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Emerging Implications of Blockchain in Global Trade

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ABSTRACT

International trade involves the cross-border exchange of goods and services, reflecting the interconnected flow of commodities and offerings between distinct geographical areas. It is an essential tool for economic interactions between countries. Technological developments such as Blockchain have sparked stakeholders' curiosity for its possible uses in the global trade landscape. Due to its inherent features of security, immutability, and transparency, blockchain technology can significantly enhance trade security, minimize trade costs and eliminate most intermediaries from the trading process. Although Blockchain has the potential to influence international trade significantly, the existing literature has not yet produced any conclusive evidence. This study examines how Blockchain technology influences international trade dynamics. Our findings reveal that Blockchain has a prominent role in shaping the future landscape of global trade. However, specific challenges need to be addressed by organizations before reaping the full benefits offered by this innovative technology, which is still in its early stages.

SARI PATI

IPerdagangan internasional melibatkan pertukaran barang dan jasa lintas perbatasan, yang mencerminkan arus komoditas dan layanan yang saling terhubung antara berbagai wilayah geografis. Perdagangan internasional merupakan instrumen penting dalam interaksi ekonomi antarnegara. Perkembangan teknologi, seperti Blockchain, telah memicu ketertarikan para pemangku kepentingan terhadap potensi penggunaannya dalam lanskap perdagangan global. Dengan karakteristik keamanan, ketidakberubahan (immutability), dan transparansi, teknologi blockchain berpotensi meningkatkan keamanan perdagangan, meminimalkan biaya perdagangan, dan menghilangkan sebagian besar perantara dalam proses transaksi. Meskipun Blockchain memiliki potensi besar untuk memengaruhi perdagangan internasional, literatur yang ada belum menghasilkan bukti yang benar-benar konklusif. Studi ini mengkaji bagaimana teknologi Blockchain memengaruhi dinamika perdagangan internasional. Temuan kami menunjukkan bahwa Blockchain memainkan peran penting dalam membentuk lanskap perdagangan global di masa depan. Namun, terdapat sejumlah tantangan yang perlu diatasi oleh organisasi sebelum dapat sepenuhnya memperoleh manfaat dari teknologi inovatif ini, yang hingga kini masih berada pada tahap awal pengembangan.

INTRODUCTION

International trade allows nations to expand beyond their domestic markets and facilitates the exchange of technologies, goods, and services that may not be accessible in their home markets. With the rise in interconnectedness among nations over the past few decades, international trade has become more critical. Financial investments from foreign companies, the rise in multinational firms, and foreign employees in organizations are examples of increasing economic ties among the nations. The expansion of these economic ties results from what we understand as 'globalization'. From the perspective of shipping and transportation, the main issue facing the trade and financing sector, especially in emerging to matured markets, is coordination and confidence between importers and exporters. Due to the intricate nature of the operational procedures involved in the international trading of products and commodities, the industry also retains several operational inefficiencies. For example, trade and shipping are still highly dependent on human resources and are impacted by labour-intensive, sluggish, and prone-to-error manual and paper-based operations. Importers and exporters face difficulty in financing or guaranteeing their transactions, which obstructs growth and reduces the overall advantages of globalization. The international trade domain has been particularly slow compared to other industries adopting digital technologies.

On the other hand, in the rapidly evolving landscape of the digital world, numerous businesses have undergone substantial transformations across various aspects, such as organizational behaviour, business processes, managerial strategies, and technology adoption (Wong & Chin, 2007). These changes have often led to enhanced business efficiency by integrating innovative technologies (Popović et al., 2019). We are navigating a world dominated by data and interconnectedness as the Fourth Industrial Revolution, or Industry 4.0, takes shape. Trade 4.0, a manifestation of how digital evolution reshapes international trade, is also introduced by this seismic upheaval that unites the physical and digital worlds. The core of Trade 4.0 is a revolutionary method of doing business internationally that signifies the change from conventional trade models to an ecosystem propelled by digital technologies, market integration on a global scale, and the pursuit of efficiency and transparency. The advantages for enterprises are unmatched market access, real-time data analytics insights, and a fair-trading platform that gives even the smaller firms a seat at the international table. Significant commercial and economic changes are being brought about by the unprecedented speed at which it is transforming the global trade ecosystems. The processing of goods at the entry ports, the safety of the global supply chains, and the increase in trade agreements are just a few of the aspects of global trade that respond to this wave of change. Blockchain technology is leading the change in Trade 4.0 by providing secure, transparent, and traceable digital ledgers. This facilitates international trade while reducing fraud and the expenses incurred by trading partners' laborious, paper-based procedures. In the current scenario, it is necessary to understand Blockchain and its value to implement Industry 4.0 effectively.

Problem Statement

International trade is crucial in the global economy as it contributes to efficiency. Countries rely on each other to import and export goods and services. However, this complex dynamic comes with its own set of challenges. Some prominent challenges faced by foreign trade today include geopolitical tensions between countries, security crises, logistical costs, varied regulatory and legal problems in countries, currency fluctuations and environmental impacts of supply chains. These may result in delays, uncertainties, increasing costs in the supply chain process and greenhouse gas (GHG) emissions. At this stage, it is crucial to invest in technological advancements to overcome the current challenges and ensure resilience in the international trade domain.

