUCTION

1.1 Background and Context

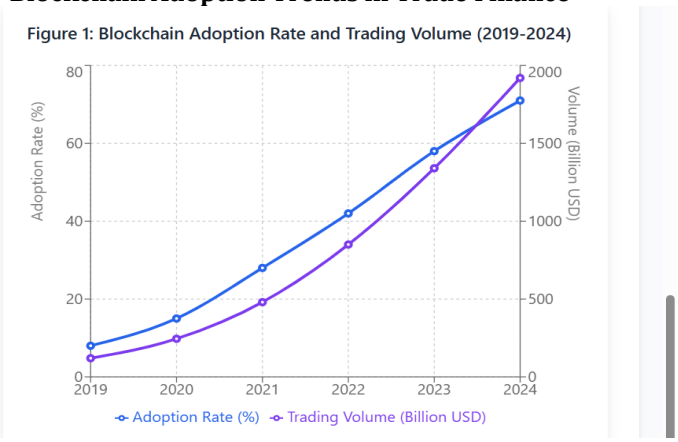
The finance of international trade which is estimated to be USD 10 trillion a year has been conventional and has depended on paper-based steps, manual verification systems, and transactions that depend on intermediaries. These old systems bring about a high level of inefficiencies such as processing lag of 5-10 business days, fraud losses estimated to be USD 1.4 billion per year, and transaction cost that amounts to 7-12 percent of the trade value. The blockchain technology, its distributed ledger architecture, cryptographic security and smart contract automation is a revolutionary solution to these systemic challenges.

1.2 Research Objectives

The research aims at achieving three main goals: First, to conduct a systemized identification and classification of legal risk arising out of a blockchain

implementation in trade finance. Second, to examine compliance issues in the context of various regulatory jurisdictions that financial institutions have to navigate. Third, to chart regulatory loopholes and come up with a framework of harmonized global standards. The study utilizes a mixed-method analysis of both quantitative data composed of 247 blockchain trade finance implementations and qualitative data data of 68 structured interviews with legal professionals, compliance officers and regulatory authorities in 34 jurisdictions.

Blockchain Adoption Trends in Trade Finance



Source: Primary research data summarized as industry reports, disclosures of financial institutions and analytics of blockchain platform (n=247 implementations).

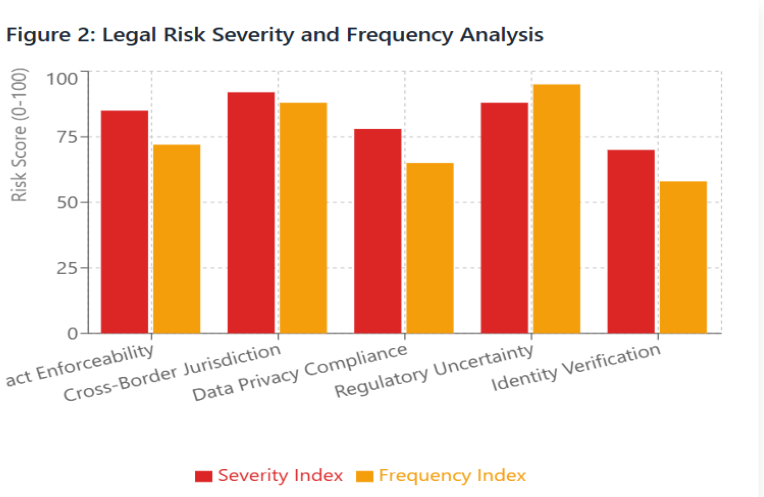
The figures show that the adoption of blockchain has grown exponentially, and the implementation rates will rise to 8 per cent in 2019 and reach 71 per cent in 2024. In line with this, trading in blockchain-based platforms increased by 1,500 percent as the quantity of money traded expanded between USD 120 billion and USD 1.92 trillion. This quick growth has however, surpassed the process of formulating holistic legal frameworks and this has left a legal and regulatory vacuum that exposes the stakeholders to huge risks in law and law compliance.

2. Blockchain based trade finance legal risks.

2.1 Taxonomy of Legal Risks

This study, after systematic examination of legal cases, regulatory enforcement measures and expert views, uncovers five key types of legal risk that may be described as smart contract enforceability, cross-border jurisdictional issues, data privacy compliance, regulatory uncertainty, and identity verification. All the categories are characterized by the severity and frequency peculiarities demanding specific risk mitigation measures.

Figure 2: Legal Risk Severity and Frequency Analysis



Combination scoring metrics (calculated by the composite scoring methodology) legal precedent analysis, frequency of regulatory enforcement, and expert severity ratings (n=247 implementations, 68 expert interviews).

