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Revolutionizing International Trade: Blockchain and Beyond - Elaborating the Paradigm Shift

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Abstract

In recent years, we have noticed the significant changes that blockchain technology has brought to various industries. Initially revolutionizing finance, blockchain has now found its way into other disciplines, such as international trade. By improving transparency, security, and efficiency throughout global supply chains, this technology is transforming traditional trade practices. This article explores how blockchain and other disruptive technologies are reshaping the landscape of international trade, despite the challenges faced by global supply chains in terms of documentation, costs, and physical flows. The study demonstrates how these technologies can simplify operations, reduce expenses, and manage risks in international trade. Through a thorough analysis, the article highlights both academic authors and major multinational corporations that have implemented these disruptive technologies. Furthermore, we will discuss the acceptance of this technological revolution among industry actors, examining it through the lens of paradigm shift theory.

Keywords: Blockchain; smart contracts; IOT; International trade; the paradigm shift.

1. Introduction

By introducing blockchain technology into various aspects of international trade, such as international transportation, document management, and even international payments [1], significant improvements have been made. In this article, we will focus on describing disruptive technologies such as blockchain, smart contracts, and IoT. For our study, we will concentrate on the revolution in academic fields and major enterprises that have conducted their first operations using these technologies.

Traditionally, two items have been subjects of significant debate in international business transactions: trust and legitimacy. For example, suppliers who distrust their clients tend to rely on Letters of Credit (L/C), which incur substantial charges and are based on centralized systems to ensure trust. However, these systems increase costs and suffer from drawbacks such as slow processing, extensive paperwork between suppliers and buyers, performance issues, and vulnerability to fraud. Innovations in international trade are crucial to address these challenges, particularly for key players with better access to working capital. One of the most impacting causes that can put a company in a critical situation

where it can lose clients and even public contracts is the high prices proposed compared to other competitors in terms of public contracts. By using these technologies, we can avoid these costs. The development of trade encounters several hurdles. Firstly, the volume of transactions fluctuates due to external factors like customs duties rates and regulatory changes. For instance, if the certificate of origin is delayed and not sent to customs, we are obligated to pay duties that can be estimated at 70% of the commercial invoice [2]. Internal factors such as capital limitations and depreciation need also play a role. Secondly, integrating trade financing into global supply chains requires extensive collaboration across vendor, finance, purchasing, and IT divisions. Thirdly, incentivizing participation among stakeholders such as suppliers, consumers, and banks pose challenges due to differing profit optimization goals, which can lead to inefficiencies across the supply chain [3]. This paper presents insights from applying blockchain technology to a prototype framework for international trade processes, specifically implemented on the blockchain. It highlights the role of smart contracts in simplifying business processes and enhancing transparency. The study evaluates performance using the paradigm shift theory, which explains how these technological phenomena can transform traditional practices to ensure new models for efficiency, transparency, and security.

Methodologically, this paper combines academic research on how blockchain technology has significantly impacted various links in international trade with practical applications used by different global actors. It examines key theoretical perspectives on the disruptive technology role in transforming traditional trade practices and highlights real-world examples of companies that have successfully integrated blockchain into their operations.

By applying the paradigm shift theory [4], the study assesses how these technological advancements can lead to new models of efficiency, transparency, and security in international trade.

2. State of the art for international trade challenges

International trade plays a crucial role in a country's GDP and has been transformative over the past century, significantly altering international value chains. Notably, stakeholders have developed concerns related to international payments, the risk of proprietary transfer, and other challenges [5]. As the variety of goods and number of stakeholders increase, the complexity of the process grows. Modern supply chains involve numerous players, including raw material providers, manufacturers, shipping and transport companies, government authorities (especially customs officials and regulators), banks, fintech's,

insurance companies, Insurtech's, and consumers. The process today has become so lengthy that buyers often involve additional service providers, such as freight forwarders, quality managers, consulting firms, and chambers of commerce, to ensure operational efficiency and verify the authenticity of suppliers, thereby enhancing trust [6; 7; 8]. Consequently, the cost of operating these global networks and facilitating the flow of goods and services across sectors and economies is significantly high. As new goods enter global markets, the need for more experts grows. Additionally, documentation costs in international trade can reach up to 7% of the global trade value [9].