Research objective

The study aims to understand and generate insights into Blockchain technology's impact on international trade and how this domain can benefit from integrating Blockchain into its overall trade processes.

Research questions

RQ1 How does blockchain technology impact international trade processes?

RQ2 What are the challenges of integrating blockchain technology into the international trade framework?

Literature Review

History of Blockchain

Blockchain technology is a decentralized and widely distributed digital ledger system. It consists of individual records, known as "blocks," which document transactions spanning multiple computer nodes. In essence, Blockchain functions as a rigorous verification mechanism, ensuring the legitimacy of each transaction. One of its hallmark features is its inherent resistance to retroactive alterations; any attempt to modify a single transaction necessitates the alteration of all subsequent blocks in the chain. Consequently, cryptocurrency transactions conducted through Blockchain are irrevocable and immutable, a quality that has propelled this technology into the limelight across diverse industries (2022). Blockchain technology was introduced in 2008, initially within the cryptography community, and plays a significant role in international trade and business. Blockchain is among the various emerging innovative technologies that are prominent in many business aspects.

Blockchain gained popularity as the technology backing Bitcoin, one of the world's leading Cryptocurrencies. This concept was formulated by an unnamed individual or a group operating under the pseudonym Satoshi Nakamoto. In 2009, it developed as an integral part of the cryptocurrency Bitcoin. Blockchain constitutes the technology that underlies Bitcoin, serving as the virtual infrastructure that empowers it (Nakamoto, 2008).

On the other hand, Bitcoin represents a specific cryptocurrency, although the term is often used to encompass both the digital currency and the underlying protocol—in essence, the Blockchain itself. This overlap in terminology contributed to the delayed recognition of Blockchain's potential beyond cryptocurrency applications. The fact that Bitcoin was introduced soon after the financial crisis of 2008 has led to the misconception that it is a direct result of the latter. However, the history of cryptocurrencies dates back to before the global financial crisis of 2008. Although blockchain technology was initially used in Bitcoin, it combines several underlying principles that have been used for at least forty years. Blockchain technology, also used in other cryptocurrencies like Ethereum, began to gain recognition in 2013.

One of the notable Blockchain initiatives is Hyperledger, hosted under the Linux Foundation's support. The Linux Foundation, a non-profit organization, serves as a unifying force, convening industries across diverse sectors such as finance, banking, and the Internet of Things (IoT), encompassing machine-to-machine devices, supply chains, manufacturing, and technology. The primary objective of this collaboration is to propel the evolution of cross-industry blockchain technologies.

Hyperledger, a pivotal constituent of this initiative, represents a joint effort to design enterprise blockchain frameworks and tools. Hyperledger's impact extends far and wide, with applications across many domains, including the delicate landscape of international trade (Ganne, 2018).

Blockchain Technology

Blockchain is being widely used in many fields and has grown significantly in importance. It is a distributed digital ledger. Since its inception in 2008, Blockchain has evolved as a disruptive technology that could change the way we communicate, incur expenses electronically, track transactions, and monitor them. Blockchain might be more cost-friendly, as it eliminates the need for centralized control to oversee and manage transactions between participating businesses. Every Blockchain transaction is cryptographically secured and verified by other companies who also have a copy of every transaction on the Blockchain network. As a result, records become distributed, which means they can be shared with all the participants, synchronized, and safe due to various cryptographic techniques, and they cannot be changed over time. Additionally, it is well-recognized that blockchain technology is an information technology that may be applied to the software, commercial, and trade sectors (Sharma et al., 2020).

Blockchain architecture is the organizational framework of a peer-to-peer (P2P) computer network consisting of computers or servers called “nodes” that act as the backend for applications and other systems. Blockchain is a distributed ledger, or a decentralized database of transactions, updated and maintained by a computer network that validates a transaction before approving and adding it to the ledger (Morkunas et al., 2019). The network does not have a centralized organization to control the interaction between the nodes for authentication, such as banks for transactions involving finance; it is decentralized – although in recent years, 'private' blockchains have emerged that give a finer grain of control over the system. Based on the Blockchain's consensus protocol, data uploaded to the Blockchain is shared with all network users and is subject to verification and validation by anybody with the necessary rights.

Blockchain data is hashed using a mathematical function to ensure integrity, prevent forgery, and verify authenticity. The sender of the transaction has the option to encrypt the message to make the data unintelligible to those without authorized access if they do not want other network users to be able to read the message's content, which is the plaintext data contained in the submitted documents. Once transactions have been verified, they are kept in "blocks" and "chained" (in chronological order) to one another using cryptographic techniques.

A characteristic feature of Blockchain is that every participant, referred to as a peer, maintains a copy of the ledger's data. Any changes to this ledger are instantly sent to all participants, ensuring everyone has access to the same information. A blockchain serves as a shared and trusted ledger, open for inspection by all participants at any moment. Interestingly, no single entity controls this ledger except for fully private blockchains. This decentralized structure empowers individuals to collaborate without the need for intermediaries, even in the absence of mutual trust.