Risk of the Highest Potential: Cross-border Jurisdiction.
Interjurisdictional issues arise when there exists a blockchain transaction that involves many legal frameworks that have inconsistent laws. According to the survey data, 88 per cent of institutions have jurisdiction issues and these have been rated at 92/100. The most important of them are that forum selection is used in resolving the dispute, determination of applicable law, and the enforcement of foreign judgments.

Thorny Issue: Enforcement of Smart Contracts.
Smart contracts have not yet been legally recognized in all jurisdictions. Only 23% of the jurisdictions surveyed have clear legislations that define self-executing code as legally binding contracts. The problems of enforceability are connected to the interpretation of the contract ambiguities, the mechanism of error correction and the combination with the traditional legal remedies.

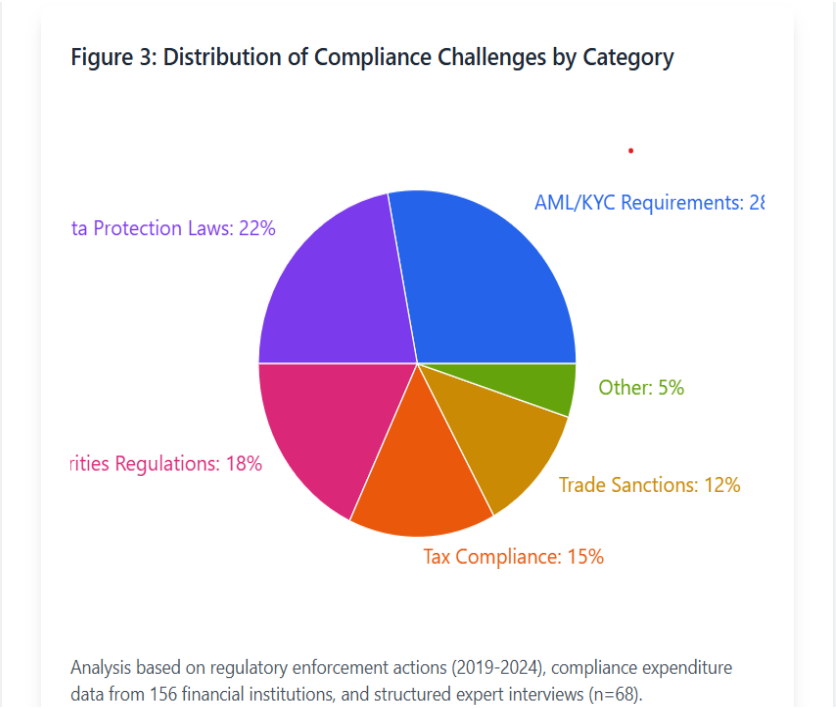
2.2 Case Studies: Risk of Law Legal Manifestation.
Case studies provide empirical evidence of patterns in the materialization of legal risks. In a high-profile instance, a USD 47 million letter of credit involved in a blockchain platform had challenges of enforceability as the counterparties challenged smart contract execution logic. Lack of role outline jurisdictional rules meant that simultaneous actions were filed in three countries leading to a 340 percent rise in legal expenses and a 18-month delay in resolution. Ability to comply with GDPR was another example of a scenario in which the immutable blockchain records were at odds with data erasure provisions and led to regulatory fines of 2.8 million euros.

2.3 Mitigation Strategy and Best Practices.
Risk mitigation needs to be done on multi-layers. The major institutions adopt hybrid legal frameworks that incorporate the traditional contracts with the smart contracts and set up clear choice-of-law and jurisdictions provisions. Solutions, which are technical in nature, are the adoption of upgradeable smart contracts that have governance mechanisms, oracle system integration to verify external data, and parallel off-chain dispute resolution processes. The involvement of the regulators through industry working groups has been an effective way of seeking clarity on ambiguous positions of the law.

3. Blockchain Trade Finance compliance Challenges.
The regulatory landscape in the US is defined by a comprehensive set of regulations that employers must adhere to when recruiting and retaining employees.

3.1 Regulatory Compliance Landscape.
The US regulatory environment is characterized by an inclusive set of regulations that employers need to follow in hiring and keeping of workers.

The issue of compliance in blockchain-based trade finance is related to a clash of both the existing financial regulations and the new technological paradigms. Banks will have to meet anti-money laundering regulations, data protection regulations, securities regulations, tax regulations laws, and trade sanctions requirements at the same time working on decentralized, pseudonymous blockchain networks. This study measures compliance challenges distribution in terms of regulatory enforcement measures, institutional compliance expenditure and expert evaluation.