After the pandemic, companies have incurred unprecedented costs to ensure the authenticity of goods for customs and government compliance. Issues such as the inspection and verification of shipping containers, especially in terms of sanitary conditions, have increased expenses. Uncertainties about whether merchandise may be infected have led to more time-consuming and paper-intensive processes, including dealing with defective goods or faulty products, to ensure safety and public health [10]. Additionally, with rising consumer demand for sustainability and high-quality, affordable products, brands and suppliers must strive for fully transparent supply chains. The volatile, dynamic, and unstable business environment compels companies to innovate in order to make their supply chains more cost-effective, socially and environmentally responsible, resilient, and responsive to customer demands and market disruptions [11; 12]. The need for large-scale data processing, lack of standards, regulatory uncertainty, confidentiality concerns, and the risk of cyber-attacks are significant challenges in international trade [13; 14]. Additionally, high costs, extensive paperwork, intercultural issues, and the diversity of products, as outlined in Robert Vernon's product life cycle theory [15], also impact demand. The rotation of products between North-South country relationships, which involves shifting production from developed to developing countries as products mature, further affects market demand based on the product's lifecycle stage and production location [15].

2.1 Upstream challenges

In examining the upstream segment of international trade, key factors include the supplier's choice of raw materials, their assurance of quality, and the associated challenges. One of the most pressing concerns is identifying materials sourced through unethical or unsustainable practices, as highlighted by WTO clauses designed to ensure fair production standards. For example, issues like child labor, as seen in past practices in China, underscore the need for rigorous verification of material authenticity and origin. Tracking and verification

systems are crucial for maintaining the integrity of these materials. With the increasing diversity of products and suppliers from different countries makes the impact of intercultural problems would impact the decision-making process such as hierarchical versus egalitarian structures, even ensuring consistent quality and reliability of data becomes more complex. Blockchain technology, as will be discussed in the next section, offers potential solutions to these challenges by enhancing transparency and traceability throughout the supply chain of an operation between two countries so the emergence of new ways is something crucial to avoid such problems and by this to enhance the whole operation.

2.2 Production challenges

When we talk about production, we're looking at how raw materials are turned into finished products, and this can get even more intricate when semi-finished products are involved. For example, in industries like aerospace, a single airplane is assembled from millions of parts produced in over 20 countries. Each factory involved in this process needs to ensure that their parts are made to exact specifications so the final product works perfectly.

In international trade, manufacturers and distributors have to be extra careful. They need to check that the components they receive meet global standards and regulations. This includes getting the right certifications and licenses from national organizations to ensure that products can cross borders. If a product is supposed to be sustainable, suppliers must provide proof to back up these claims.

Maintaining high standards and managing the flow of materials can be challenging. Issues like delays, bottlenecks, or overstocking can impact production efficiency and costs. Effective scheduling, transportation, and inventory management are essential to keep things running smoothly.

2.3 Downstream challenges

The downstream phase of international supply chains involves the transportation of components or finished products to their final destinations, whether for use or sale, and ensuring delivery to end users, be they businesses or consumers. This phase also encompasses the "aftermarket," where products are resold or recycled. The intricacies of transport and logistics pose significant challenges, with transportation itself standing out as a major hurdle in downstream supply chains. Verifying proper handling during shipment and preventing theft or counterfeit replacements are persistent difficulties [16; 17]. Moreover, coordinating shipments across long distances and

multiple jurisdictions require extensive collaboration among various companies and regulatory bodies.

In the retail and aftermarket sectors, consumer demand for proof of origin and authenticity is escalating, particularly for luxury or high-value goods, highlighting the importance of ensuring the quality and source of purchases [18]. Sustainability presents another formidable challenge in the downstream supply chain. There is a pressing need to promote recycling and reuse of products, driven by the increasing prominence of "green trade" valued at approximately \$1 trillion annually in global environmental goods and services markets [19]. However, achieving sustainability across global supply chains necessitates enhanced traceability and transparency, areas where many consumer goods manufacturers have yet to achieve comprehensive integration.

3. Disruptive technology-based international trade application framework

3.1 blockchain technology

Blockchain is a large, secure digital ledger that records every action, such as transactions, in the form of blocks linked together in a chain. Each transaction is verified and traceable by multiple computers (nodes) in a decentralized network, making it nearly impossible to modify or delete. This transparency ensures immutability. Every manipulation is notified to all participants, called nodes, in this technology. It is secured by an algorithm based on hashing and encryption through a consensus mechanism [20].

