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Review

Blockchain in trade finance: The Good, the Bad and the Verdict

Tarik Kellaf [1]*

[1] Laboratory QUALIMAT-GRTE, Faculty of Economics, Law and Social Sciences, University of Cadi Ayyad, Marrakech, Morocco
* Correspondance: e-mail: kellaftarik@gmail.com

Abstract: This study explores the potential of blockchain technology to optimize trade finance processes and to address inefficiencies and fraud risks in centralized systems that contribute to a growing global trade finance gap, particularly affecting SMEs. Through documentary analysis and the case of Morocco's OCP Group, with insights for practitioners, we explore the benefits and challenges of integrating blockchain into trade finance. Our findings suggest a hybrid solution integrating blockchain into existing infrastructure, relying on both off-chain and on-chain governance mechanisms in smart contracts. This approach aims to bridge the gap between traditional and blockchain solutions in trade finance and discusses the potential for a more pragmatic way forward for the industry.

Keywords: blockchain; trade finance; smart contracts; letter of credit; factoring; supply chain; trust; transparency; cost; scalability; security; regulation

1. Introduction

The financial landscape is profoundly transforming in an era of rapid technological advancements. Trade finance, a critical component of global commerce, is crucial in facilitating international trade by providing the financial infrastructure and instruments to reduce risks and improve liquidity. However, it is traditionally plagued by inefficiencies, high costs, and a lack of transparency. Integrating new and innovative technologies becomes imperative, and enterprises constantly seek ways to improve productivity and gain competitive advantage. Among these technologies, blockchain stands out as a revolutionary force and the most disruptive, capable of reshaping trade finance processes. However, despite advancements in this technology, there remains a lack of comprehensive studies addressing how blockchain can specifically enhance trade finance operations.

This study explores, through documentary analysis, the potential of blockchain to optimize trade finance processes, which have traditionally relied on inefficient, paper-based systems involving multiple stakeholders. Our findings reveal that blockchain offers significant benefits for trade finance, including reduced cost and time, increased efficiency, transparency, and security. However, its implementation faces several challenges that hinder widespread adoption in banking sector operations with its decentralized distributed ledger architecture.

The key contribution of this research is to propose a hybrid solution that integrates blockchain technology into existing banking systems for trade finance. This approach addresses the limitations of traditional methods and pure blockchain-based solutions, offering a pragmatic path forward for the industry. We also explore how OCP's Moroccan Group has used blockchain in one of its trade finance operations and how this technology can improve SMEs' access to trade finance by removing barriers and paper-based processes.

Our study aligns with recent developments in the field, such as implementing blockchain-based trade finance platforms by major banks while providing a more

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nuanced approach to overcoming technological and regulatory hurdles. By proposing this hybrid solution, our study addresses the gap between on-chain and off-chain governance regarding smart contracts' use and primary impact. It provides a potential pathway for banks to realize the promised benefits of blockchain technology, as described in the literature review.

Delahaye (2015) describes the distributed ledger of blockchain technology as "a huge notebook, which everyone can read freely and for free, on which everyone can write, but which is impossible to erase and indestructible"; with this characteristic, blockchain technology possesses the capability to transform trade finance through the resolution of inefficiencies and obstacles encountered within conventional paper-centric systems. It can diminish friction while offering benefits like efficiency, transparency, collaboration, and auditability (Neelika et al., 2020; Shuchih et al., 2019). Integrating blockchain technology with trade finance can streamline the entire process and notably decrease transaction time (Ferri et al., 2020; Kamble et al., 2020; Singh et al., 2019; Bonson, 2019). Using distributed ledgers and smart contracts, blockchain can alter the trade finance landscape and enhance financial mechanisms (Chang et al., 2019).

Smart contracts play a central role in on-chain governance, enabling the automated execution of rules and decisions without human intervention (Wright & De Filippi, 2015). This automation increases transparency and reduces the need for intermediaries, making transactions more efficient and cost-effective.

This technology facilitates automated financial decision-making and ensures the validity of transactions, which fosters greater trust and security. Platforms based on blockchain can potentially disrupt traditional finance procedures, such as payment through Letter of Credit (LC), and establish a trustless environment for participants in international trade. Prospective implications encompass the possibility of automation and restructuring financial processes within trade finance. The blockchain can alter the foundations of trust that underpin how society organizes the transfer of values. Blockchain technology, as the underlying technical infrastructure of crypto-currency, possesses qualities such as decentralization and immutability (Gao et al., 2018). Catalini and Gans (2019) argue that the idiosyncratic market design choices underlying Bitcoin go beyond mere speculation. The capability to monitor transaction characteristics, finalize transactions, and enforce agreements across a wide range of digital assets distinguishes blockchain technology as a general-purpose innovation. It mitigated the drawbacks associated with traditional trade finance, such as cost, time, and the errors involved. With its new paradigm shift based on a decentralized system, businesses can leverage blockchain in the domain of trade finance to provide an adept model and shift the business model of banks in trade finance, simplifying the end-to-end process. Blockchain technology can successfully solve the information asymmetry problem in warehousing, logistics, and supervision (M. Du et al., 2020).

In this context, the concept of a "paradigm shift," introduced by Thomas Kuhn (1962), refers to a radical change or a revolution in a scientific discipline in terms of personal beliefs, basic concepts, thought patterns, and technological or social system practices (Gutting,1980), we concur with Guo and Liang (2016) that blockchain has the potential to bring about a significant transformation in the conventional operations of the banking sector, especially in payment systems, by establishment of a decentralized and less-intermediated framework. Meanwhile, blockchain technology in logistics is believed to offer solutions to logistical challenges, which require sifting through complex trade finance procedures and exploring the restructuring of LC processes to illustrate blockchain's innovation and paradigm-shifting capabilities. With traditional processes in trade finance, many studies, such as those of McDaniel and Norberg (2019), Ciccaglione (2019), Rijanto (2021), and Sun et al. (2021), suggest that SMEs are facing increasing challenges in gaining access. Recent regulatory modifications, such as Basel III, result in heightened capital requirements for banks. Nevertheless, supply chain finance involves stakeholders beyond banks, particularly noticeable in the diverse backgrounds of supply

chain participants from various countries. Consequently, the risks associated with international trade typically encompass a wide range of challenges that firms from distinct countries or regions may confront in their cross-border trade and business activities, culminating in trustless interactions.

In the subsequent sections, we will delve into a comprehensive review of trade finance figures, SMEs' access to finance, and the benefits and challenges of blockchain technology in trade finance. We will also present a case study of the OCP Group in Morocco, illustrating a practical application of blockchain in trade finance operations. This will be followed by a discussion contextualizing these findings within the broader landscape of trade finance, concluding with implications for practice and suggestions for future research.

2. Research method

Regarding a large number of academic articles and popular press that revolve around the blockchain, we focused our attention on peer-reviewed scholarly articles and the pertinence of the information they provided to ensure the quality, credibility, and usefulness of the studies in our investigation of blockchain technology's utilization in trade finance, Certain articles, research, or even press pieces may not have been directly cited in the study. However, we were instrumental in shaping the concepts that underpinned the research.

2.1. Research strategy

This study is focused on documentary analysis of several sources such as official reports, studies, scientific articles, press articles, statistical studies, and others to provide a holistic view of the topic. This multi-source qualitative approach may help identify gaps in the literature and highlight different perspectives on blockchain's impact on trade finance. To secure the comprehensiveness of our study, a specific keyword string was employed during literature searches, encompassing terms like "blockchain in trade finance" and "decentralized finance" or "decentralized finance" (with the capital Z) to encompass articles pertinent to the innovative financial framework given the new paradigm in finance with this decentralized ledger technology. Furthermore, "Blockchain in the supply chain" was added to enhance the analysis of the supply chain's relationship with blockchain and trade finance.

2.2. Selection criteria

Stringent criteria were applied to the articles chosen, ensuring quality and relevance through methodological clarity, analytical rigor, and result validity. Only articles from reputable, peer-reviewed scientific journals were considered for our analysis.

2.3. Analysis of figures

Official data and metrics from recognized sources such as the World Trade Organization (WTO), The International Fund Monetary (IFM), The Asian Development Bank (ADB), The International Financial Company (IFC), The International Chamber of Commerce (ICC), as well as other reports.