As data is replicated across multiple nodes, the entire network can only be threatened if a certain number of nodes are compromised, which is a near-impossible task. Theoretically, a blockchain network can be compromised if attackers gain control over more than half of the computing power of the Blockchain network, a scenario known as a "51 per cent attack." While this vulnerability applies to all blockchains, it assumes particular significance in public blockchains, given the challenge of ascertaining the true validators of blocks (Ganne, 2018). Although the potential for a 51% attack persists, it remains highly improbable on significant blockchains such as Bitcoin. The financial burdens associated with such an endeavour significantly outweigh any potential gains. Even in the unlikely scenario of an attacker deploying all possible resources to compromise a blockchain, the continuous addition of blocks would provide them only a relatively small window to change a few transactions (Mcshane, 2023).

Blockchain Architecture

Blockchain architecture has three main types, based on who manages the blockchain platform and user authentication, linked to the degree of anonymity.

Public Blockchains: A public blockchain is the oldest type of blockchain technology. This is where distributed ledger technology (DLT) first emerged, and cryptocurrencies like Bitcoin were introduced. It mitigates the shortcomings associated with centralization. It addresses issues like compromised security and reduced transparency. Distributed Ledger Technology (DLT) disperses data across a peer-to-peer network, rather than consolidating it in a single location. Given its decentralized architecture, specific data authentication mechanisms become imperative. Through the implementation of a consensus mechanism, participants within the Blockchain can collectively validate the current state of the ledger. The two consensus techniques that have gained the most popularity are proof-of-work (PoW) and proof-of-stake (PoS). Anyone with an internet connection can become an authorized node after signing up with a Blockchain platform because the public Blockchain is open and permissionless (Geroni, 2023). Recent and past data can be accessed, and mining operations can be performed. Within the network, any valid record or transaction remains impenetrable to alteration. Due to the usual open-source nature of the source code, individuals can scrutinize transactions, identify potential errors, and propose necessary fixes. The advantage of public blockchains is that they are independent of any organization, so even if the Blockchain creator does not exist, the network will continue to run if nodes are connected to it. Another advantage is the transparent nature of the network. Users must strictly adhere to security protocols to maintain the security of the Blockchain. The drawbacks might be the slow network due to unlimited access or use and scalability issues.

Private Blockchains: A private blockchain is controlled by a single authority. It is like a public blockchain in terms of decentralization and peer-to-peer nature, but it is on a smaller scale compared to a public blockchain. It is only restricted to a particular company or organization that operates it and controls permission levels, security, authorizations, and accessibility for the private Blockchain network. For instance, establishing a private blockchain network allows organizations to have more control over the network in terms of each node's privilege levels. A private blockchain offers higher efficiency and faster transaction processing times than public blockchains. Another benefit is that private blockchains use less computing power because the verification of transactions is done by a comparatively smaller number of nodes (per the Blockchain's regulations). According to the Blockchain's protocols, the transaction fees could be charged for validating transactions. Since "decentralization" is at the core of blockchain technology, there is a controversial claim that private blockchains are not truly decentralised in the sense of the word. (Anwar, 2023).

Consortium Blockchains: Consortium blockchains are also referred to as federated blockchains. These blockchains are suited for those organizations that require both public and private blockchains. A shared record of transactions is maintained on the private blockchain network and is accessible only to individuals who have been pre-validated. Current participants can choose future members, a regulatory body can award licenses to new users, or a consortium can select who can use the Blockchain (Morkunas et al., 2019).

METHODS

This paper adopts a conceptual research design supported by a systematic literature-based approach to examine the impact of blockchain technology on international trade. The methodology focuses on synthesizing existing academic and institutional insights to develop a comprehensive conceptual framework rather than conducting empirical analysis. Relevant literature for the study was identified through a search of academic databases, including Scopus, Web of Science, Google Scholar, and IEEE Xplore. Specific company websites and white papers were also referenced, such as the World Trade Organization (WTO) and the World

Bank. The search employed keywords such as "**blockchain and international trade**," "**blockchain impact on global trade**," "**trade efficiency through blockchain**," and "**blockchain and supply chain**." The review primarily covered studies published between 2018 and October 2025 to ensure the inclusion of recent technological and policy developments. Sources were selected based on relevance to the study's focus areas, as indicated by their titles and abstracts, and included peer-reviewed journal articles, conference proceedings, and authoritative white papers. Key information was extracted from the selected studies on **blockchain applications**, **trade finance innovations**, **supply chain management**, and **regulatory or interoperability challenges**. The selected materials were then analyzed thematically to identify recurring concepts, patterns, and trends. This thematic synthesis formed the basis for developing a conceptual framework illustrating blockchain's transformative role in enhancing transparency, efficiency, and trust in global trade processes.

RESULTS AND DISCUSSION

The rapid development of digital technologies is reshaping all aspects of our societies, including how international trade is conducted. Integrating artificial intelligence (AI) and distributed ledger technology (DLT), alongside the widespread adoption of 3D printing and 5G networks, marks a transformative era in technological advancement. An article published in 2018 by the World Economic Forum (WEF) explores the potential impact of these technologies on global trade. However, as technology advances, it is necessary to examine some tangible applications that are gaining traction, particularly in the exchange of goods: digital compliance, banking, and shipping. Trade and technology specialists are becoming increasingly excited about investigating how digital technologies might transform every link in the value chain. Together, they focus on identifying the problems these technologies can solve and understanding any obstacles that may arise. (Fan & Mans, 2019). The findings for RQ1 and RQ2 are presented below.