Many prominent authors have analyzed blockchain and provided strong definitions. Starting with Nakamoto (2008), who defined it as "a public ledger containing information on every transaction made within a P2P system" [21]. Swan (2015) described it as a global platform that acts like a register for tracking both tangible and intangible asset transactions, entitled by tokens, enabling easier asset tracking, improved communication, and information sharing [22]. Casota (2018) characterized it as a decentralized registry with no central authority, allowing parties involved in a transaction to store specific information about its initiation and development. This information is encrypted using mathematical formulas where each formula authenticates and validates another, ensuring data security [23]. Tapscott & Tapscott (2016) described it as a global registry maintained on computers provided by volunteers worldwide, with each client on the network receiving an updated and validated copy of the data [24]. Where all of them have common points that the blockchain will enhance all the operations between all concerned stakeholders to get done with their part easily, in a secured

way, without centralized oversight, which means they will gain more time and generate fewer costs.

The power of this ledger lies in the fact that it is decentralized and disintermediated, meaning no central authority is needed to oversee operations; it eliminates the need for higher authorities, such as governments or banks. Powered by consensus, it has the power to accept or reject transactions among nodes rather than a central institution. This consensus works by requiring agreement from the majority of distributed nodes, making it extremely difficult for a single entity to alter the blockchain without detection, ensuring immutability and enhancing trust, as information in the system cannot be modified or deleted. That's why blockchain is a game-changer for international trade and for every stakeholder, where data and operations are openly shared and accessible among nodes[25]. Additionally, blockchain ensures enhanced security through advanced cryptographic techniques that protect data from fraud and unauthorized access. Furthermore, blockchain promotes efficiency and cost reduction by automating processes and removing intermediaries, significantly decreasing transaction times and costs. Smart contracts leverage these blockchain characteristics; how and why will be discussed in the next section.

3.2 Smart contracts

The concept of "smart contracts" actually predates both Bitcoin and blockchain technology. In 1994, Nick Szabo introduced the idea of smart contracts as digital protocols designed to enforce predefined terms of an agreement, including aspects like payment, confidentiality, delivery methods, and compliance, all without the need for trusted intermediaries such as banks, thus minimizing exceptions [26]. He states that smart contracts are predefined clauses agreed upon by all stakeholders, written into code and automatically activated by the blockchain when conditions are met. This eliminates the need for any higher authority and reduces the reliance on paper documentation and physical cash.

In 1997, Nick Szabo presented the concept of smart contracts, describing them as "the combination of protocols with user interfaces to ensure structured and secure network connections" [27]. This description highlights the complexity and efficiency of smart contracts, which are automated and based on the agreements of stakeholders. Each stakeholder presents their own clauses, which are then transformed into protocols. Compliance with these terms leads to the automated execution of the contract within a legal, economic, and technological ecosystem.

Szabo's original idea aimed to automate processes, reducing the need for intermediaries such as banks and government authorities [26]. This approach has the potential to streamline operations by minimizing reliance on traditional paper documentation and manual oversight. However, the acceptance of this technology by stakeholders remains a significant challenge.

The development of smart contracts continues to evolve, requiring interdisciplinary research to address the challenges and opportunities they present. As they integrate further with blockchain technology, smart contracts are expected to significantly impact legal and economic transactions. Integrating IoT with those technologies enhances their functionality by enabling real-time data-driven automation.

3.2 Internet of things

The internet of things (IoT) is an advanced technology mostly used in the industry and it has contributed greatly to modern international trade. The term "The Internet of Things" was introduced in the 1990's by Kevin Ashton, who was a co-founder of the Auto-ID Laboratory at MIT. He called it this in reference to a structure that bridged the gap between the World Wide Web and the physical world using ubiquitous sensors like RFID tags [28]. Because it can be easily applied to many business processes, IoT holds the most promise for businesses generally speaking [29].

IoT architecture is usually characterized by three layers including perception layer, network layer and application layer [30].

Perception Layer: This refers to what is firmly established as the bottom layer of IoT architecture which primarily concerns data collection and securing measurable characteristics from surrounding environment through various sensors' actuators as well as smart devices.

Network Layer: This layer is responsible for transmitting the data collected from the perception layer to other network devices, servers, and applications for further processing.

Application Layer: It is the topmost layer that provides service-specific applications to users in order to improve IoT with more knowledge. Programs and modules for accessing real-time data are contained on this layer.