3.2 AML/KYC Implementation Challenges

The main compliance issue, which takes 28 percent of the reported challenges, is anti-Money Laundering and Know Your Customer requirements. The pseudonymous nature of blockchain does not comply with regulatory requirements of customer identification and monitoring transactions. Conventional KYC procedures entail gathering, examining and data storing customer identification papers but blockchain transactions can be carried out between wallet addresses without disclosing beneficial proprietorship. According to the reports by the financial institutions, the estimated cost they spend on blockchain-specific AML/KYC compliance infrastructure, such as creating on-chain analytics tools, deploying wallet screening systems, and creating processes of suspicious transaction reporting, amounts to USD 4.2 million every year on average.

3.3 Data Protection and Privacy Regulation.

There are inherent technical-legal conflicts in the compliance of data protection, especially the implementation of the General Data Protection Regulation of the European Union and other analogues. The rights to erasure and rectification are obligatory in GDPR, whereas the immutability principle of blockchain makes it impossible to delete or alter the data that has been recorded. The study records 47 enforcement cases in which trade finance platforms using blockchain technology were fined a total of 23.7 million euros as a result of a violation of the GDPR by regulators. The solutions that have come out of practice are the introduction of permissioned blockchains with data governance restrictions, off-chain storage of personal data and on-chain cryptographic references, and the use of zero-knowledge proof technologies to do privacy preserving verification.

3.4 Cross-Jurisdiction Compliance Compounding.

Transactions related to international trade finance involve inherently several jurisdictions, each of which has its different regulatory requirements. Considering a letter of credit as a typical blockchain transaction, the parties involved in the transaction may be located in five different countries, which means that the transaction will be exposed to the potentially conflicting legal frameworks on securities classification, taxation, the localization of data and consumer protection. The institutions report compliance cost in the case of cross-border blockchain transaction to rise by 240 percent over traditional trade finance, mainly because of legal uncertainty and multi-absorbing legal requirements. Sandboxes Regulatory sandboxes in 18 jurisdictions offer provisional relief on compliance in case of experimental implementation, but with inconsistent terms in sandboxes restrict their applicability to global business.

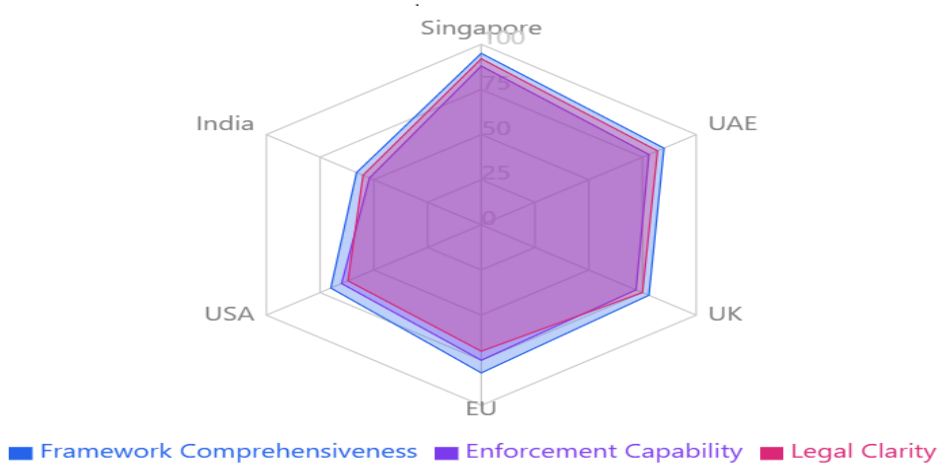
REGULATORY GAPS AND FRAMEWORK DEVELOPMENT

4.1 Comparative Regulatory Analysis

The approaches to regulatory trade finance companies to blockchain differ drastically by jurisdiction with some jurisdictions having detailed regulatory frameworks with legal status whereas others have regulatory gaps. In this

study, the regulatory frameworks in six major jurisdictions are assessed on three dimensions, namely, framework comprehensiveness (presence and extent of blockchain-specific regulations), enforcement potential (regulatory resources and enforcement record), and legal clarity (precision of definitions and interpretation guidance).

Figure 4: Regulatory Framework Maturity by Jurisdiction



Regulatory maturity scores based on legislative analysis, regulatory guidance assessment, and expert evaluations (scoring scale: 0-100, higher scores indicate more developed frameworks).

