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A Survey on Applications of Distributed Ledger Technology in International Trade †

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Abstract: With its potential to address persistent issues like inefficiency, fraud, and a lack of transparency, distributed ledger technology (DLT), and in particular blockchain, has become a game-changing breakthrough in the realm of international trade. With a thorough examination of its potential to revolutionize trade processes, this study examines the applications of DLT in global commerce. It starts by examining the conventional cloud-based models that predominate in global trade procedures and contrasting them with the blockchain-based approach that has been suggested. The viability and effect of blockchain technology (BCT) in this industry are evaluated by the research using both qualitative and quantitative approaches, such as data collecting, comparative analysis, and SWOT analysis. The main impediments to blockchain adoption are noted, along with suggested fixes for them. A discussion of potential future possibilities and suggestions for using blockchain technology into global trade networks round out the report. The purpose of this study is to offer theoretical understandings and useful suggestions for the successful use of blockchain technology in international trade.

Keywords: distributed ledger technology (DLT); blockchain; international trade; SWOT analysis

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1. Introduction

The rapid evolution of digital technologies has brought transformative changes across various industries, and international trade is no exception. A rapidly globalizing economy is making traditional trading systems, which are frequently characterized by convoluted middlemen, protracted procedures, and a lack of transparency, more inefficient. In order to solve these inefficiencies, distributed ledger technology (DLT), and in particular blockchain, has gained attention. Decentralized, safe, and transparent mechanisms provided by blockchain promise to save expenses, simplify processes, and lessen the likelihood of fraud and mistakes in business dealings.

Notwithstanding its promise, blockchain adoption in global commerce is still in its infancy and presents a number of possibilities and difficulties that require careful consideration. Surveying the several uses of blockchain technology in international commerce, evaluating its advantages via comparison, and offering a thorough SWOT analysis to gauge its implementation readiness are the objectives of this study. This study aims to provide important insights into how DLT might change the global trade environment by critically examining the advantages, disadvantages, possibilities, and risks related to blockchain in international commerce.

This study also addresses the present obstacles to implementing blockchain technology in global commerce and suggests possible ways to overcome them. This paper ends with suggestions for future developments and ways to incorporate blockchain technology into business processes to improve security, efficiency, and transparency.

2. Theoretical Framework

International business is a complex system that includes importers, exporters, financial institutions, customs authorities, and other participants. Data silos, a lack of transparency, and cyberattack susceptibility are among of the disadvantages of traditional trade management methods, which mostly rely on centralized cloud-based platforms. Blockchain technology, with its decentralized and immutable record, offers a novel way to overcome these limitations. Because blockchain ensures real-time data transmission, increases confidence between parties, and uses smart contracts to automate processes, it may radically reimagine international commerce workflows and eliminate the inefficiencies found in conventional systems.

2.1. Traditional Cloud-Based Model for International Trade

International trade is a business process with transactional aspects [1] based on a deal between an importer and an exporter intending to engage in exchange with various stakeholders, such as banks, customs, and transporters [2]. This may involve exchanging products, money, information, or service requests [2]. Operations, discussions, and actions are employed to ensure a business transaction [2] by multiple people or organizations [3], referring to Peer-to-Peer (P2P) transactions as an economic event, normally including the transfer of money between two parties, which a third party traditionally intermediates. Peer-to-Peer transactions function without established power structures, occurring regularly but without deep relational ties [4]. This process usually creates a large number of records, such as invoices, letters of transport, and even bank statements [5]. The stakeholders involved in this economic event contribute to or validate specific elements, generating a consolidated document that defines its context and data [3]. As mentioned, traditional international trade processes involve multiple stakeholders. These processes are often labor-intensive, relying heavily on paper-based documentation, which can lead to inefficiencies, errors, and significant delays [6]. For instance, a single transaction may require numerous documents to be exchanged across various intermediaries, increasing the chances of discrepancies and fraud [7]. The reliance on manual verification further exacerbates delays, reducing efficiency and increasing costs.

One example of inefficiency is the use of letters of credit, a traditional payment mechanism designed to mitigate risks between buyers and sellers. While effective in ensuring payment security, the process is time-consuming and expensive, involving multiple intermediaries such as banks, which must manually verify and authenticate transactions [8]. Moreover, traditional supply chain systems often lack real-time visibility, resulting in poor coordination and inventory management challenges [9].

As a result, book-keeping is essential for maintaining transaction records for all parties involved [2]. Throughout this process, documents or data fragments move between participants or services to establish procedural context and capture outcomes [3]. However, due to their intrinsic complexity, international commerce transactions frequently face dangers including fraud, data breaches, delivery problems, payment delays, security flaws, and reliance on middlemen.

