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THE APPLICATION OF BLOCKCHAIN IN VALUE CHAIN FINANCE FOR AGRO-FOOD CHAIN: A LITERATURE REVIEW AND FUTURE RESEARCH AGENDA

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ABSTRACT

This study aims to investigate the application of blockchain technology within the agro-food chain and to compare conventional value chain models with blockchain-enabled value chain frameworks. To achieve this objective, the study adopts a gray literature review approach and employs a backward–forward snowballing technique to identify and extract relevant literature. The study contributes by; 1. the characteristics, benefits, and challenges related to three forms of value chain financing (chain liquidity, involvement of value chain stakeholders, and short-term loans), 2. a visual representation of the incorporation of blockchain into the collaborative value chain design inside value chain financing, 3. it offers a comparative analysis of conventional and blockchain-based value chain financing frameworks together with the influence on the cash conversion cycle. Finally, this study inferred that the inventory holding period is a crucial factor affecting chain-level efficiency within the value chain financing framework. It also proposes the analysis of a feasible blockchain-based financial derivative in the agro-food sector employing a dynamic or stochastic model. However, the conceptual framework and disclosure related to blockchain technology lack empirical assessment, particularly concerning financial risk, cost, and viability, presenting a significant opportunity for future research.

Keywords: Blockchain, value chain finance, backward-forward snowball approach

INTRODUCTION

Blockchain is a digital and decentralized ledger that records transactions. It enhances information dissemination and generates value throughout the agri-food supply chain. It is an emerging notion that was first developed toward the end of 2008. Blockchain is a dependable and transparent connection mechanism that provides a digital solution to reduce the expenses and time associated with intermediation, eliminating the necessity for credible third-party companies (Nagano et al., 2017; Crosby et al., 2016). It enhances corporate operations and functions as a risk management tool relevant in various business scenarios (O'Brien, 2017). A smart contract within the blockchain framework serves as a consensus mechanism that utilizes a credibility score and creates a private blockchain using proof of stake (POS). A private blockchain focused on smart contracts reduces the risk of monopolistic resource control and guarantees transaction security (Watanabe et al., 2016). It reduces the costs related to diverse interoperable corporate networks (McMyn and Sim, 2017). It enables peer-to-peer automated payment systems (Huckle et al., 2016), promotes transactions of illiquid securities on a platform (Chiu and Koeppl, 2018), and diminishes value chain costs (Casado-Vara et al., 2018).

Conversely, VCF denotes the short-term borrowing and exchange of items within a supply chain. It influences corporate profitability (Yu and Rehman, 2022), liquidity (Appuhami, 2008), and serves as a financial performance indicator (Belhadi et al., 2021). VCF is a significant factor influencing corporate social responsibility, value generation, and value-enhancing elements (Chen et al., 2023). Consequently, each actor in the chain retains a specific quantity of VCF for short-term investment decisions and effective management (Ding et al., 2011). VCF has been employed for the optimization of working capital and the reduction of costs across several industries, generating attention for both academic researchers and practitioners (Yan et al., 2016). Value chain actors seek to assume greater risk for increased profit by controlling the value chain framework to sales (Vishnani and Shah, 2007). To fulfil the objective, information dissemination is facilitated by sophisticated technology and stringent coordination along the value chain (Lee and Whang, 2000; Bechtsis et al., 2022). Moreover, the value chain of any industry comprises upstream actors (e.g., producers and suppliers), transporters, trade intermediaries, and downstream actors.

The existing value chain is intricate and has numerous hurdles, such as logistical difficulties, transparency, and security concerns (Trienekens et al., 2012). Furthermore, COVID-19 has significantly disrupted the global value chain, and numerous scientific research have been conducted on the relationship between VCF and technology. Nonetheless, most scientific studies examined VCF from an individual company perspective and a limited viewpoint. They concentrate on the performance metrics of an individual actors within the chain. This constitutes a partial study of an individual actor inside the chain. Nonetheless, there exists an opportunity for research to examine VCF from a chain-to-chain viewpoint. Incorporating chain-level analysis would enhance inclusivity and cost-efficiency (Frohling, 2011). This extensive analysis demonstrates the association between VCF and CCC for all actors in the full value chain. It also demonstrates how the blockchain-centric VCF influences inventory turnover ratio, accounts payable and receivable amounts, cost of products sold within the chain, and subsequently impacts the cash conversion cycle (CCC). Prior value chain studies examined quality, sustainability (Zhang et al., 2024), logistics (van der Vorst et al., 2009), time tracing and tracking (Simatupang and Sridharan, 2002), and inter-organizational net chains.