RQ1 – The Promising Role of Blockchain Technology in Global Trade

Smart Contracts for International Trade

Cross-border trade often encounters multifaceted challenges during contract implementation. Exporters and foreign customers face inherent risks, leading to increased costs for contract preparation and execution. The process involves lengthy documentation, ranging from international contracts to various accompanying papers, which increases administrative burdens. Labour costs are also notably high in international trade in services. Additionally, the complexity and risk associated with cross-border payments involving multiple banks add another layer of challenge.

One of the most promising aspects of blockchain technology, especially in international trade, revolves around smart contracts. Smart contracts are blockchain-based programs that execute when specific criteria are met. Frequently employed to automate the execution of agreements, they ensure that all involved parties can promptly ascertain the outcome without relying on intermediaries or facing unnecessary delays. They can also automate a workflow to execute a specific action when certain circumstances are met. Smart contracts follow the blockchain code's simple "if/when. ./then. .". statements. Upon verification of predetermined conditions, a network of computers executes the corresponding actions. These actions may involve disbursing funds to the rightful recipients, registering a vehicle, dispatching notifications, or issuing a ticket. The Blockchain is updated once the transaction completes, ensuring its immutability, and only those granted permission can access the results. Smart contracts can incorporate as many conditions as necessary to assure participants that the intended activity will succeed. Participants need to reach a consensus on the "if/when...then" rules that govern transactions, anticipate potential exceptions, and establish a framework for dispute resolution to define the terms. Additionally, participants must make decisions regarding the representation of transactions and data on the Blockchain.

Following this, a developer can proceed to program the smart contract. Notably, an increasing number of businesses leveraging Blockchain for their operations are opting for templates, web interfaces, and other online tools to streamline the construction of smart contracts (IBM).

Smart contracts are fast, efficient, and accurate. Since they are digital and automated, they eliminate the need for paperwork processing and the time-consuming task of rectifying errors that frequently arise from manual documentation. The absence of a third party and the sharing of encrypted transaction records among participants eliminate the need to question whether information has been tampered with for personal gain. Blockchain transaction records are fortified with encryption, rendering them highly resistant to hacking attempts. Furthermore, the interlinked nature of each record with its predecessors and successors on a distributed ledger necessitates that hackers alter the entire chain to modify a single record. As smart contracts eliminate the need for intermediaries to supervise transactions, there are no longer any associated costs or time delays (IBM). Thus, blockchain-based smart contracts have great potential to facilitate cross-border trade by minimizing expenses, simplifying paperwork, and expediting payments. Since smart contracts are software code, they are vulnerable to security breaches on the other side. The 2016 DAO (Distributed Autonomous Organization) stemmed from a vulnerability within the smart contract program code employed in that instance (Ganne, 2018).

Cryptocurrencies for International Trade

The past decade has witnessed the rise of cryptocurrency as a global financial phenomenon that has the potential to disrupt international trade. This digital currency facilitates quicker, cost-efficient, and more secure transactions than traditional banking systems. Using standard banking channels to handle transactions for international trade frequently results in long processing times. Fees from intermediaries, such as banks, are frequently included in traditional trade processes. Because cryptocurrency reduces the need for these middlemen, buyers and sellers can save money. Blockchain technology behind cryptocurrency offers strong security characteristics. Blockchain-based transactions are safe, transparent, and tamper-proof. This is important to international traders who are more concerned about fraud risks. Cryptocurrency mitigates currency risk by enabling transactions in a stable digital form, such as Bitcoin or Ethereum. International buyers and sellers can bypass the complexities and uncertainties associated with multi-currency exchanges by trading in one standard currency, such as cryptocurrency. This streamlined process enhances the accessibility of international trade, thereby making it more inclusive and efficient (Nesbitt, 2021).

Impact of Blockchain on International Trade Finance

Trade finance is often subject to the same laborious operational procedures as international trade. This has often posed several challenges for various stakeholders, resulting in the involvement of costly intermediaries and often lengthy processes. Many of these problems are resolved by blockchain technology, streamlining operational procedures, authenticating documentation, and making it easier for stakeholders to coordinate. This technology can be essential in establishing trust, expediting transactions, and simultaneously reducing costs and entry barriers, particularly for small and medium-sized enterprises (SMEs) (Fan & Mans, 2019). Blockchain can facilitate transactions between importers and exporters by enabling them to trust one another without the need for an intermediary (Derindag et al., 2020). In 2017, the Asian Development Bank estimated a substantial trade financing gap of $1.5 trillion. This represents a significant 10% of the global merchandise volume. The consequences of this gap were far-reaching, as it meant that numerous businesses needed access to the necessary credit to participate in international trade. Alarmingly, around 75% of the affected businesses were SMEs (Fan & Mans, 2019). In response to this challenge, blockchain technology has emerged as a favoured solution among international trade stakeholders. Integrating blockchain with digital currencies and other financial technologies can make payments faster and cheaper, reducing fees and exchange rate risks in international transactions(Adeoye, Osunkanmibi, Onotole, & Ogunyankinnu, 2025).