These inefficiencies show how creative and practical solutions are needed to improve transparency, optimize processes, and lower operating expenses in global commerce. A viable substitute is blockchain technology, which provides decentralized,

safe, and instantaneous data sharing. Blockchain technology (BT) offers a transformative solution to enhance transparency, security, and efficiency while addressing these challenges. It can automate documentation processes, improve traceability, and foster trust among stakeholders by providing an immutable and transparent ledger of transactions [10].

As international trade grows in complexity, adopting blockchain technology is increasingly seen as a transformative tool for addressing longstanding inefficiencies. By replacing outdated manual systems with automated, digital frameworks, blockchain has the potential to revolutionize global trade practices and enable seamless integration among stakeholders [6].

2.2. Proposed Blockchain Model for International Trade

The integration of efficient technologies such as blockchain technology, Internet of Things (IoT), and smart contracts can open up an array of transformative opportunities to address the inefficiencies of traditional international trade systems. As previously discussed, traditional systems often suffer from a lot of inefficiencies due to the involvement of multiple intermediaries and fragmented data [11]. In contrast, the proposed model aims to enhance international trade by creating a seamless, secure, and efficient environment where all stakeholders can interact with greater transparency and more trust [12].

The proposed model is built on the synergy between blockchain, IoT, and smart contracts, each playing a distinct but complementary role in modernizing the international trade landscape.

- Blockchain technology functions as a decentralized, tamper-proof ledger that records all international trade transactions. Each transaction such as purchase orders, shipment updates, or payments is securely logged as a block and connected to preceding blocks, forming an unalterable chain. This system allows all trade participants, including exporters, importers, customs agencies, and financial institutions, access to real-time data any time. By offering a transparent, unified ledger, blockchain solutions such as TradeLens by IBM and Maersk, Dubai's Blockchain-Enabled Trade, and Ripple's blockchain-based payment network reduce fraud and operational mistakes. These technologies provide real-time tracking, secure data sharing, and seamless international transactions, creating a trusted, single source of truth [13].
- IoT for Real-Time Monitoring and Data Collection: The Internet of Things (IoT) plays a critical role in enabling real-time tracking and data collection across global supply chains. IoT devices, such as GPS trackers, temperature monitors, and humidity sensors, gather continuous updates on the location and condition of goods [14]. This information is transmitted to a blockchain network, offering stakeholders instant access to shipment status [15]. Several organizations use IoT in international trade: Geotab optimizes fleet routes with real-time data, the Port of Rotterdam improves container tracking and cargo handling, and ZIM Shipping enhances shipment security with IoT-enabled smart containers.
- Smart Contracts for Automation and Efficiency: Smart contracts have the power to automate the execution of pre-defined contractual agreements [11]. In international trade, smart contracts can be used to automate several processes, such as payments, customs clearance, and delivery confirmation. For instance, once IoT devices confirm the delivery of goods to a specified location, the smart contract automatically triggers payment from the buyer to the seller [12]. By doing away with the need for middlemen like banks, smart contracts such those found in platforms like VAKT and CargoX improve transaction speed and lower human error. Furthermore, they guarantee adherence to trade laws by automatically confirming the existence of the necessary paperwork, such as bills of lading and certificates of origin, before completing transactions.

- Smooth Integration for International Trade: The combination of smart contracts, blockchain, and the Internet of Things creates a unified and effective ecosystem that makes it possible for data to move securely and automatically across the whole supply chain.
- This model markedly diminishes the necessity for manual interventions and intermediaries, which frequently contribute to delays and inaccuracies in conventional international trade systems [13]. Furthermore, because blockchain technology is decentralized, all participants, regardless of where they are in the world, can access the same data, which promotes greater consistency and confidence among stakeholders. The ability to instantly entice payments, monitor items in real time, and expedite compliance evaluations improves the whole trade process's dependability, efficiency, and cost-effectiveness.

3. Methods

This study's methodology, which analyzes the use of distributed ledger technology (DLT) in international commerce, is based on qualitative methodologies. This study highlights important facets of blockchain adoption and its effects by combining findings from peer-reviewed publications, industry reports, and case studies. SWOT analysis offers a methodical assessment of DLT's advantages, disadvantages, possibilities, and threats, whereas comparative analysis assesses the company's performance in terms of efficiency, security, cost, and transparency. This comprehensive approach ensures a nuanced understanding of blockchain's transformative potential and its implications for global trade systems [14,16].