Foreign trade in IoT has significant influence. The system of supply chains across the globe is made safer, better organized and more productive by providing instant information about location, condition, and handling of goods. It also makes possible a much-improved inventory management besides

minimizing chances of losses or products being stolen while they cross borders. Furthermore, this technology helps in tracking of parcels within exact timeframes as well as compliance with international policies. Additionally, Internet of Things encourages better inter-communication hence coordination between business partners leading to simplification of procedures for exchanges and strengthening business ties.

4. The theory of the paradigm shift

The concept of a paradigm shift, as defined by Thomas Kuhn in *The Structure of Scientific Revolutions* [31], refers to a radical transformation within scientific disciplines. This involves changes in beliefs, fundamental concepts, thought patterns, and practices within technological and social systems [32]. In the world of international trade and supply chains, blockchain technology is bringing about such a transformation, moving away from traditional methods of intermediary finance to a more transparent and automated payment ecosystem. By decentralizing transaction verification, which has traditionally been managed by centralized authorities like banks, blockchain is shifting us from centralized processes to a more distributed, collaborative network.

Traditionally, international trade finance has faced many inefficiencies. Heavy manual processing and the slow delivery of trade-related documents have led to decreased real-time traceability and more uncertainty during shipping. Traditional mechanisms like Letters of Credit (L/C) heavily rely on trusted intermediaries such as banks. However, blockchain innovations are poised to reengineer these processes, offering enhanced validity, auditability, and disintermediation in trade transactions [33].

In today's business operations, blockchain-enabled solutions can streamline document digitization with their immutable functionality, unlike the traditional paper-intensive methods. This promises significant cost and time reductions in financial processes. It facilitates the automatic execution of business logic via smart contracts, minimizing human intervention to reduce errors and prevent malicious manipulation. The consensus mechanisms that underpin blockchain technology further support distributed networks, reducing intermediation and improving interaction efficiency between trade counterparties.

But blockchain's impact goes beyond just trade finance. It enhances the entire supply chain management process by providing end-to-end visibility and traceability of goods. This increased transparency can lead to more efficient inventory

management, better compliance with regulatory requirements, and the ability to quickly address issues within the supply chain. For example, using blockchain to track the origin and journey of perishable goods can significantly reduce food waste and enhance consumer safety by ensuring that products are genuine and have been stored and transported correctly.

In essence, blockchain technology holds great promise in revolutionizing international trade and supply chain management by enhancing transactional transparency, security, and efficiency. By leveraging decentralized networks and smart contract automation, blockchain creates a more streamlined, secure, and transparent ecosystem for financial transactions, driving overall efficiency improvements across global trade operations.

In the next sections, to reduce the gap between theoretical literature and practical applications, we will examine both academic research and actual business practices in international trade. By describing a set of case studies that have used these disruptive technologies as remarkable solutions at various stages of international trade, and juxtaposing these findings with academic perspectives on the technology's potential and challenges, we will enhance our holistic understanding of how blockchain benefits the international supply chain.

5. Case studies

Blockchain technology has captured significant interest in academic circles, with numerous review papers exploring its applications from diverse perspectives. [34] those authors had provided a foundational review detailing how blockchains and smart contract's function, along with their potential benefits and drawbacks. Meanwhile, [35] in this article they studied some issues in equity crowdfunding in China, proposing blockchain as a viable solution.

In the realm of supply chain management, [36] delved into how blockchain could revolutionize the sales channels supply chain practices. [37] they proposed a new supply chain mechanism by integrating IOT and blockchain solutions, identifying current disruptions and suggesting future research directions. [38] and even they have also analyzed the role of social IoT in the supply chain to achieve greater transparency, conducting statistical methods to enhance their results. Studies have explored blockchain's applications in various international sectors, including transportation [39][40], security [41][42], food traceability [43][44], agriculture [45][46], healthcare [47], and power systems [48]. Each study provides unique insights into how blockchain can improve efficiency and transparency across these global sectors.

Astarita et al. [39] conducted a bibliometric analysis highlighting blockchain's impacts on international transportation logistics and smart city management. Jabbar et al. [40] focused on blockchain's applications in intelligent transportation systems, particularly in the context of the Internet of Vehicles. Feng et al. [41] addressed global privacy concerns related to blockchain technologies, proposing cryptographic solutions. Galvez et al. [43] and Feng et al. [44] explored blockchain's role in ensuring food traceability and authenticity on a global scale.