2.4. An example case

Alongside the theoretical examination, a specific example case about using blockchain technology in trade finance in Morocco was selected. This case centered on a unique operation within the OCP Group in Morocco, a leading global phosphate derivatives and fertilizers industry entity.

2.5. Limitations

It is important to acknowledge potential limitations in this study. The selection of sources may introduce biases based on availability and accessibility, particularly regarding peer-reviewed literature, official reports, and studies versus popular press

articles. Additionally, the rapidly evolving nature of blockchain technology means that some recent developments may not be fully captured within the existing literature.

2.6. Addressing the look-ahead bias

To maintain methodological rigor and ensure the validity of our findings, it is crucial to emphasize that only information available during prediction formation was used in this study. Our exploratory research is based on empirical and documentary analysis and - in addition to the benefits of blockchain in trade finance - focuses on examining potential challenges and barriers to blockchain implementation in trade finance. By strictly adhering to contemporaneous data and maintaining a chronological perspective in our analysis, we have taken deliberate steps to mitigate look-ahead bias.

This approach ensures that our examination of blockchain's potential impact on trade finance remains unbiased. It reflects the information landscape as it existed at each relevant point, enhancing our conclusions' reliability and practical applicability.

3. Findings

Speaking at the World Trade Organization's (WTO) 2023 Annual Conference in London on 6 October, Deputy Director-General Angela Ellard highlighted the significant opportunity to improve international trade through various technological solutions, such as artificial intelligence, blockchain, and electronic customs declarations. These tools can potentially significantly reduce trade costs (WTO, 2023). According to her discourse, blockchain technology can enhance the transfer of information between companies and customs officials, thereby streamlining customs procedures. She highlighted the case of BConnect, a platform that links customs authorities of Mercosur countries, which has been praised as an innovative initiative using blockchain technology to speed up the exchange of customs information between stakeholders (WTO, 2023). The WTO (2021) suggests that blockchain has emerged as a highly efficient method in the rapid development of international trade. This assertion is based on using blockchain technology in asset management, expediting payments, and establishing robust transaction monitoring mechanisms.

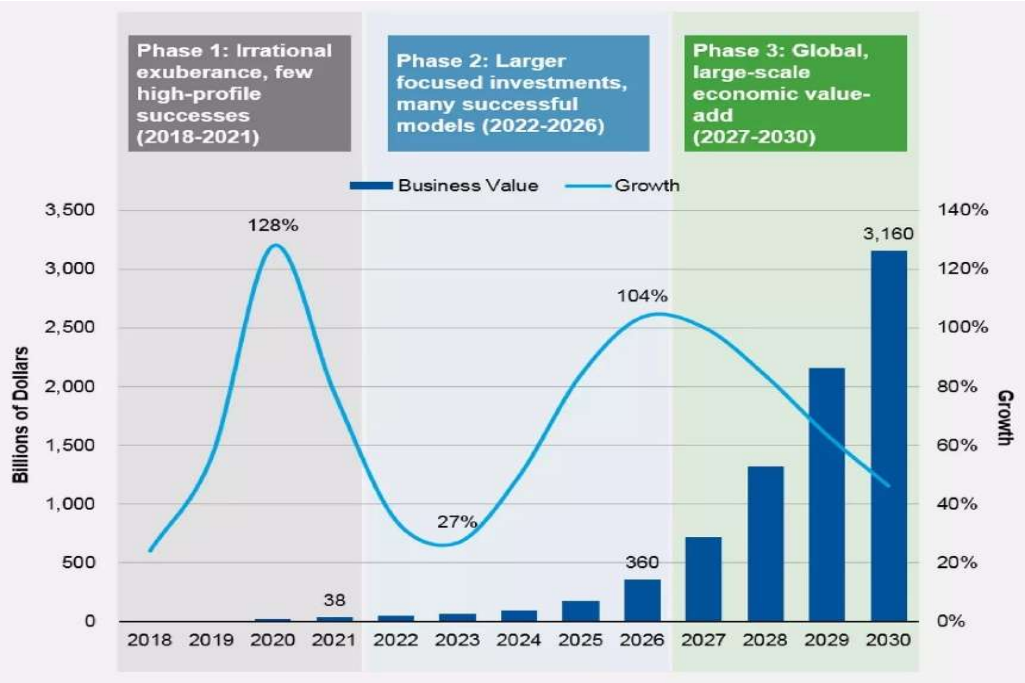
As noted by experts from the WTO (2023), blockchain is deemed to have a transformative impact on trade finance and the advancement of financial enterprises (Derindag et al., 2020; Sirimanne & Freire, 2021). According to the analysis conducted by the WTO, approximately 80% of the total financial flows in international trade are facilitated by conventional financing methods (Sirimanne & Freire, 2021). The implementation of blockchain has the potential to enhance the financing process, resulting in increased speed, reliability, and inclusivity. Numerous financial institutions recognize these benefits and integrate this technology into their operations to enhance the overall quality of their offerings. Recent research indicates that many banks are interested in using Distributed Ledger Technology (DLT).

3.1. Current trade finance figures:

*A*ccording to the analysis of Gartner experts Kandaswamy and Furlonger (2018), the project that the economic importance attributed to blockchain technology will experience a significant increase, reaching a valuation of just over $360 billion by the year 2026. Subsequently, this value is expected to experience a significant surge, exceeding $3.1 trillion by 2030, as indicated in the 2018 Gartner Trend Insight Report (Figure 1).

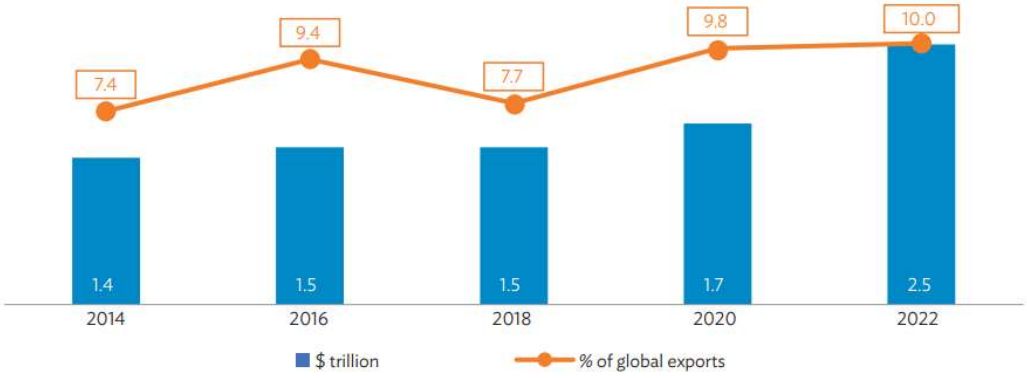
However, according to ADB (2023), the global trade finance gap is estimated at $2.5 trillion in 2022, representing a significant increase of 47% from the $1.7 trillion reported in 2020, as highlighted in its latest report (Figure 2). This increase includes the widening gap arising from the COVID-19 crisis and the corresponding escalation in the rejection rates of trade finance applications. Systemic issues related to macroeconomic factors and geopolitical tensions, including the Ukraine-Russia war, further complicate matters (ADB, 2023).

Figure 1. Blockchain Business Value Forecast, 2018-2030



Source: Gartner Report. Kandaswamy and Furlonger (2018).

Figure 2. Global Finance Trade Gap



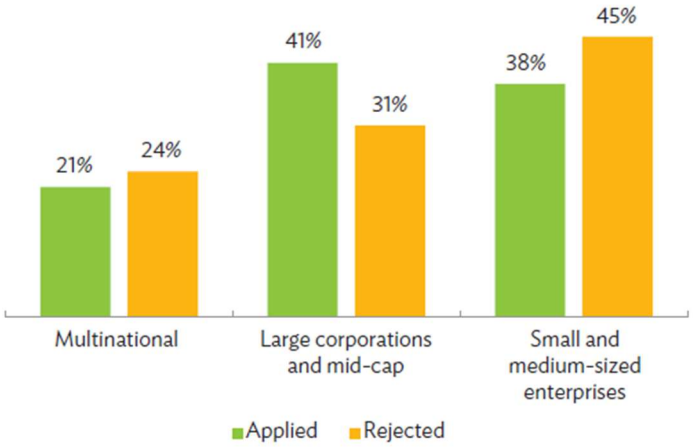
Sources: ADB. 2023 Trade Finance Gaps, Growth, Jobs Survey - Banks; and World Trade Organization.