3.1. Data Collection

Data may be gathered from a variety of sources in order to conduct a thorough SWOT analysis for the suggested model of blockchain, IoT, and smart contracts in international commerce. These consist of trade journals and case studies from companies like IBM, Maersk, and TradeLens [17] that offer useful information about the application of these technologies in supply chains. Academic papers from journals that are indexed in Scopus, as well as studies from consulting organizations like Deloitte and PwC, include important empirical data on the possibilities and difficulties of using blockchain and IoT in business. Furthermore, primary data about the advantages and disadvantages of these systems may be obtained through surveys and interviews with important stakeholders, such as logistics managers and trade specialists. While trade associations and customs officials give operational insights, market research databases such as Statista and Gartner provide quantitative data and market projections. Lastly, regulatory papers aid in evaluating legal issues, guaranteeing a comprehensive assessment of the viability of the suggested model. The diverse nature of the data collected will form the foundation for a detailed SWOT analysis, linking each section to real-world evidence.

3.2. Comparative Analysis

Distributed ledger technology (DLT) has emerged as a disruptive force in global trade, with major improvements in efficiency, security, cost, and transparency. The use of blockchain-based technologies, such as Maersk's TradeLens, has been shown to significantly increase operational efficiency. TradeLens reduced customer clearance times by up to 30% by optimizing procedures and removing delays associated with manual interventions and traditional paperwork [9]. In addition to speeding up trade, lowering processing time helps to minimize inefficiencies seen in older systems.

DLT's security advantages are similarly impressive. Traditional international commerce systems, which frequently rely on centralized middlemen, are vulnerable to fraud,

paperwork problems, and illegal data tampering. In contrast, blockchain's decentralized nature protects the integrity and immutability of transaction records, making it a more secure option [17]. Blockchain uses cryptographic methods and consensus procedures to create a secure, transparent, and verifiable record, increasing confidence among trade participants.

DLT provides considerable cost reductions by automating operations that were formerly handled by middlemen. Digital trade finance platforms, which leverage blockchain for document verification and transaction processing, have been shown to drastically reduce the cost of cross-border trade [7]. The need for multiple intermediaries, such as banks and clearinghouses, is diminished, as DLT enables peer-to-peer transactions, cutting down on administrative overhead and transaction fees. Furthermore, automating document verification minimizes human error and the requirement for manual labor, cutting overall operating expenses [8].

Transparency is another important area where DLT surpasses traditional trading systems. In traditional international trade, visibility is frequently limited, with information silos and data transmission delays causing uncertainty and inefficiency. In contrast, blockchain provides real-time access to transaction data for all supply chain actors. By establishing a single, immutable source of truth, stakeholders such as suppliers, customs authorities, logistics providers, and purchasers can follow the status of items, shipments, and payments in real time. This increased transparency promotes responsibility and confidence, lowering the risk of conflicts and fraud [15]. In conclusion, a comparison of DLT-based systems with conventional international commerce systems shows how blockchain significantly improves efficiency, security, cost-effectiveness, and transparency. By resolving the long-standing issues that have impeded the movement of products and information across borders, DLT has the potential to completely transform the global commerce scene, as seen by the success of platforms such as TradeLens. With efficiency, security, and transparency as top priorities, the move to digital, decentralized solutions holds promise for the future of global trade.

It is clear from the data in Table 1 that several facets of international trade are greatly improved by distributed ledger technology (DLT). The contrast highlights the greater security, efficiency, and transparency provided by DLT-based systems, including Maersk's TradeLens, which has significantly shortened customs clearance times [17]. Additionally, DLT platforms automate document verification, which streamlines procedures and significantly lowers costs. By using a blockchain-based trade platform, for example, Dubai Customs was able to improve stakeholder communication and document verification while cutting clearance times by as much as 50%. In a similar vein, the Marco Polo Network reduces the danger of fraud by providing a digital ledger that cannot be altered, hence enhancing security in trade finance. Processing times for letters of credit have drastically decreased from a week or longer to less than a day, which has reduced paperwork and administrative expenses, all thanks to Contour's digital system. VeChain's real-time monitoring, meanwhile, provides an extra degree of confidence by enabling all parties to confirm the origins of items and their authenticity. When taken as a whole, these developments demonstrate how distributed ledger technology (DLT) can at last address some of the tenacious inefficiencies that have long hampered international trade.

3.3. SWOT Analysis for BCT Implementation in International Trade

The potential of blockchain technology to alleviate inefficiencies in a number of industries, especially international trade, has attracted a lot of attention. The purpose of this section is to present the SWOT analysis of the use of blockchain technology in international trade. We evaluate the potential for blockchain to transform trade processes by looking at its advantages, disadvantages, possibilities, and dangers. The technology's implementation

readiness and its potential to increase international trade's efficiency, transparency, and security will be discussed in this analysis [16].