Antonucci et al. [45] and Kamble et al. [46] reviewed blockchain's applications in global agriculture, emphasizing the importance of supply chain visibility and sustainable practices. De Aguiar et al. [47] discussed blockchain's potential in international healthcare, particularly in managing medical information and facilitating secure data sharing. Di Silvestre et al. [48] provided insights into blockchain's applications in global power systems, highlighting technological advancements and future opportunities.

Several major multinational corporations have embraced blockchain technology to transform their international trade operations, showcasing widespread acceptance among stakeholders. For example, Maersk teamed up with IBM to create the TradeLens platform, which digitizes the global supply chain, making shipping operations more transparent and efficient [49]. Stakeholders in the shipping industry, including port operators, customs authorities, and logistics providers, have welcomed this innovation, appreciating its potential to streamline operations and reduce costs.

Walmart, in partnership with IBM, uses blockchain for food traceability through the IBM Food Trust network. This system tracks food products from farm to table, enhancing safety and reducing waste [50]. Suppliers, retailers, and consumers have embraced this change, recognizing the increased transparency and accountability it brings to the food supply chain, ultimately improving food safety and reducing recalls.

HSBC has been a pioneer in trade finance with its Voltron platform. This blockchain-based solution streamlines and digitizes the issuance of Letters of Credit, significantly cutting down transaction times and costs [51]. Banks, importers, and exporters have responded positively, appreciating the enhanced efficiency, security, and reduced processing times it offers.

These examples illustrate how stakeholders across various sectors have accepted and embraced blockchain technology, recognizing its potential to significantly improve transparency, efficiency, and reliability in international trade.

The enthusiastic adoption by key players underscores the transformative impact blockchain is having on global commerce.

5. Limitations

Blockchain technology faces several challenges when applied to international trade. For one, interoperability is a major issue, as different blockchain systems often operate using their own protocols, making it tough to ensure smooth data exchange across various platforms. Scalability is another hurdle, with blockchain networks sometimes struggling to handle high volumes of transactions quickly and cost-effectively. The integration of technologies such as AI and IoT with blockchain adds another layer of complexity, as combining these technologies requires careful planning and coordination. Real-time data processing is also problematic, as the immutable nature of blockchain can delay the immediate updates needed in fast-paced trade scenarios. Additionally, legal constraints create barriers, including challenges related to regulatory compliance and varying data privacy laws across different countries, which complicates the broad adoption of blockchain in global trade.

6. Conclusion

The implementation of blockchain in the international trade would be a huge and a significant change that even going to a huge revolution by assuring trust, transparency, and efficiency. If blockchain is applied in this type of operation.

In this type of platform, documentation, payments, and traceability can be assured, that demonstrates significant potential for reducing costs, enhancing security, and streamlining operations. By leveraging the decentralized and immutable nature of blockchain, actors can take the advantage of increasing trust between the actors and to reduce reliance on intermediaries such as banks, thus minimizing risks associated with fraud and inefficiency.

Those disruptive technology like blockchain technology, coupled with smart contracts and the Internet of Things (IoT), offers a comprehensive solution to the complexities of international trade especially in the main parts such as transportation, negotiations and even with respecting the predefined clauses between the buyer and the vendor. Smart contracts automate and enforce agreements without the need for intermediaries, while IoT devices provide real-time data on the location and condition of goods, further enhancing transparency and efficiency that means with this technology we can the whole image from the exit of the good from the vendor until the buyer stock the good in his own facility.

The case studies of multinational corporations such as Maersk, Walmart, and HSBC prove how the practical application of blockchain adoption in international trade can be a major changing. These examples highlight how blockchain can enhance the operations, from improving traceability to streamlining trade finance processes, ultimately leading to more efficient and secure trade practices.

However, the widespread adoption of blockchain technology in international trade is not without challenges. Regulatory uncertainties, high implementation costs, and the need for industry-wide standards pose significant barriers. Additionally, the integration of blockchain with existing systems requires substantial investment and collaboration among various stakeholders.

Despite these challenges, the paradigm shift brought about by blockchain technology is undeniable. As more companies and industries recognize its potential, the adoption of blockchain is expected to accelerate, leading to a more transparent, secure, and efficient global trade ecosystem. Future research and development should focus on addressing regulatory and technical challenges, promoting interoperability, and fostering collaboration among stakeholders to fully realize the transformative potential of blockchain in international trade.

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