Impact of Blockchain on Tracking and Traceability in International Trade

"Track and trace" is a term commonly used in the supply chain industry that refers to identifying a product's past and present locations and maintaining a comprehensive record of the entire journey of a product from manufacturing to delivery(Agarwal et al., 2022). Tracking and tracing necessitate monitoring products as they navigate a complex journey, beginning with raw materials and progressing through various geographic regions for processing and manufacturing, regulatory oversight, and ultimately reaching retailers and consumers. Establishing a detailed record of a product's journey is paramount in guaranteeing its authenticity. In today's supply chains, the task of track and trace often proves to be quite challenging due to antiquated paper-based procedures and disparate data systems, which results in ineffective communication. The absence of data compatibility exposes supply chains to numerous issues, including visibility gaps, inaccurate predictions regarding supply and demand, manual errors, counterfeiting, and compliance breaches. The end-to-end delivery of goods to customers in today's world requires the collaboration of manufacturers, suppliers, logistics firms, and retailers, resulting in the creation of today's global, dispersed, and complex supply chains. These complexities can cause delays, mistakes, and higher expenses. Participants in the modern supply chain must have access to a single, unified picture of the data, such as updates on manufacturing and logistics. Blockchain technology is rapidly gaining traction, enabling tracking and traceability across diverse industries. By providing an immutable and decentralized ledger, Blockchain effectively enhances transparency, mitigates fraud, and boosts operational efficiency within supply chains and across various sectors. Supply chain enterprises can leverage blockchain technology to document production updates on a distributed ledger, providing comprehensive data visibility. Businesses can always track and trace a product because all transactions are time-stamped. This helps prevent problems like waste, delays, and counterfeit items in compliance violations. Additionally, the ledger audit trail provided by Blockchain ensures transparency and accountability, which are essential for regulatory compliance. This detailed, tamper-proof record allows businesses to adhere to legal and industry standards. In emergencies, such as product recalls, the audit trail enables fast identification of affected products and their locations, facilitating a prompt and effective response to mitigate risks.

Moreover, by integrating Blockchain technology with smart devices powered by the Internet of Things (IoT), supply chains can achieve automated and real-time monitoring of production, transportation, and quality control processes. Such devices can collect and transmit data like temperature, humidity, or location, which is then securely stored on the Blockchain. This integration ensures that the entire supply chain operates with greater accuracy and precision, helping to maintain product quality and address issues proactively while enhancing trust among its global stakeholders. (Blockchain for Supply Chain: Track and Trace, n.d.)

The Promising Role of Blockchain in Sustainability Efforts

Blockchain's potential to revolutionize sustainability efforts in international trade is another preferred reason for its adoption in the business sector. In the global trade landscape, goods are transported from one place to another. This will require the use of transportation services, whether by land, air or water. A report by the International Transport Forum on GHG emissions highlights that the transport sector is a major contributor to GHGs, leading to the most pressing issue on our planet now: climate change. With each passing day, the effects of our unsustainable practices become more apparent. The need for innovative solutions to tackle this problem has never been greater. One of the solutions that has gained traction in recent years is the use of carbon credits. Carbon credits are a way of minimizing the negative effects of greenhouse gas emissions. They represent the reduction or removal of carbon dioxide and other greenhouse gases from the atmosphere. These credits can be traded on carbon markets, allowing companies and individuals to offset their emissions and contribute to reducing the effects of climate change. Carbon credits can be accurately tracked and verified using blockchain technology, thereby preventing fraud and double-counting. This can ensure that every credit is legitimate and has a tangible environmental impact. With the integration of blockchain technology, the carbon credit market can become more reliable, transparent, and capable of meeting the sustainability goals of businesses (Singh, 2024). As the complexity and opacity of supply chains increase, blockchain can be a game-changer, as it provides end-to-end visibility of every transaction on the decentralised network. This transparency feature ensures the authenticity and ethical sourcing of products and the reduction of waste through inventory optimization, thereby mitigating the environmental impact of global supply chains.

Although Blockchain can positively impact global trade in various ways, as the study discusses, its adoption in global trade encounters specific challenges that must be addressed.

RQ2 – The Challenges of Blockchain Integration in the International Trade Ecosystem

Technical Expertise and Interoperability Issues

Implementing Blockchain Technology requires a high degree of technical expertise and robust infrastructure. Issues related to interoperability with existing systems, software, and business practices (Wang et al., 2019) must be addressed before the technology's full potential can be realized.

Regulatory Uncertainty and Compliance Factors

The legal and regulatory landscape surrounding Blockchain is still uncertain. Questions and risks related to data privacy, jurisdiction, liability, taxation, and sanctions arise. To ensure compliance, stakeholders must navigate these challenges (Wang et al., 2019).

Cultural Resistance

Blockchain adoption requires a cultural transition from conventional, centralized corporate methods to cooperative, decentralized models. Coordination between several stakeholders is necessary for such a shift.