Table 1. Comparison of traditional trade systems and DLT-based systems in international trade.

Aspect of International Trade	Traditional Challenges	Impact of DLT
Efficiency	High delays due to paperwork and manual processes.	30% reduction in customs clearance times, faster processing.
Security	Vulnerable to fraud and errors in document handling.	Blockchain ensures immutability and tamper-proof records.
Cost	High costs due to intermediaries and manual verification.	Reduced transaction costs through automation and fewer intermediaries.
Transparency	Limited visibility into the supply chain.	Real-time visibility and tracking of goods and payments.

- Strengths

The capacity of blockchain technology to improve transparency and lower fraud in global trade is one of its many strong points. Blockchain's decentralized and unchangeable structure guarantees that transactions are documented in a safe, traceable way, reducing the possibility of fraud and illegal record-keeping changes. One of the issues facing international trade is document fraud and manipulation, which has an important impact on global trade. The technology of blockchain has shown significant improvements in making the trade process more efficient and transparent by enhancing visibility for stakeholders and promising the accuracy of transaction data, as shown by Maerk's TradeLens system. The inefficiencies linked to conventional systems that depend on manual verification and paper documentation are decreased by this increased openness [7].

Additionally, the ability of blockchain's smart contracts to automate transaction execution leads to quicker and more effective trade settlements. These advantages are particularly noticeable in the trade finance sector [18], where blockchain technology has been used to cut down on the time and expense of processing and certifying trade-related papers [9].

- Weaknesses

Despite its benefits, blockchain technology has certain disadvantages that keep it from becoming extensively embraced in international trade. One major issue is regulatory uncertainty around the use of blockchain, particularly for cross-border transactions. Varying countries have varying rules and regulations on digital currencies, smart contracts, and blockchain-based solutions, which complicates worldwide interoperability. According to [6], the lack of defined legal frameworks and governance structures hampers the integration of blockchain into conventional trade operations. Regulatory approaches to blockchain in commerce vary greatly among countries. The European Union pushes blockchain integration through projects such as EBSI, but China enforces cryptocurrency limitations while encouraging blockchain use in commerce. The United States and Singapore have clear frameworks to facilitate adoption, but nations like India have obstacles owing to ambiguous rules. Developed governments, such as the United Kingdom and Canada, promote blockchain through favorable policies, but underdeveloped countries have infrastructural and expertise challenges.

- Opportunities

Blockchain has the ability to revolutionize global trade. Blockchain integration with the Internet of Things (IoT) presents a significant possibility to improve supply chain automation and enable real-time tracking of items. Blockchain enables IoT devices to monitor inventory levels and update them quickly by securely storing and transferring

data, which will result in more accurate and timely trade processes [10]. By reducing the number of agents in financial systems, this technology has shown an improvement in the need for expensive and ineffective traditional banks. Digital currencies can provide an alternative for payments and even reduce transaction costs, helping the enterprises break into untapped markets.

Blockchain-based trade finance solutions, as mentioned in [8], can create new funding opportunities in areas where traditional banking infrastructure is scarce, thereby fostering economic inclusion.

- Threats

Furthermore, a number of blockchain-related issues might preclude its broad application in international trade. One of the biggest risks is resistance to change from established players in the trading ecosystem. Traditional players, such as banks, customs officers, and logistics companies, can be hesitant to adopt a decentralized system that contradicts their established economic frameworks. As stated in [9], these stakeholders may object to the seeming loss of control and the trust placed in the decentralized nature of blockchain.

Cybersecurity dangers are also a source of concern. Despite the intrinsic security of blockchain technology, its auxiliary infrastructure, including exchange platforms and smart contract apps, is susceptible to hacking and data breaches. The integrity of blockchain might be compromised by inappropriate use, just like any new technology. Therefore, maintaining the security of blockchain applications in commerce is essential to their long-term survival and broad adoption.

4. Challenges and Solutions

4.1. Challenges

Distributed ledger technology (DLT) has shown significant potential to change the rhythm of global trade for greater accessibility; however, there are a number of obstacles that prevent its use. Uncertainty in regulations is one of the main obstacles. Businesses wishing to integrate blockchain into their trade operations face uncertainty due to the absence of uniform legislation governing its use, particularly across international boundaries. When implementing blockchain in international transactions, there may be issues because different nations have different policies on digital currency, smart contracts, and data protection [6]. Companies are discouraged from using blockchain technologies globally due to the fragmented landscape caused by the lack of a unified regulatory framework.