About 20% of the banks surveyed in the Asian Development Bank's report said that some trade finance applications - meaning requests from companies for financial support to back their import or export operations - were rejected. Reasons for this included factors such as perceptions of high country risk, lack of collateral, poorly presented documentation, and issues related to know-your-customer (KYC) compliance issues (ADB, 2023) (Figure 3). Rejected applications had a more significant impact on SMEs than larger firms or Multinationals, particularly evident in 2022. In that year, SMEs accounted for 38% of the total applications submitted to banks but faced a higher percentage (45%) of rejections, as reported by ADB (2023) (Figure 4).

Figure 3. Reasons for Rejecting Trade

Source: ADB. 2023 Trade Finance Gaps, Growth, and Jobs Survey—Banks.

Figure 4. Trade Finance Application and Rejections by Major Client Segment in 2022



Source: ADB. 2023 Trade Finance Gaps, Growth, and Jobs Survey—Banks.

Grounds for rejection included perceptions of increased country risk, lack of collateral, inadequately prepared documentation, and concerns associated with adherence to KYC compliance (Figure 3).

Lack of collateral remains required for lenders who adhere to conventional credit and risk assessment methods when dealing with SME clients. SMEs often lack transaction records or established long-term relationships with financial institutions, which makes it challenging to assess their creditworthiness or risk levels. Moreover, insufficient credit or performance history further complicates the risk assessment. The prevailing market conditions also play a role in this scenario. According to the ADB's Jobs Survey (2023),73% of surveyed firms attribute the rejection of their trade finance applications to these combined factors. Also, 73% of the surveyed firms recognize the substantial enhancements in productivity and efficiency that can be attained through the digitization and standardization of trade documentation processes, including increasing rates of paperless trade (ADB, 2023). Banks also express a similar view, with more than 70% of the

bank participants intending to enhance their assistance to SMEs by leveraging technology. This aligns with the recognized benefits of digitization, as noted by banks (ADB, 2023). Over 63% of banks agree that the extensive integration of digitization facilitates regulatory compliance checks while allowing for better client profiling and risk management for SMEs (ADB, 2023).

However, the traditional approach to trade finance still has weaknesses that can be exploited, ultimately leading to inaccurate and/or undesirable outcomes. First and foremost, it is a costly and time-consuming process involving numerous follow-up steps by either the importer seeking goods or the exporter seeking payment (ADB, 2023).In addition, trust assumes a pivotal role in instances of trade taking place among entities across the globe. In today's technological landscape, the generation of manual contracts presents a notable drawback (Neelika et al., 2020). The importer sends the sales contract to its financial institution, which then checks it before forwarding it to the exporter's bank, first within the banking sector as part of a letter of credit, and at the same time within the supply chain or sometimes the factoring company; this leads to redundant but essential verifications by intermediaries, causing delays in deliveries (Neelika et al., 2020). This predicament can be categorized as a delayed timeframe. A similar scenario may unfold for the exporter, resulting in a payment deferral.

The gap and rejection rate is much greater in Africa, according to a survey conducted by the IFC (2022) on the trade finance gap in West Africa, and rejection rates for trade finance applications are high, at an average of 21 % of applications and 25 % in value terms.

Rejections fall disproportionately on SMEs, particularly those owned by women. Overall, they calculate that the unmet demand for trade finance—the trade finance gap—is around $14 billion annually for the four economies combined related to Cote d'Ivoire, Ghana, Nigeria, and Senegal. The same survey of financial institutions in the four ECOWAS4 countries revealed that trade finance supports only 25 % of merchandise trade in these countries, far below the African average of 40 % and the global average of 60–80 % (IFC, 2022).

(Nyantakyi et al, 2021) Highlighted that strict compliance measures drive up due diligence costs, which forces less-productive banks to shun the trade finance sector in Africa. Support is needed thus to minimize the cost of AML/KYC compliance. We believe that one way to do so is to consolidate the credit records of firms with interoperable credit systems that allow multiple banks to share and access records on exporters and importers in real time.

3.2. Benefits of using blockchain in trade finance:

Yaga et al. (2018) posit that trust in blockchain technology is enabled by four of its key characteristics: the use of an append-only ledger to provide an entire transactional history, a cryptographically secure mechanism, a shared ledger, and a distributed protocol that allows for the expansion of the number of nodes on the network, thereby enhancing resilience to attacks. However, other robust and effective mechanisms may also benefit trade finance.

3.2.1. Smart Contract

One of the most valuable applications of blockchain technology is the smart contract, a set of promises agreed upon by parties and encoded in software. The smart contract is executed automatically when the agreed-upon criteria are met (Morris et al., 2014).

In his paper, Szabo (1994) defines smart contracts as computerized transaction protocols that meet the conditions of a contract, reducing exceptions and the need for intermediaries. Digital cash protocols, such as online payment systems that retain the features of paper cash, serve as illustrative examples. In a subsequent publication (Szabo, 1997), the author elucidates that smart contracts, as protocols integrated with interfaces for secure network relationships, are informed by legal, economic, and technical considerations inherent to their design. The stipulations of a smart contract are initially

set forth as a mutual understanding regarding the terms of the contract. Subsequently, these terms are delineated in program code, crafted to accept specific data, analyzed following predetermined logic, and generated new information derived from the analysis outcomes. Additionally, the code encompasses directives that are automatically executed (Valeria et al., 2022).

These smart contracts are executed on a blockchain as general-purpose computations on a distributed ledger technology (DLT) (Buterin, 2014). This configuration enables the implementation of efficient, transparent, cost-effective payment flows and tamper-proof record-keeping (Roturier et al., 2017). Since 2008, there has been a notable acceleration in the advancement of this technology. As Buterin (2014) notes, a proposal for a second-generation blockchain has been put forth, enabling users to formulate more complex smart contracts. Consequently, this facilitates the establishment of automated digital protocols, such as the automatic execution of payment upon the arrival of a shipment. Once transactions have been validated, they are transformed into an immutable, auditable, enduring, and safeguarded state within the blockchain. (Swan, 2016) further supports this proposition by introducing additional attributes of blockchain technology that facilitate financial transactions.

The blockchain offers trade stakeholders a more secure, transparent, auditable, and automatic transactional environment when used with smart contracts. The underlying event-driven mechanism enables interactions between smart contracts (Swan, 2016). As de Filippi and Wright (2015) posit, blockchain may facilitate the transfer of authority from governmental regulations to code-driven protocols within decentralized blockchain networks. This may occur because trust in blockchain technology may be able to replace trust in and through the government and central authority (Kevin Werbach, 2018).

This proposal brings us to the question of on-chain and off-chain governance in smart contracts. On-chain governance refers to the decision-making processes and rules encoded directly in the blockchain protocol. In contrast, off-chain governance encompasses the decision-making processes outside the blockchain network (Wright & De Filippi, 2015).

Smart contracts can also be used in off-chain governance, and one of their key aspects is integration with existing systems. It can be designed to interact with off-chain systems and processes, bridging the gap between on-chain and off-chain environments.

3.2.2. Improving The Settlement In Trade Finance

To illustrate, the World Food Programme's blockchain-based Building Blocks system, which is employed for managing payments for food assistance to Syrian refugees in Jordan, underwent a redesign to operate on a permissioned version of the Ethereum protocol, as reported by experts from the BCG consulting firm (Philipp Bender et al., 2019). This modification resulted in a notable decrease in transaction expenses, reducing approximately 98% compared to conventional bank-dependent options (Philipp Bender et al., 2019). Many banks have initiated adopting blockchain technology, engaging in collaborative efforts to reduce financial and temporal expenditures. Examples of such initiatives include Ripple, Marco Polo R3, Corda, eTrade Connect, Voltron, and Komgi, which are engaged in partnerships with conventional banks and other stakeholders to enhance operational efficiency within the sector (ICC, 2019).