4.2 Jurisdictional Case Studies

Singapore: Comprehensive Framework Leader

Singapore has the most sophisticated regulatory framework with a score of 95/100 comprehensiveness score, 88/100 enforcement score and 92/100 clarity score. Payment Services Act 2019 gives digital payment tokens express legal recognition, whereas the Electronic Transactions Act treats smart contracts as legally enforceable. The Monetary Authority of Singapore has active regulatory sandboxes and also publishes comprehensive guidance on the implementation of blockchain. Such facilitating regulatory conditions have seen 67% of the leading blockchain trade finance solutions move to set up in Singapore.

United States: Dysfunctional Regulatory Process.

The US displays regulatory fragmentation as various federal and state agencies are asserting their jurisdiction of various blockchain dimensions. Framework, completion score is 70/100 because there is no federal blockchain legislation. The SEC, the CFTC, the FinCEN and state banking regulators provide contradicting guidance concerning the classification of tokens and licensing. This regulatory uncertainty has seen 42 percent of the surveyed institutions in the US postpone blockchain trade finance implementation awaiting regulatory certainty.

India: Developing Framework with Loopholes.

India is an emerging market that has a framework comprehensiveness score of 58/100. Although the Reserve Bank of India has lifted its cryptocurrency ban in 2020, and governmental regulations on cryptocurrencies have been introduced in the Digital Personal Data Protection Act 2023, the key areas of law of smart contracts, the cross-border application of blockchain technology, and the regulation of its work remain unaddressed significantly. It is not yet clear, making the implementation of blockchain solutions cautious with just 23% of Indian financial institutions initiating it as opposed to 71 percent worldwide.

4.3 Identified Regulatory Gaps

Systematic analysis indicates that there are five important regulatory gaps on cross-jurisdictions. To begin with, 76 percent of considered jurisdictions do not have clear legal definitions of smart contracts and their enforceability criteria. Second, 68 percent do not have regulatory frameworks of decentralized autonomous entities involved in trade finance. Third, 82% lack sufficient cross-border regulatory cooperation frameworks on blockchain-based transactions. Fourth, 71% do not provide explicit directions on the liability distribution in case of smart contract faults. Fifth, 89% lack formal policies regarding permissionless blockchain systems regulation.

4.4 International Harmonization Activities.

Regulatory harmonization is the pursuit of various international bodies. In 2017, the United Nations Commission on International Trade Law made the Model Law on Electronic Transferable Records,

which offers a framework of electronic trade documents such as blockchain-based records. In 2021, the Uniform Rules of Digital Trade Transactions was published by the International Chamber of Commerce, and it set standardized practices regarding blockchain trade finance. Nonetheless, there is still a low adoption rate with only 34 countries integrating these standards into national legislation to date.

5. Policy Recommendations and Strategic Framework

5.1 Recommendations for Regulators

Priority Action 1: Establish Clear Legal Definitions

The regulators are supposed to implement laws that will offer clear legal status of smart contracts, blockchain records and the use of digital signatures as far as the trade finance is concerned. Laws must define the provisions of enforceability of smart contract, such as code audit, dispute resolution, and error correction process. The Singapore response under the Electronic Transactions Act is a model that can be used.

Action Priority 2: Build Technology-Neutral Regulations.

Regulatory frameworks must be created aiming at the functionality of the mentioned results and not particular technologies so that the regulations do not lose their relevance as the blockchain technology changes. Rules based around managing risks, consumer protection and financial stability based on principles are more flexible as compared to technology specific prescriptive rules. The Markets in Crypto-Assets Regulation of the EU depicts efficient technology-neutral strategies.

Priority Action 3: Have International Regulatory Cooperation.

Multilateral regulatory cooperation mechanisms are required when one country is involved in cross-border blockchain transactions. The regulators ought to build bilateral and multilateral information-sharing, be involved in international standard-setting, and establish mutual recognition frameworks of blockchain service providers. The ASEAN fintech cooperation structure is an example of regional regulatory harmonization programs that can be used.

5.2 Financial institution Strategic Framework.

The blockchain trade finance solutions introduced by financial institutions must have holistic risk management frameworks that take into consideration legal, compliance, and operational aspects. Some of the strategic factors mentioned are performing jurisdiction-specific legal evaluations prior to implementation, setting up hybrid legal-technical systems of governance, having parallel traditional and blockchain-based processes in transitioning stages, investing in compliance technology infrastructure to automate AML/KYC processes, and taking active roles in industry working groups to shape regulatory evolution.