Overcoming these challenges is essential to realizing blockchain technology's full potential in global trade. Technical, legal, and cultural barriers must be addressed effectively, requiring joint efforts from governments, industries, and organizations.

Conceptual Framework

Based on the synthesis of findings from RQ1 and RQ2, this study proposes a conceptual framework that illustrates how blockchain technology impacts international trade and the challenges that hinder its adoption. The framework consolidates key findings from the literature, including technological enablers, trade transformation mechanisms, and integration challenges, to explain how blockchain enhances global trade processes while identifying barriers that affect the large-scale implementation of this technology in the current scenario of global trade.

Framework Components

Technological Enablers of Blockchain in Trade (RQ1): This element determines the key technological value propositions of blockchain determined in the literature review. These are the essential characteristics of change.

Smart Contracts: Automate trade agreements and payments, ensuring transparency and reducing the need for intermediaries.

- *Cryptocurrencies*: Facilitate low-cost, cross-border payments, minimizing currency and transaction risks.
- *Trade Finance Applications*: Simplify documentation, build trust, and close financing gaps, especially for SMEs.
- *Tracking and Traceability*: Improve visibility, authenticity, and compliance in complex global supply chains.
- *Sustainability Support*: Enable carbon credit tracking, ethical sourcing, and reduced environmental impact.

Outcomes in International Trade: This element indicates the top-tier effects that emanate from implementing the fundamental capabilities.

- *Increased Transparency and trust*: There is only one source of truth that minimises disagreements.
- *Better Productivity*: Automation through smart contracts and increased speed of payment minimizes cycle times.
- *Lower Costs*: The low overhead of administration and transactions is achieved by the disintermediation of third-party verifiers and a decrease in paperwork.
- *Increased Security and Fraud Prevention*: Cryptographic security and non-alterable records guard against damaged records and forgery.

Integration Challenges (RQ2): This element determines the major obstacles to the adoption process, as mentioned in the literature. These variables undermine the positive interaction between blockchain potentials and trade performance.

Technical Expertise and Interoperability: Need for infrastructure, skilled professionals, and system compatibility.

- *Regulatory and Compliance Barriers*: Ambiguity in international data laws, taxation, and jurisdictional issues.
- *Cultural and Organizational Resistance*: Hesitance to move from centralized to decentralized models.

Enabling Conditions for Adoption

Successful integration requires supportive policies, training programs, and investments in digital infrastructure. The Blockchain Innovation Adoption Framework (BIAF) (Upadhyay, 2020) emphasises that successful blockchain adoption will depend on innovation readiness, organisational strategy, and environmental support. This element represents the external circumstances that should be used to address the challenges and successfully implement blockchain. These circumstances enhance the positive correlation between blockchain potential and trade performances.

- *Favourable Policy Environment*: Government laws that are pro-innovation.
- *Digital Infrastructure*: Large-scale access to fast internet and computing capability.
- *Multi-Stakeholder Collaboration*: Industry-wide standards and platforms.
- *Human Capital Development*: Education to develop technical competency.

Theoretical Propositions

Based on the framework, the following propositions are developed:

P1: Blockchain technology positively impacts international trade by enhancing transparency, efficiency, and trust.
P2: The use of smart contracts and decentralized finance mechanisms reduces administrative costs and delays in trade processes.
P3: Regulatory ambiguity, interoperability issues, and lack of technical expertise significantly hinder blockchain adoption in global trade.
P4: Multi-stakeholder collaboration and supportive digital infrastructure are crucial for the sustainable

integration of blockchain in emerging economies. Figure 1 illustrates the proposed conceptual framework for Blockchain in International Trade.

MANAGERIAL IMPLICATIONS

From a strategic perspective, Blockchain technology holds a transformative potential for the way international trade is conducted, as it simplifies the intricate processes of cross-border trade by enabling real-time, tamper-proof data sharing across multiple entities, including suppliers, customs, financial institutions, and logistics providers. Managers can gain 360-degree visibility into their supply chains, reduce fraud, and automate key transactions via smart contracts. However, for emerging and developing nations, Blockchain adoption may be challenging due to their limited financial resources, poor infrastructure, and lack of technological know-how. The adoption of blockchain technology in developing nations is hindered by several significant issues, including stakeholder ignorance, a shortage of experienced and qualified personnel, and a lack of familiarity with the technology (Li et al., 2019). For integration to be successful, it is essential to comprehend these difficulties.

Potential inequalities may exist. There may be a widening gap in the global supply chain's efficiency, transparency, and competitiveness if some nations require assistance in adopting blockchain technology, while others achieve success with it. This could increase the economic divide between countries that have progressed in technology and those that have not. The practical application of blockchain technology can boost economic expansion. However, if some countries are left behind due to challenges in adopting technology, their economic growth may be hindered. Policymakers need to consider how blockchain integration can promote social and financial inclusion. Sustainable development requires that technology benefits all segments of society, including smaller businesses and local communities. Governments in developing and rising nations significantly impact the adoption of blockchain technology.