Using letters of credit (L/C) represents a prevalent method of facilitating settlements. However, a recent shift was observed favoring open accounts (Derindag et al., 2020) (Narayan et al., 2022). Nevertheless, conventional financial frameworks entail supplementary expenses (potentially reaching 1% of the transaction), which presents challenges for many companies and limits opportunities for enhanced, more dynamic development (Valeria S. et al., 2022). Instead of relying on the SWIFT system, commercial banks may collaborate on decentralized system-based cryptocurrencies such as stablecoins. In this context, the advent of blockchain technology can potentially transform SWIFT, such as its impact on the Telex system, which was previously utilized for

comparable operations (Kellaf, T, 2023). The increasing cybersecurity measures and the growing number of participants in a decentralized network provide an opportunity to introduce a payment system. It is recommended that payments related to trade financing activities be incorporated into smart contracts (Möser, M., 2014). The capacity to execute transactions on the platform will enhance the speed and efficiency of trade finance operations.

3.2.3. Reduction in intermediation costs and time

Weiyangx (2016) illustrated that the collaboration between Wave and Barclays Bank led to implementing blockchain technology within the blockchain infrastructure established by Wave, resulting in a drastic reduction in the duration of the transaction process. The typical 7 to 10 days was reduced to a mere 4 hours. Hofmann et al. (2018) and Tribis et al. (2018) offer insights indicating that blockchain has the potential to yield substantial benefits for all stakeholders involved in SCF operations. This is achieved by enhancing process efficiency and reducing the overall costs of financing programs.

Carson et al. (2018) posit that in the immediate timeframe, the primary benefit of integrating blockchain technology within organizations is the reduction of costs, as opposed to the processes of disintermediation or disrupting existing business models. Other studies by S. Benjaafar et al. (2018), D. Allen et al.(2018), A. Pinna, and W. Ruttenberg (2016) further corroborate the conclusion drawn by Carson et al.(2018). In a study conducted by The International Monetary Fund (IMF Fintech Note, 2023), the experts posit that the market maker may replicate the traditional correspondent banking model but with differences in cost and competition. The digital marketplace model reduces costs and boosts competition through a multi-ownership model. Market makers can engage in various transactions, including trading A-coins, exchanging currencies, and offsetting exposures without a reverse payment. Managing liquidity, credit, and exchange rate risks is more straightforward in the marketplace. Introducing coins as a standardized contract, open to any market maker's bidding, enhances the competitive nature of market making. The necessity for a specific bilateral relationship with issuer A is no longer a prerequisite for market makers to conduct business, thereby enhancing participation and reducing costs for cross-border payments. This is consistent with findings by Catalini and Gans (2019) and Tapscott (2016).

A study conducted by analysts at Juniper Research (2018) projected that by 2030, financial institutions worldwide would save more than $27 billion annually in cross-border settlement transactions through blockchain technology. Moreover, the study indicates that implementing blockchain-driven solutions will result in an 11% reduction in operational costs for banks (Juniper Research, 2018). These findings corroborate the assertions made by Catalini and Gans (2019) regarding the comparative benefits of blockchain networks over traditional marketplaces, namely the reduction in the cost of networking and verification. According to experts, it would be unwise to anticipate a rapid cost reduction, emphasizing the necessity of patience (Juniper Research, 2018). Incorporating existing verification methodologies alongside blockchain-based techniques will occur gradually and phased over an extended period until a unified standard is reached. The Juniper study anticipates the potential for yearly savings of $1 billion by 2024 (Juniper Research, 2018).

3.2.4. Trust and transparency

Banks serve as financial guarantors and payment operators in trade finance, with their primary objective being facilitating rather than creating and maintaining proprietary technological systems. Consequently, they initiated participation in existing blockchain platforms that exhibit characteristics such as trust, transparency, and impartiality in decision-making (Walport, M., 2015). Prominent consortiums like R3 and Fabric Hyperledger are noteworthy among these platforms, which have already introduced multiple software solutions tailored to the needs of banks and businesses. These solutions include the Corda and Digital TradeChain blockchain platforms that streamline trade

finance operations (Walport, M., 2015). It is conceivable that the blockchain could also enhance transparency concerning transactions and supply chain traceability (Chang et al., 2019; Kshetri, 2018). Tapscott (2016) and Vigna (2015) underscore that as blockchain technology progresses, it gains the capacity to tokenize and decentralize currencies and various limited assets, thereby significantly broadening its disruptive capabilities. Blockchain can reshape the frameworks of trust that underpin the exchange of values within society.

The issue of information asymmetry among relevant stakeholders in the supply chain is addressed, reducing the costs associated with information dissemination through establishing a corporate information infrastructure. Consequently, implementing an online supply chain financial framework provides an efficient and expeditious avenue for funding or delivering additional financial products to supply chain businesses (Z. Li et al., 2019; Bohannon, 2016).

Benton et al. (2018) emphasize blockchain technology's advantages in establishing provenance. The authors delineate the historical challenge of creating a cost-effective and trustworthy information pathway, a hurdle that can be overcome by adopting blockchain-generated records. Furthermore, the scholars underscore the strategic advantages arising from the operational efficiencies provided by blockchain systems, including the detailed nature of the data, which can prove invaluable in supply chain management.

Returning to the smart contract, its transparency and immutability have been highlighted as key benefits of on-chain governance. All network participants can verify the terms and execution of these contracts, ensuring complete transparency in decision-making processes (Wright & De Filippi, 2015). This feature is particularly valuable in Decentralised Autonomous Organisations (DAOs), where smart contracts facilitate collective decision-making by voting on proposals using governance tokens.

3.2.5. Enhanced security and fraud prevention

The blockchain's underlying protocol enables participants to monitor and document transactions and assets without relying on a centralized trust institution like a bank. Blockchain networks can create proof of ownership throughout the end-to-end trade finance process with digital signatures that rely on encryption keys known only to authorized members. This reduces the potential for fraud and collusion (Satoshi Nakamoto, 2008).

Security is a widely discussed aspect of blockchain and often ranks at the forefront of any enumeration of benefits that this technology may offer to a particular sector. The trade finance industry currently relies on many communications and documentation exchanges between various entities, predominantly through email and traditional paper-based procedures (Toorajipour et al., 2022). This situation is particularly vulnerable to exploitation and cyber threats. Recently, there has been an increase in illicit financial activities linked to international trade, which emerged to support radical organizations and their activities. The security provided by blockchain technology is derived from its encryption capabilities and the immutable characteristics of data retention (Shelley, 2020).

Transactions are grouped into blocks and then subjected to a verification process conducted by a distributed computing network before being appended to the blockchain. Subsequently, the block is assigned a hash value and a timestamp and is integrated into the blockchain. Consequently, the data becomes tamper-proof, necessitating the alteration of all succeeding blocks and the cooperation of the majority of the network for any modifications (Martinez-Rendon et al., 2022). Moreover, the deployment of smart contracts has the potential to automate the monitoring and enforcement of terms within a trade agreement. All these aspects collectively result in trade finance operations being conducted on a highly secure platform resilient against the industry's prevailing threats.

3.2.6. Blockchain in the Supply Chain

The theories of information asymmetry and principal-agent posit that the entities involved in SCF selectively disclose their advantageous information during business collaborations, leading to a lack of comprehensive business information (Sappington et al., 1991). The efficiency of capital flow and logistics in the supply chain is contingent upon the complete exchange of financial information and its trustworthiness. The predominant challenges currently facing SCF can be attributed to the inherent credit risk associated with it. The extant supply chain financial framework is beset with difficulties in acquiring reliable data and mitigating risks. It is, therefore, imperative to establish a platform that facilitates data sharing to address these issues.

One of the key factors contributing to blockchain technology's efficiency in the context of supply chain management is its capacity to enhance traceability (Zhang et al., 2021). Utilizing blockchain technology in the context of supply chain management enhances traceability by providing an immutable record of transactions and the movements of goods (Zhang, 2020). Mao et al. (2018) consider that the blockchain can be conceptualized as a system that extends beyond its primary function of enhancing traceability to bolster the effectiveness of supervision and management in a food supply chain. The system collates traders' credit assessment text through smart contracts on the blockchain, employing machine learning algorithms to perform semantic analyses (Hofmann et al., 2018). CargoX (2020) provides electronic transport documents on the Ethereum blockchain, including a blockchain Bill of Lading, developed and exchanged via the platform, offering an enhanced electronic format that boasts superior reliability, security, and confidentiality while being incredibly user-friendly.