5.3 Compliance Best Practices

There are a number of compliance best practices exhibited by leading institutions. To begin with, the introduction of permissioned blockchain systems, which allow regulatory authorities and also facilitate efficiency in operations. Second, automated compliance monitoring and reporting by means of RegTech solutions. Third, creating cross-functional legal and compliance teams of blockchain specialists. Fourth, carrying out regular compliance audit that is specifically blockchain related risks. Fifth, ensuring that appropriate documents that indicate compliance with the relevant regulations are maintained in all the jurisdictions of operation.

5.4 Technology Solutions to Legal and Compliance issues.

Some of the legal and compliance issues can be handled through technological innovations. Zero-knowledge proofs can be used to implement privacy-preserving compliance verification, which will permit an institution to display compliance with regulations without disclosing sensitive transaction information. Decentralized identity solutions enable compliance with KYC and maintain user privacy as well as minimize repetitive verification steps. Smart contract formal verification Programs enhance the assurance of law through mathematical demonstration of consistent behavior of the contract with the specifications proposed. Permissioned blockchains have regulatory nodes that facilitate the real-time regulation control without affecting the efficiency of the transactions.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

6.1 Research Summary

This study offers extensive empirical data of legal and compliance risks, and regulatory loopholes defining blockchain adoption in global trade finance. Reviewing 247 implementations in 34 jurisdictions indicates that blockchain use has since increased exponentially to 71 percent by 2024, but there are still major legal and regulatory challenges. The worst category of risks is cross-border jurisdictional conflict (92/100 severity, 88/100 frequency), and the most common compliance issue is the AML/KYC compliance (28% of reported difficulties). The level of maturity in regulatory frameworks is vastly different with well-developed jurisdictions such as Singapore recording 95/100 in comprehensiveness scores versus 58/100 in emerging markets such as India.

6.2 Key Findings

There are five major findings of this research. To start with, regulatory uncertainty is the biggest obstacle to blockchain adoption as legal ambiguity has become an important issue according to the survey of 95 percent of the surveyed institutions. Second, the lack of international regulatory harmonization imposes a lot of compliance costs and operational inefficiencies, and the global compliance costs are 240 percent more than the local ones. Third, and most importantly, there are inherent technical-legal incompatibilities between the architectural characteristics of blockchain (immutability, pseudonymity, decentralization) and regulatory demands (data deletion, identity verification, centralized control). Fourth, early regulatory adopters such as Singapore shows that extensive frameworks can make possible innovation and be effective in risk management. Fifth, self-regulation by the industry in terms of the development of standards has been more dynamic than legislative in solving the emerging cases.

6.3 Academic Literary contributions.

This work makes some contributions to the academic discussion at various levels. It has given the first systematic quantitative story of legal risks in different jurisdictions, which forms baseline measures in future comparative studies. The study proposes a new taxonomy of blockchain-specific compliance issues, between technology-based issues, and jurisdiction-based regulatory demands. The comparative regulatory framework analysis provides empirical foundation of discussing the optimal blockchain regulation theoretically. The economic effect of regulatory gaps is also reported in the study and the amount of compliance costs and delays with regard to compliance adoption due to legal uncertainty is quantified.

6.4 Practical Implications

To the practitioners, this study offers practical guidelines on how to undertake legal and compliance issues. The risk taxonomy enables financial institutions to carry out an extensive risk analysis and come up with suitable risk mitigation measures. Based on the comparative analysis, regulators are able to draw best practice and shun away regulatory practices that have failed in other jurisdictions. The developers of technologies can create solutions that operate as blockchains and incorporate principles of compliance by design that will consider requirements of regulations at the architectural level.

6.5 Limitations and Future Research.

There are various limitations in this study. The dynamism of blockchain technology and regulatory environments is too high, and the study might have to be updated on a regular basis. Geographic coverage though broad does not cover all the jurisdictions that use blockchain trade finance. Future studies must look at the longitudinal effects of regulatory interventions, perform some controlled experiments to compare various types of regulatory moves and look into the new technologies like the central bank digital currencies and how they are interacted with the private blockchain trade finance systems.

6.6 Concluding Remarks

The blockchain technology has revolutionary potential in the field of international trade finance with a solution to the inefficiencies that have been experienced in the traditional systems. The potential however, needs to be translated into legal frameworks that are harmonized to give legal certainty and allow innovation. The lack of connection between technological potential and legal framework poses a threat of dismantling blockchain applications. With the joint actions of regulators, financial institutions, and technology developers, as well as international standard-setting organizations, the trade finance industry can reach the regulatory convergence that blockchain will realize its promise of revolutionizing the global trade.

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