Policy Recommendations for Emerging and Developing Nations

- Investing in digital infrastructure is essential for weaker nations. Such nations face challenges

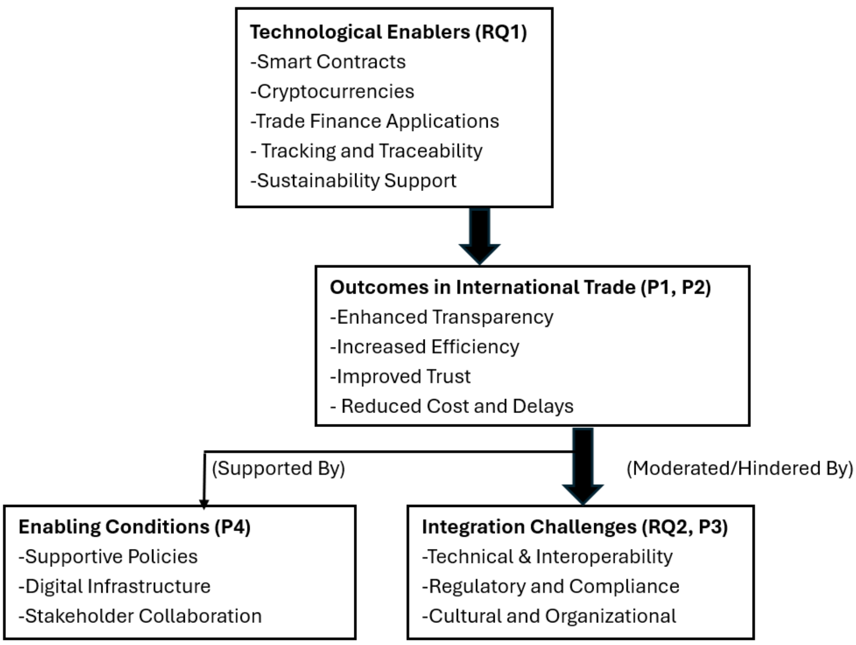

Figure 1. Proposed Conceptual Framework for Blockchain in International Trade

with expensive internet connectivity and limited access to internet services, which will obstruct the adoption of blockchain technology. Governments of these nations need to invest in robust and affordable internet coverage and access, along with smart grid technologies, to optimize the energy requirements of digital networks.

- Spreading awareness among senior management about the benefits of blockchain integration is crucial for emerging and developing nations, as senior leadership plays a major role in shaping organizational strategies and investment decisions. Once they start realizing the potential of the blockchain network, they can consider possible ways of making technology part of their long-term goals.
- Developing training programs and skill-development workshops for the workforce is an important part of blockchain adoption. Without the right digital expertise and technical skills, the diffusion of blockchain technology will be limited.
- Establishing clear and supportive regulatory frameworks that encourage innovation while ensuring security and compliance is essential for fostering blockchain adoption. Clarity on regulations and policies will encourage organizations to experiment with blockchain technology through pilot projects at the initial stage. Supportive frameworks will promote investment and bring in more national and international collaborations.
- Providing financial support for businesses adopting blockchain technology will speed up the adoption process by reducing the cost barriers. This is especially important for SMEs (small and medium enterprises) integrating blockchain into their operations. Financial support can be provided through grants, subsidies, and low-interest loans.
- Encouraging collaboration between public and private sectors and educational institutions and fostering global partnerships can facilitate technology transfer and knowledge exchange. This will bridge the gap between technologically advanced and less developed countries. The government should make significant investments in universities and research institutions to facilitate the rate of adoption of the technology. Universities can set up training programs in skills related to blockchain, such as cryptography, blockchain architecture, data structures, and programming languages. Industry-academia collaboration will equip young talent with the necessary skills and will set the pathway for blockchain adoption in the future.
- International organizations and developed countries can support emerging economies through innovative initiatives, funding, and knowledge-sharing to overcome the challenges associated with blockchain integration.

Action Plan Implementation

Upadhyay (2020) proposed the Blockchain Innovation Adoption Framework (BIAF), a structured guide for organizations and industries seeking to integrate blockchain technology into their operations (Figure 2). This framework has three main phases: initiation, adoption decision, and implementation. It involves evaluating the suitability of Blockchain for specific use cases, addressing technical and regulatory challenges, and defining clear strategies for successful adoption.

The Initiation phase involves the early recognition and exploration of blockchain technology within an organization. First, the organization needs to identify the problems that blockchain can address. Then, it is essential to learn about technology and its applications, understand blockchain's relevance to the organization, and understand its benefits and drawbacks before formally considering integrating blockchain within the current business environment. The Adoption Decision phase focuses on the decision-making stage, where the organization should decide whether to accept or reject the decision of blockchain adoption,