The platform Wave connects banks, carriers, traders, and other trade-related entities, obviating the necessity for creating electronic duplicates of documents, thereby enhancing trust and reducing costs (Bianchini & Kwon, 2020). As indicated in a report by McKinsey (2022), an electronic Bill of Lading could save $6.5 billion in direct costs and enable between $30 billion to $40 billion in new global trade volume.

3.3. Blockchain is used in two main instruments of trade finance

Letter of credit (L/C) and factoring. It can be significant in trade finance operations, as it provides financial security and liquidity for businesses involved in international trade. However, L/C is widely used in international trade finance (Chang et al., 2019).

3.3.1. Letter of credit-based blockchain

The estimation provided by The WTO (2016) indicates that a substantial proportion, precisely 80 %, of international trade heavily relies on trade finance or credit insurance. An essential element inherent in international trade dealings is a temporal gap between the departure of the product from the seller and its arrival at the buyer's location. In this context, exporters and importers rely on external entities to provide assurances of payment backed by collateral and to guarantee the protection of the exporter, importer, and other relevant entities in the event of damage, theft, or loss of the goods during transit. Before issuing an L/C in trade finance, banks typically require prospective clients to demonstrate a robust credit history and a healthy financial position. These requirements tend to favor larger establishments, as evidenced by The Capital Source Group (2019).

In different stages of the processes for a transaction related to an L/C and its related operations. There are various forms of risk, including fraud, that can also depend on 1) false exchanges of information;2) maintenance and record keeping, which makes it more prone to human error and lack of accountability ; 3) Custom rules that require multiple transmissions of information primarily using physical documentation mean that critical paperwork often gets lost in the shuffle; 4) Forged documents: Buyer can forge the L/C with fake bank's credential and send them to advise bank; 5) Seller ships the goods, but no payment is received; 6) Besides, the seller can forge the bill-of-lading from the shipping company without the actual shipping of goods; 7) Bill of Lading can be made by using

fake names for carriers or shipping companies; 8) Delayed timeline: The international shipping industry carries 90 % of the world's trade in goods and still relies on paper documentation (Subramaniam, 2020). The process would take days and weeks to complete, involving multiple parties in each L/C-related transaction. That is why the distributed data shared by all stakeholders and its immutability (Crosby et al., 2016; Lu, Y, 2018; Viryasitavat et al., 2018) may reduce significant risks and prevent them, and the digitization of paper-based documents on a blockchain platform will indeed reduce time consumption and the carbon footprint.

Furthermore, implementing conventional payment techniques entails the necessity for additional documentation, which imposes an additional burden on financial transactions. Using L/C in transactions leads to the generation of additional documentation, which in turn necessitates the involvement of at least a dozen personnel from banking institutions (Valeria S et al., 2022). Several institutions have sought to streamline these procedures by converting documents into a digital PDF format. However, this approach also gives rise to several additional challenges. The estimated cost of an electronic version of a bill of lading is approximately 15% of the price of a paper document to be transferred through the global trade shipping network (Marine Insight News Network, 2018).

Conversely, according to the UNCITRAL Law (2017), a fundamental element of a paperless trading environment, it may significantly contribute to trade facilitation. Transferable documents or instruments commonly consist of bills of lading, bills of exchange, promissory notes, and warehouse receipts (UNCITRAL, 2017). These documents could be particularly pertinent to transportation, logistics, and finance (UNCITRAL, 2017).

In the context of document presentation, a number of benefits are associated with DLT within the field of financial technology. The inherent tamper resistance of these ledgers is of critical importance in meeting the stipulations of UCP 600, particularly Article 17, which mandates the presentation of at least one original document per the credit requirements outlined in Article 9(4)(a) of the United Nations Convention on the Use of Electronic Communications in International Contracts, established in 2005 (Takahashi & Koji, 2018). Article e9 of eUCP Version 2.1 can fulfill this obligation by presenting a single electronic record, a provision that may initially seem inconsequential. However, a more nuanced interpretation reveals compliance hinges on a trustworthy guarantee regarding the information's integrity (Takahashi & Koji, 2018). Given their resistance to tampering, distributed ledgers are better equipped than centralized registries to offer such a guarantee.

According to the United Nations Economic Commission for Europe (UNECE, 2019), obtaining a letter of credit typically involves eight main steps; however, the practical implementation can exceed twenty steps without any changes (Credit Research Foundation, 2019). Each step is independent of the previous ones, with some steps requiring the repeated exchange of identical documents for authentication purposes. It is worth noting that the administrative burden associated with this process is significantly higher for SMEs than for larger companies.

A study by the US International Trade Commission (USITC, 2010) of 2,350 SMEs and 850 large firms found that limited access to credit is a significant barrier for SME manufacturing firms seeking to export or enter new markets. This constraint is also one of the top three challenges SME service firms face with similar goals (USITC, 2010). The observed shortfall can be attributed to the complicated and uncertain nature of trade finance, which often involves numerous stakeholders, which can lead to the inadequate utilization of available funds (Deloitte & ASSOCHAM, 2018).

Decentralizing operational business networks could enhance transparency, real-time tracking, and trustworthy exchanges between participants. Researchers have highlighted the importance of ensuring a sustainable business environment through sustainable finance, corporate social responsibility, and performance (Kant, R, 2016; Guo

& Liang, 2016; Tapscott, 2016). With its quality as a decentralized system, incorporating smart contracts and blockchain technology into trade finance operations alleviates concerns related to counterfeiting and unauthorized modifications (Chang et al., 2019).

3.3.2. Factoring operations

Factoring, especially (Reverse factoring), is one of the most widely used instruments within various SCF schemes and has been implemented by large corporations possessing high-quality credit ratings to alleviate the financing challenges their suppliers face. This practice entails a tripartite agreement involving a buyer (hereafter, "she"), a factor (usually a bank), and a supplier (hereafter, "he"). Within this framework, the buyer commits to ensuring timely payment of invoices resulting from transactions with the supplier to the factor, thereby enabling the factor to offer a financing solution based on approved invoices to the supplier. Suppose the supplier desires to get payment for an approved invoice before its maturity date. In that case, they can sell the relevant invoice to the factor at a discount determined by the buyer's credit rating (Lekkakos et al., 2016).

In trade finance, with invoice factoring, the factoring institution pays the invoice amount at a discount to the supplier or (in the case of a transport service) the carrier, typically within one day of the goods being shipped, and the delivery is completed to the shipper. The factoring institution collects its fee as a discount on the invoice amount. As the case may be, the importer or shipper pays the invoice amount to the factoring company, typically within 60 days after delivery of the goods (Narayanamet al., 2022). This benefits each party involved as follows:

- Buyer or Carrier: gains quicker access to money it owes soon after goods delivery.
- Supplier or Shipper: can get more time from the factoring institution to pay off the invoice amount.
- Factoring institution: earns by invoice discount.

Many suppliers opt for credit loans instead of factoring, with the initial interest rate typically between 12% and 15% (Lu Wang et al., 2022). We believe that with blockchain, this rate can decrease, and access to trade finance will become more open to SMEs. This system effectively mitigates issues related to counterfeit seals or fraudulent transactions conducted offline, resulting in a reduction of problematic financial liabilities (Lu Wang et al., 2022). The introduction of online lending services undoubtedly improves operational efficiency by allowing borrowers to access funds within the same day. With the digital nature of cryptocurrency, a factoring company could integrate the payment of funds directly into the invoice itself (Narayanan et al., 2022).

The smart contract is one of the advantages of blockchain technology that can be used in factoring. It has the potential to be an SCF solution in terms of security and transparency, where sellers, buyers, and financial institutions can copy encrypted ledger data because the distributed ledgers are guaranteed by modern cryptography (Hofmann et al., 2011; Lekkakos & Serrano, 2016). On the other hand, the factoring institution, as a provider of funds, can perform credit checks on its customers who apply for factoring and core companies using the blockchain credit management module (M. Du et al., 2020).

Blockchain technology may establish a rigorous regulatory framework by addressing the issue of information asymmetry. Regardless of SMEs' creditworthiness and the extent to which profits can be shared through collusion, the transparent business oversight built by blockchain technology effectively resolves the challenge of achieving a stable decision-making process between SMEs and financial institutions. As a result, introducing blockchain technology reduces credit risks in the SCF, promotes system stability over time, and significantly accelerates the evolution of decision-making processes. This enhanced transparency also increases the willingness of financial institutions to consider business proposals, thereby alleviating the financing constraints faced by SMEs (Sun et al., 20-21).