Interoperability is still another major obstacle. A major obstacle to the smooth integration of blockchain into the current international commerce infrastructure is the fact that many blockchain networks now function in isolation and are unable to communicate with other platforms and systems. Inefficiencies may result from distributed ledger technology (DLT) solutions' limited scalability due to incompatibilities among different blockchain platforms [7]. In addition, enterprises, especially small and medium-sized organizations (SMEs), may encounter obstacles related to the blockchain's difficult use. Its initial costs and the need for significant resources and specific knowledge can make it difficult for enterprises without the proper resources. Furthermore, issues related to scalability arise when blockchain systems must handle high volumes of transactions typical in international trade. As blockchain networks like Bitcoin and Ethereum have demonstrated, efficiently processing large numbers of transactions remains a challenge, especially when systems are not optimized for high throughput [9].

Finally, issues about cybersecurity in blockchain-based platforms must be addressed. While blockchain's decentralized nature makes it fundamentally safe, vulnerabilities exist in the surrounding infrastructure, such as smart contracts and exchanges. The danger of

hacking and fraudulent conduct remains a key barrier to blockchain implementation in international commerce [10].

4.2. Proposed Solutions

It takes a multifaceted approach to overcome the obstacles to blockchain adoption in global trade. International regulations are developed as the initial stage. Governments and global institutions like the International Chamber of Commerce (ICC) and the World commerce Organization (WTO) ought to work together to develop uniform laws and regulations that offer clarification on the application of blockchain technology in international commerce. Businesses may confidently use blockchain technology by creating a common legal basis, ensuring that their operations adhere to global regulations [6].

Industry-wide initiatives should concentrate on developing open-source platforms and standards that enable smooth communication across various blockchain networks in order to address interoperability problems. There has been development in this area, and initiatives like the Linux Foundation's Hyperledger project, which attempts to create open-source blockchain frameworks, ought to be extended. Furthermore, in order to integrate blockchain with current international commerce systems and guarantee seamless data transmission and transaction processing, cross-platform protocols must be established [7].

The adoption of hybrid blockchain architectures is another suggested remedy to address scalability and technical complexity difficulties. The finest aspects of both public and private blockchains are combined in hybrid blockchains, which enable increased scalability while preserving the advantages of public systems in terms of security and transparency. For SMEs wishing to use blockchain technologies without requiring a large upfront investment or overcoming technological obstacles, this might be very advantageous [9].

Multi-layered security mechanisms must be put in place to combat cybersecurity attacks. This includes using cutting-edge encryption techniques to protect important trade data and conducting smart contract audits to find and fix any possible flaws before implementation. Furthermore, the dangers associated with the implementation of blockchain in global trade might be reduced by establishing more robust security infrastructures through collaborations with cybersecurity specialists [10].

5. Future Directions and Recommendations

Significant legal and regulatory obstacles that differ between jurisdictions stand in the way of blockchain technology's incorporation into global trade as it develops. Through the European Blockchain Services Infrastructure, for example, the European Union is promoting blockchain technology and fostering cross-border trade efficiency by supporting secure digital services among member states [10]. On the other hand, nations like China support blockchain technology for commerce but enforce strict laws on cryptocurrencies, making the legal environment for blockchain adoption complicated [7]. Blockchain integration in commerce and logistics is made possible by more benevolent regulatory regimes in the US and Singapore, which offer precise guidance [9]. However, building blockchain infrastructure and gaining legal acceptance for digital contracts continue to be obstacles in other countries, such as India.

These differences in regulatory frameworks emphasize how international policy alignment is essential to enabling blockchain's smooth entry into international trade. With standardized norms, uncertainty would be removed, blockchain deployment would be expedited, and international trade would grow.

When compared to other trade technologies like cloud-based systems and AI-powered platforms, blockchain's particular benefits become evident. While cloud technologies offer scalable trade management solutions and artificial intelligence (AI) may optimize trade

through data-driven decisions, blockchain is unique in that it provides an immutable, transparent ledger. Finally, the combination of these technologies may result in a more efficient, secure, and effective global trade environment.

6. Conclusions

To conclude, the technology of blockchain has been used in different fields, especially international trade, offering more than one solution to address long-standing inefficiencies and enhance transparency. However, to ensure the development of this technology, other technologies can be merged, creating an even bigger impact, like the Internet of Things and digital identity verification which have the ability to ensure additional security and transparency for stakeholders. All of these benefits satisfy the needs of international trade. This technology is a game-changer that helps to develop safer and more efficient strategies, and thus we can ensure a long-lasting global trade system.

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