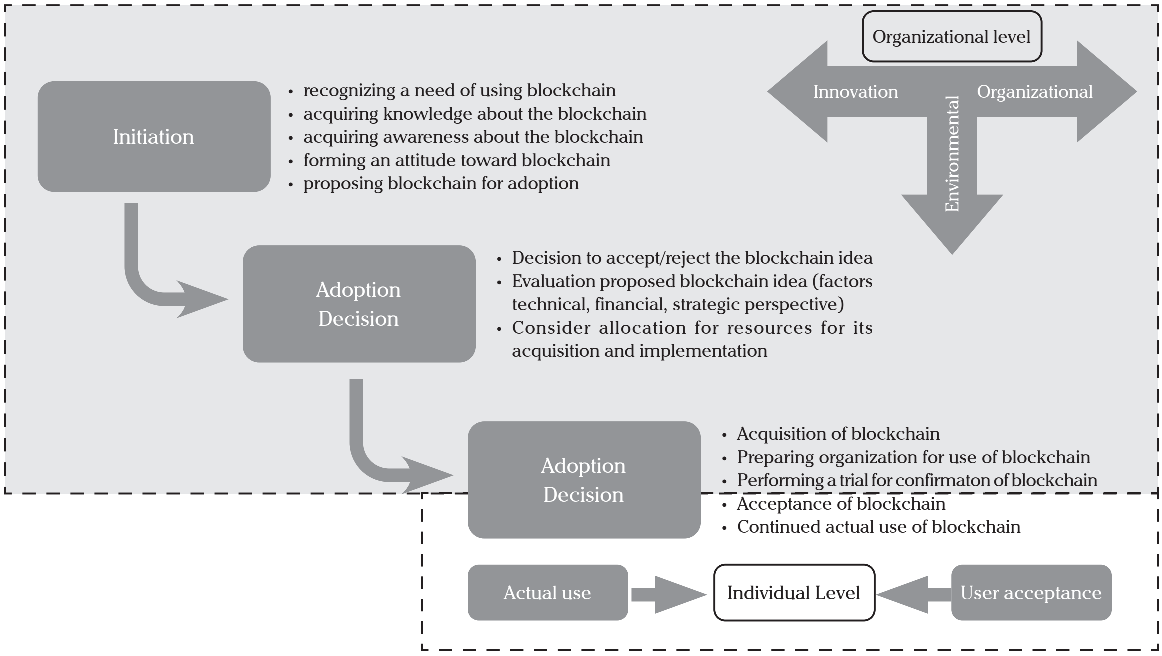

Figure 2. BIAF (Upadhyay, 2020)

analyzing its technical, financial and strategic aspects. It should also consider cost factors related to resource allocation for blockchain's adoption and implementation. The last phase, the Implementation phase, will come into play only if the adoption decision is positive in the previous stage. At this stage, the organization should prepare to procure the tools, platforms and services required for blockchain acquisition. The staff should be trained to equip them with the required skills and technicalities to engage with the blockchain architecture. The business should run a test or pilot project to assess the effectiveness of blockchain. Upon successfully accepting the technology within the organizational framework, the business should continue its use in its day-to-day operations to become more adept with Blockchain. The adoption process is influenced by three external factors – innovation, organizational and environmental, as illustrated in the framework of Figure 1. These factors are crucial to be considered while in the decision stage to have a holistic approach towards blockchain adoption by addressing both strategic and organizational dimensions. It is also evident in the framework that user acceptance at the individual level is important to ensure the actual and continued use of Blockchain within the organization. It is necessary to ensure that the users understand the benefits of technology and are equally eager to make the most out of it, considering the organizational goals of maintaining a competitive edge in the dynamic business landscape against competitors.

The framework can be enhanced to include considerations for collaboration, standardization, and ongoing monitoring to ensure the effective and sustainable integration of blockchain innovations.

CONCLUSION

Conclusively, this paper has summarised the literature available to show that the introduction of blockchain technology in international trade is beneficial on a deeper level. Blockchain prevents major obstacles to traditional trading systems by promoting trust, transparency, and efficiency, bringing the world a less burdensome and more secure trading environment. The unchangeability of the ledger improves the integrity of the data, whereas smart contracts make thorough processes less complicated and time-saving and less expensive in terms of time and money spent on paperwork and intermediaries. With the examples of blockchain implementation in countries such as Saudi Arabia and Thailand, the technology is being seen as an inseparable part of the national innovation policy targeting economic development and modernization.

The main value that this paper will bring to the body of literature is the creation of a conceptual framework to arrange the fragmented literature in this field. This framework recognizes the targeted technological facilitators (such as smart contracts and traceability) and connects this to real-world results of international trade (such as enhanced efficiency and trust). In addition, it determines the key integration issues (technical, regulatory, and cultural) and offers a series of falsifiable propositions (P1-P4) that can be used in future empirical research.

This study is a conceptual paper, which has significant limitations. Its results are not empirically proven, as it is based on the systematic review of the available literature. The mentioned advantages and difficulties are not specific to certain industries or geographic areas that have varying amounts of digital preparedness and regulatory maturity.

Such constraints pave the way forward for further studies. To begin with, we suggest the empirical test of the propositions (P1-P4) formulated in our framework. An example is that in future research, quantitative methodologies may be used to estimate the effects of the adoption of smart contracts on the costs of trade finance (P2) in a given trade corridor. Second, case studies are required to analyze how SMEs, especially in emerging economies, overcome the aforementioned challenges of adoption (P3). Lastly, studies are needed on how to establish interoperability and data governance global standards to overcome the most critical barriers to its adoption.

The cooperation of governments, companies, and innovators will be critical to the maximum use of blockchain. Although the process is disruptive, its effectiveness is based on the fact that these technological and regulatory issues need to be resolved collectively so that the future of international trade can be transformed. ■

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