3.4. OCP group case in Morocco

Using blockchain in trade finance, OCP Group, the world's largest phosphate miner and leading fertilizer company, has launched a significant export operation beyond the conventional framework of international banking. On 30 March 2021, the Eastern and Southern African Trade and Development Bank (TDB) announced blockchain-enabled fertilizer trade finance transactions totaling US$400 million. At the time, USD 270 million of this amount had already been executed, with the remaining transactions expected to be completed in the coming months, according to The OCP Group (2021), as the company engages in pilot projects that demonstrate how blockchain can facilitate smoother transactions in its supply chain.

OCP Group has achieved a significant milestone by becoming the first African company to conduct an intra-African trade transaction using blockchain technology. Using dltledgers' blockchain platform, OCP Group facilitated the delivery of phosphate fertilizers from Morocco to Ethiopia. This intra-African trade endeavor, an integral part of OCP's digitizing strategy, seeks to diminish the trade finance gap in Africa and enhance inter-African trade, especially within the fertilizer industry, by embracing digital inclusivity (OCP, 2021).

According to the explanations given by OCP and dltledgers, blockchain technology enables all stakeholders to carry out the transaction digitally and complete the import-export operation in less than two hours. Equivalent "paper" transactions are typically completed in three weeks or more, the same source adds, attributing this to the time suppliers need to transfer physical documents to the buyer via the traditional banking system. "With the current slowdown in global logistics and supply chains, trade finance transactions can take up to six weeks, as border and airport closures continue to cause further delays," says The OCP Group (2021).In this transaction, the parties can upload, view, modify, and validate documents on a private blockchain simultaneously and in real time. The benefits of this technology include a low carbon footprint, transaction security through encryption and verification technologies, transparency and traceability, and risk reduction through eliminating potential errors and ambiguities in the exchange and modification of documents. In addition, the OCP points out that "transactions will take place at a time when world trade in 2020 will have shrunk by 5 to 10% compared to the previous year" (Les Ecos. ma, 2021).

Headquartered in Singapore, #dltledgers is the leading autonomous blockchain platform dedicated to digitizing trade and supply chain processes in a distributed manner. The platform facilitates the transformation of trade documents, contracts, and banking interactions for organizations, automating multi-party transactions, streamlining operations, and reducing costs. The result is faster, more cost-effective trade execution, improved collaboration between robust and auditable companies, and an enhanced ability to secure financial support.

We were invited to attend an online workshop entitled "Digitizing Supply Chains" hosted by the dltledgers team on 20 May 2024, where we explored their blockchain-based platform that integrates suppliers, customers, banks, transporters, and freight forwarders, providing comprehensive details and references about each participant. The platform provides detailed information about transactions, including orders, amounts, products, dates, invoicing, incoterms, LC applications, payments, tracking, provenance, booking, shipping, and more. It also provides various configuration options for changes, cancellations, or additions. In addition, the platform includes a discussion area for participants to collaborate. The primary tool used in this platform is the smart contract, which executes transactions and program agreements between partners (dltledgers, 2024).

The platform is only used to exchange documents and agreements, not to make direct payments or use cryptocurrencies. However, for Morocco, it is essential to specify that at the time of writing this paper, the Moroccan Central Bank (Bank Al Maghreb) continues prohibiting the use of cryptocurrencies.

3.5. Challenges and limitations of implementing blockchain for trade finance

Despite the advantages of blockchain and its exceptional characteristics, it is still an immature technology that presents well-known challenges in scalability, performance, and interoperability with other systems. Furthermore, apart from the technical hurdles, organizations face formidable management issues as blockchain applications must be assimilated into complex institutional, regulatory, social, economic, and physical systems (Lacity, 2018).

One challenge in implementing a technology such as blockchain in an industry that predominantly relies on paper-based documents in trade finance is integrating it with existing systems and infrastructure. The trade finance sector, which continues to rely heavily on paper documents, can be considered one of the least digitized industries (Burri & Polanco, 2020; Lahkani et al., 2020). Many business transactions still revolve around manual data entry into banks' back-end systems, particularly through methods such as letters of credit and other trade finance instruments. The lack of uniformity in trade finance banking systems is a notable obstacle to implementing distributed systems, as blockchain technology is most efficient in replacing systems with standardized regulations and data management practices (Gencer, 2017).

3.5.1. Integration with existing systems and infrastructure

Wegner (1996) states that interoperability is the ability of two or more software components to work together effectively despite disparities in language, interface, and execution platform.

According to the Bank for International Settlements (BIS, 2012), interoperability is a means, not an end; the aim is to enable banks and other payment service providers from different systems or jurisdictions to transfer payments so that end-users can transact with each other seamlessly, regardless of their geographical location or choice of PSP,while the opposite increases costs accordingly. Justifying this cost is difficult because trade finance can be a highly fragmented industry. Justifying these costs is complicated because trade finance can be a highly fragmented industry. This means that there are a large number of market participants spread across different global locations. These participants have varying propensities to embrace new technologies. Omarova (2020) and Zetzsche et al.(2020) argue that blockchain is the most effective system when adopted and utilized across the entire network rather than just at the intra-firm level. This means that in a scenario where only some market participants use blockchain, its usefulness is reduced (Accenture, 2018; Choi et al., 2018).

Firms wishing to use blockchain for trade finance prefer a scenario where all their counterparties and business partners use blockchain (Carson et al., 2018). In such a situation, firms could use smart contracts to automate the process and execute transactions with significantly reduced counterparty risk, with automatic enforcement if contractual obligations are not met. However, in a fragmented industry, there are fewer opportunities to reap the benefits of blockchain, as it is challenging to get all counterparties and business partners to use the technology. Therefore, a company may be deterred from using blockchain if its partners and counterparties continue to rely on traditional methods.

Efforts to incorporate blockchain technology into a diverse range of existing systems will likely result in developing a hybrid private blockchain, with higher implementation costs and lower transparency and security benefits than a complete system replacement. The result could be a fragmented blockchain that operates similarly to the current state of digital record-keeping in trade finance (Prewett et al., 2020).

3.5.2. Regulatory and legal implications

Complex legal implications are expected to be a norm for blockchain implementation in industrial systems. Trade finance, known for its strong legal framework, is particularly impacted by cross-border transactions, transshipment activities, and different national legal systems (Lehmann, 2021). The enforceability and admissibility of blockchain-based

records and smart contracts at the national level will likely depend on specific legislative measures to integrate this technology. This process will involve examining potential modifications to existing e-commerce laws, electronic transaction acts or introducing regulations tailored to blockchain technology (Kimani et al., 2020; Dimitropoulos, 2020).

Recent UNCITRAL initiatives on electronic transferable records may also become significant. The widespread use of private and permissioned blockchains may require a clear distinction from public blockchains regarding data security and integrity while accommodating the former due to its proven effectiveness. This distinction could be facilitated by establishing blockchain registries and regulatory sandboxes (Schellekens, 2017). It is important to acknowledge that the novelty of this technology and the lack of global consensus may initially lead to legal uncertainty and increased compliance costs (Zetzsche et al., 2020; Lehmann, 2021).

Global finance also requires a unified legal infrastructure to facilitate transactions across different jurisdictions, and trade finance would similarly benefit from an international approach to blockchain regulation. This type of initiative has begun in data protection and blockchain technologies, with standards such as the General Data Protection Regulation in the EU providing much-needed clarity and raising awareness of data control issues unique to the digital age (BIS, 2021).

In response to recent calls from the financial sector for coordination between blockchain governance and interoperability, bodies such as UNIDROIT and the ICC could potentially draft conventions to harmonize private international law on the blockchain or a lex mercatoria for smart contracts. This could be in addition to future soft law mechanisms and best practice guidelines from industry associations (UNIDROIT, 2021; Toufaily et al., 2021; Lasse Andresen, 2019; ICC, 2019).

3.5.3. Adoption and acceptance by stakeholders

The potential for blockchain to evolve and change in the future has raised concerns about its longevity, which may lead to reluctance to invest in the short term. In its current speculative state, firms may decide to wait for a clear understanding of the long-term direction of blockchain and its implementation for trade finance (Swan, 2015). This is from a risk management perspective, as technological change can bring both risks and rewards, and firms may wish to allow early adopters and other stakeholders to test the technology first to catch up with competitors later (Zetzsche et al., 2018).

In Deloitte's Global Blockchain Survey (2018), 'regulatory issues' - cited by 39% of respondents - were cited as the most important factor preventing companies from investing in blockchain technology (Pawczuk et al., 2018). This is because the technology introduces concepts and methods, such as cryptographic signatures and smart contracts, which are not covered by existing regulations (Schatsky et al., 2018).

Legal implications are closely related to the issue of the acceptance of blockchain systems for trade finance and the underlying criticism that they represent a complex solution when compared to existing systems and practices (Prewett et al., 2020; Kimani et al., 2020). This may result in a limited understanding of blockchain among trade finance professionals and decision-makers (Kimani et al., 2020).

However, another study by Deloitte (2020) reveals a measurable shift in attitudes towards blockchain technology, with executives and managers recognizing the practical applications and benefits of blockchain-based solutions. Organizations are moving beyond planning and actively implementing blockchain in everyday business operations.

Some concerns are that implementing blockchain systems may require different legal and regulatory changes than the existing legal and regulatory framework for trade finance. This could create a significant barrier to entry for blockchain-based systems (Kimani et al., 2020). In order to assimilate the new technology, it is predicted that the law and legal institutions will adopt what has been termed 'blockchain law,' which may take a significant amount of time to define and understand.

This law will likely aim to reduce inconsistencies between countries' legal structures for trade finance, which affect transactions between importers and exporters from different countries. Although a change in the law that promotes technology neutrality is a long-term benefit for all IT-based systems in trade finance, the Blockchain Act may seek to define what smart contracts mean in a legal sense. As they are automatically self-executing, the defined terms of smart contracts could have legal implications and change the current understanding of letters of credit and transaction settlement.

3.5.4. Scalability and performance issues

The scalability challenge in blockchain technology is a significant concern regarding its implementation in trade finance (Chang et al., 2019). Scalability issues arise from the growing volume of transactions on the blockchain network (Dicaprio & Jessel, 2018; Kshetri, 2019).

In trade finance, where numerous parties are involved in complex, multi-step processes, the scalability of the blockchain becomes crucial to ensure efficient and timely transactions (Dicaprio & Jessel, 2018; Hellwig & Huchzermeier, 2019; Dahdal et al., 2020). One approach to this challenge is sharding, which involves dividing the blockchain network into smaller, more manageable parts. As the trade finance industry seeks to leverage blockchain for its potential benefits, addressing scalability concerns will be essential for widespread adoption and success (Fridgen et al., 2021; Belchior et al., 2021; Winn, 2020; McDaniel & Norberg, 2019).

Trade finance stakeholders are increasingly exploring various technological solutions to address the scalability challenge in blockchain implementation. One promising approach is using off-chain scaling solutions such as state channels and plasma, which enable the execution of off-chain transactions while maintaining the security and integrity of on-chain settlements. These off-chain solutions can significantly enhance the throughput and efficiency of trade finance transactions on the blockchain network (Bogucharskov et al., 2018; Ciccaglione, 2019; Dicaprio & Jessel., 2018).

In addition to technical solutions, collaboration between industry participants and regulators is crucial for addressing the scalability challenge in trade finance blockchain applications. Stakeholders can establish common standards and interoperable systems by working together, essential for scaling blockchain solutions across the trade finance industry (Dahdal et al., 2020; DiCaprio & Jessel., 2018).

Moreover, advances in interoperability protocols can also play an important role in addressing scalability issues. Interoperability protocols enable different blockchain networks to communicate and transact, thereby increasing the overall scalability and efficiency of the trade finance ecosystem (Bogucharskov et al., 2018; Ciccaglione, 2019).

4. Discussion

Blockchain technology has begun to spread into the banking and finance sector, with many banks contributing to consortia to establish a blockchain platform for trade finance, such as Corda and R3. Other platforms have created banking networks, such as blockchain company Ripple, which has partnered with over 300 banks, including financial institutions such as Santander and Western Union, to improve the efficiency of cross-border payments. Its RippleNet payments network uses a decentralized infrastructure to reduce the time it takes to send an international payment to 3 seconds, compared to up to 5 days for traditional international bank transfers.

We believe it is important to see The Ripple project in its context, particularly given that the number of correspondent banks has recently declined by approximately 20% from 2011 to 2018, according to the BIS quarterly review (2020). The same review indicates that all regions have experienced a decline, not just those jurisdictions with records marred by corruption or inadequate cross-border information sharing (Rice et al., 2020). The decline of correspondent banks is a potential concern because it could lead to an increase in the costs of cross-border payments, a decrease in the diversity of products or services

available, or even a loss of access to the world banking system, which in turn could lead to greater use of informal and unregulated payment networks. R3, another major player working on DLT for banks, has seen its technology used by Switzerland's central bank for a successful pilot to settle large transactions between financial institutions using digital currencies. Nevertheless, blockchain technology introduces a secure and cost-effective method of transmitting payments, reducing the reliance on third-party verification and outperforming the processing speed of conventional bank transfers.

As a result, the volume of B2B cross-border payments via blockchain is anticipated to surge to nearly 1.8 billion by 2025, a substantial increase from the 122 million transactions recorded in 2020 (CB Insights Research, 2018).In the supply chain, blockchain can connect the ecosystems and bring together all parties on a blockchain-based platform with a secure permissions and identity framework and help to drive accurate information sharing by enabling the seamless, secure exchange of real-time supply chain information between all parties to a trade. With its decentralized nature, blockchain can ensure the container's end-to-end track, according to Louise Wiggett (2019), the WTO expert.

Nowinski and Kozma (2017) show that blockchain technology can disrupt existing business models in three crucial ways: authenticating traded goods, disintermediation, and lowering transaction costs. This will bring solutions in trade finance based on these benefits for both financial institutions and SMEs.We believe transparency is the most influential factor in solving the information asymmetry problem.

The integration of diverse, innovative solutions in trade finance presents the potential to address current economic problems, given its key role in sustaining the production cycle. The inadequacy of trade finance in supporting the renewal of working capital for SMEs is particularly striking in different regions. This situation can be partly attributed to the lack of reliable mechanisms that provide transparency to address issues related to asymmetric information (Bogucharskov et al., 2018).

In a qualitative study conducted by Toufaily et al.(2021), the respondents appeared to take a pragmatic stance when discussing the value of blockchain adoption: business process improvements (including cost reduction, standardization, increased efficiency, and transparency, elimination of errors, fraud, duplication, and waste) were the most frequently cited benefits across the sectors and by all respondents.

In the case of Morocco and its most prominent company, the OCP Group, blockchain is not only concerned with Morocco's existing banking system for trade finance. It goes beyond it to its potential foreign partner in international trade.

As a major player in the fertilizer industry, the OCP Group's enormous operations likely incur high transaction costs in traditional trade finance offered by banks. Blockchain can also streamline lengthy documentation processes in transactions such as letters of credit, which are common in international trade transactions but often involve multiple parties and complex document exchanges. By implementing blockchain solutions, OCP Group can potentially increase efficiency, reduce processing times, and improve traceability across its global supply chain and financial operations.

In fact, in recent decades, Morocco has started to work as an emergent economy with many investments in Africa, with foreign direct investments reaching over $800 million in 2021; according to the Ministry of Finance, Morocco became the second largest African investor in the continent- after South Africa - and the largest in West Africa (IFC, 2024).

However, the development of trade finance itself faces other systematic difficulties related to all stakeholders in the global market, which may be summarised in three points: Firstly, various external and internal factors influence the volume of trade financing transactions, leading to dynamic changes in the system, such as interest rates, legislation, limited capital, and the need to provide for depreciation. Secondly, there are challenges in executing trade finance across the worldwide supply chain. The process requires significant coordination between suppliers, corporate finance, purchasing, and IT. Thirdly, incentives are challenging to provide to various participants in supply chains due

to their independent profit-seeking behavior in terms of asymmetric structure, which can lead to poor overall performance.

This is why integrating off-chain governance is crucial for supply chain management, where blockchain technology must interface with traditional business processes.

Consequently, Morocco is concerned with African SMEs' access to trade finance to foster their operations and related cash flow. A subsidiary of The OCP Africa was established in 2016 to provide fertilizer solutions tailored to the region's local conditions and crop needs; it now operates in 16 countries (IFC, 2024). An alternative to the existing system to boost trade finance seems necessary for Moroccan companies and their clients in importing and exporting in Africa, especially as it is a continent with fewer banks.

The use of blockchain is not only dependent on business logic, but policy and regulation are the first moderate variables to influence its adoption; to this end, policymakers should encourage and potentially incentivize collaboration between banks, fintech companies, and technology providers to accelerate the adoption of blockchain in trade finance. By developing clear regulatory frameworks, it will be possible to address the use of blockchain in trade finance. This may include guidelines on digital signatures, smart contracts, and the legal standing of blockchain-based trade documents.

Within the political logic, cryptocurrencies, as the main application of blockchain technology, serve as a tool that the BRICS group aims to use to enhance cooperation and bring integration to a higher level, especially in light of the war trade initiated by the United States against China, as well as the economic and financial sanctions imposed on Russia due to its conflict with Ukraine, in order to isolate it from the global community (Zharikov, 2023). The subsequent impact of these sanctions, particularly in banking transactions, has prompted various stakeholders, including governments and financial institutions, to explore alternatives to SWIFT based on blockchain technology (Kellaf, 2023). According to a study published by the Congressional Research Service (2022), which belongs to the US Congress, they highlight that after this war, the Russian actors may use the "pseudonymity" of cryptocurrency to evade sanctions. The sanctions evaders may try to obfuscate their blockchain transactions and evade the measures imposed by the exchanges through some practices, such as chain-hopping, which is the process of converting one cryptocurrency into another to hide illicit funds; using unhosted wallets to move the funds; anonymity-enhanced cryptocurrencies; or using the peer-to-peer (P2P) exchanges (Congressional Research Service, 2022). However, using cryptocurrencies to circumvent sanctions remains limited and highly theoretical, as the leading crypto exchange platforms, such as Binance and Coinbase, are in the US, the leading country that imposes economic sanctions on Russia (Kellaf, 2023).

Cryptocurrencies are divided into two categories: altcoins and stablecoins. However, even the stablecoins pegged to the USD, such as USDT issued by the company Tether, USDC issued by Circle, or BUSD issued by the platform Binance, have encountered problems with dollar parity, especially after the fall of the algorithmic stablecoin known as Terra Usd (UST; Jeff Benson, 2022; Kellaf, T, 2023). This went beyond the use of cash reserves in exchange for the USDT cryptocurrency in unsecured short-term investments; only 6.36% of cash and bank deposits during the cryptocurrency crash in May 2022, which created a liquidity problem in the market, as reported by CNBC (2022) and BFM Crypto (2022), and also undermined confidence in this type of stablecoin. The collapse of some stablecoins and DeFi platforms has highlighted the challenges of conducting risk assessments today (Kellaf, T, 2023). While blockchain transactions are theoretically transparent, accurate information on macro-financial implications remains challenging.

Going back to all these blockchain-based initiatives, what we are seeing globally is that all these initiatives are not designed to replace the existing system. They are all being implemented through collaboration in joint projects rather than independently. This trend aligns with the challenges faced when implementing new digital solutions in the banking sector, where progress is hampered by the lengthy process of obtaining security approvals

(DiCaprio et al., 2018). Therefore, it can be argued that the complex interconnectivity between banks hinders rapid disruption. All existing systems are interconnected with other systems, particularly the SWIFT system in trade finance; indeed, banks cannot invest in blockchain technology without partnering with other stakeholders in the same ecosystem.

That is why the suggested implementation of the hybrid model may also synergize on-chain functionality with off-chain operations to address governance challenges. This model aims to leverage the strengths of both on-chain and off-chain governance to create more robust and flexible blockchain systems, including smart contacts.

However, blockchain is still in its infancy, and the shift expected in existing systems by blockchain tends to be costly and time-consuming. According to the latest business analytics platform CB-Insights report, CB-Insights argues that financial services leaders have not written blockchain off. However, they are not racing to deploy it either (CB-Insights, 2024). There is a need for investment in solutions that can integrate blockchain platforms with legacy trade finance systems to ensure a smooth transition and minimize disruption to existing processes.

The usefulness and suitability of blockchain in trade finance must be high enough to justify the cost of implementation. The advantage of using blockchain technology to provide a reliable guarantee over a centralized registry appears mainly due to its resistance to tampering. However, there may be limitations in some cases. The technology does not effectively prevent the inclusion of inaccurate data in the blockchain. It is important to emphasize that the most serious form of fraud in the letter of credit (L/C) relates to creating fraudulent documents rather than manipulating documents after issuance (Takahashi, Koji, 2018).

Thus, the potential use of blockchain in trade finance is still limited to the exchange of data and digital documents in operations such as letters of credit, as it lacks the settlement function with cryptocurrencies, which plays a crucial role in blockchain, including the financing and investment functions. Moreover, given that cryptocurrencies are volatile assets, such as bitcoin and other altcoins, that are beyond the jurisdiction and supervision of central banks, the use of blockchain for counter-payment purposes in trade finance is still a long way off, especially in countries that continue to prohibit it, such as Morocco, or even with a major player in international trade, such as China.

5. Conclusion

Many of the benefits of blockchain can be applied against traditional trade finance solutions. However, rather than replacing them, banks are looking for ways to integrate blockchain into their existing infrastructure as a hybrid solution to optimize processes, rather than being completely disrupted by blockchain. On the other hand, the transformation will not be easy due to the challenges posed by blockchain. Consequently, banks' gradual adoption of blockchain technology will require adapting existing systems to these new technological processes, as interoperability remains a significant obstacle. Therefore, exploring hybrid solutions that combine traditional infrastructure with blockchain technology can provide a gradual and less disruptive path to adoption. This is why many banks seek partnerships with fintech companies rather than investing solely in their information systems.

Even though the interplay between on-chain and off-chain governance in blockchain systems presents opportunities and challenges, this approach allows for integrating blockchain capabilities into existing systems, gradually moving towards a fully decentralized and efficient framework while minimizing potential disruptions to ongoing operations. It may also improve SMEs' access to trade finance, based on an efficient technology for accurately storing and sharing data about them.

In Morocco, the issue has an additional facet; mainly, the aforementioned initiative relating to the OCP Group is the only one in the country. It mainly involved the exchange of documents within a business transaction, alongside the use of the traditional existing

payment system, until the moment when the Central Bank of Morocco (Bank Al Maghreb) banned the use of cryptocurrencies altogether. Nevertheless, the collaboration between OCP Group, the Trade and Development Bank, and Dltledgers' blockchain platform is an example of the growing influence of blockchain technology in trade finance. This collaboration shows how blockchain may soon revolutionize traditional processes.

Besides commercial banks opening up to fintech startups, Moroccan regulatory bodies such as Bank Al-Maghrib (BAM) and the Moroccan Capital Market Authority (MCMA) should engage more closely with universities and higher education institutions. This collaboration would help promote financial innovation and scientific research in an underexplored yet promising area. By fostering partnerships between regulators, academia, and the financial industry, Morocco can create a more robust ecosystem for fintech development and financial innovation, potentially leading to new insights and advancements in this rapidly evolving field, especially as the Governor of the Central Bank of Morocco (BAM) announced just a few days ago, on 26 November 2024, that Morocco is moving towards regulating cryptocurrencies with a draft law. This implies that these decisions have become deterministic, and no longer simple choices, due to the continuous evolution of blockchain.

Appendix A. Abbreviations from the study

Abbreviations	
ADB: Asian Development Bank.	PSPs: Payment Service Providers.
BAM : Bank Al Maghreb.	SCF: Supply Chain Finance.
BIS: Bank for International Settlements.	SMEs: Small and Medium-sized Enterprises.
BRICS: Group of Brazil, Russia, India, China and South Africa.	TDB: Trade and Development Bank.
DLT: Distributed Ledger Technology.	UNCITRAL: United Nations Commission on International Trade Law.
ICC: International Chamber of Commerce.	UNECE: United Nations Économico Commission for Europe.
IFC: International Finance Corporation.	UNIDROIT: International Institute for the Unification of Private Law.
IMF: International Monetary Fund.	USITC: United States International Trade Commission.
L/C: Letter of Credit.	WTO: World Trade Organization.
MCMA: Moroccan Capital Market Authority.	
OCP: Office Cherifien of Phosphate.	

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