Blockchain present an opportunity for actors in the value chain by integrating it and providing a transparent, immutable, and trust-centric framework (Asante et al., 2021). In a conventional chain, each actor collaborates with one or more financial institutions to facilitate effective VCF but incurs individual working capital expenses, various risks, extended lead times, and paperwork fees. The inaccessibility of information and restricted funding flows result in operational inefficiencies and suboptimal utilization of VCF. Furthermore, a knowledge deficiency exists regarding the blockchain, VCF and their interrelation. This work addresses the knowledge gap by systematically examining the literature and formulating a conceptual model. It employs a methodological approach that encompasses the overarching narratives of blockchain technology and VCF applications, as it facilitates deeper qualitative insights, contextual comprehension, theoretical development, complexity and diversity mapping, as well as the identification of research gaps and hypotheses for future investigation. This review seeks to address three research questions.

1. How blockchain technology be applied in the context of value chain finance?
2. Is there scope for a new integrated VCF model, and how could a collaborative VCF mechanism be designed for the agro-food chain?
3. From the conceptual perspective of blockchain technology, what is the future direction of research on its application in the agro-food chain?

This article comprises five sections, with Section 2 elucidating the conceptual underpinning of both conventional and blockchain-based VCF mechanisms. Section 3 delineates the research technique. Section 4 elucidates the ideas of value chain, VCF, and blockchain, examining their interrelationships from multiple angles. Section 5 signifies the conclusion and prospective research directions.

METHODOLOGY OF THE STUDY

This exploratory study provides adequate information on blockchain and VCF. This study delves into the research design that explores the relationship between blockchain and VCF (Prodanov and Freitas, 2013). As a method, this study follows the general narratives of blockchain and VCF. The aim of using general narrative literature is to present the range of definitions and features relevant to the topic (Vada et al., 2023; Ferrari R. 2015). Moreover, this study maps the general understanding of VCF, types of VCF, cost and benefits of VCF, blockchain concept, types of blockchains, and practical application through general narratives. This is needed to go further with qualitative insight, contextual understanding, input for theory development, mapping of complexity and diversity, and generating hypotheses for further study (Paré et al., 2015; Martins et al., 2019).

It has also followed a backward and forward snowball approach (Aldrighetti et al., 2021) and a convenient literature selection method. Consequently, this study conducts a review of the gray literature to identify existing studies and select relevant articles for the context (Saz-Gil et al., 2021). Meglio et al., (2011; p. 420) describe this general narrative literature review as 'a comprehensive synthesis of existing works that often discuss theory and context with the aim of provoking thought and controversy'.

This paper conducted a general bibliographic search for the application of blockchain in the AFC and conducted a literature review without any time constraints. It reviewed 129 documents from a large volume of scientific articles and reports from Google Open Sources and the Wageningen University and Research (WUR) library (https://www.wur.nl/en/library.htm) for further study. These one hundred twenty-nine documents include scientific articles, book chapters, working reports, and conference proceedings. Besides, browsed 13 websites related to blockchain applications that are suggested by blockchain experts and practitioners, case study reports from working papers and theses, and Google Open Source. After the

review, the conceptual orientation of three main concepts (i.e., value chain, VCF, and blockchain) has been stated in detail. This study explores the stated cost, benefits, and limitations of each VCF instrument. Subsequently, it explains how these three concepts relate to the AFC. The subsequent sections categorically derive and highlight the conceptual orientation of the VCF, blockchain, and their relationship.

RESULTS AND DISCUSSION

This section explains in detail the concept of value chain, VCF, and blockchain from different perspectives. To what extent blockchain is associated with VCF from literature and practical cases in the AFC.

Value Chain

A value chain is a strategic partnership between interdependent actors and is considered a source of collective competitive advantage (Christopher, 2016). It involves reciprocal cooperation to create value for consumers and capture value for all (Klibi et al., 2010). The value chain aims to examine all activities and understand the relationships between actors (Porter, 1985). The scope of a value chain is the entire production, processing, and marketing system of a particular product from inception to finished product (Miller and Jones, 2010). The scope of VC also includes information and finance flows (Scholten et al., 2016). For example, in a typical agro-food value chain, the collaboration refers to, e.g., processing agents, trade intermediaries, service companies, retailers, and supporting groups such as banks or technology providers. It facilitates the integration of various actors, such as those with similar scopes or purposes (Muiruri, 2007).

The global agro-food value chain had a total value of $6 trillion and contributed to a total profit pool of $ 650 billion in 2019 (KPMG International, 2019), but financial constraints remain prevalent within limited sources (World Bank, 2019). From the perspective of developing countries, the agro-food value chain is an ultimate instrument for reducing poverty (World Bank, 2018) and a source of self-sustaining income for farmers and traders (Chauffour and Malouche, 2011). In fact, many global concerns (e.g., organic food scandal in Italy; horsemeat scandal in 2013; Barnard and O'Connor, 2017) in the food industry accelerate the importance of transparent AFC. Moreover, the ongoing concern of food certification authority (e.g., EFSA) also drives to agro-food value chains for more transparency and superiority (Trienekens et al., 2012; Ramos et al., 2024).

Characteristics of the Agro-Food Value Chain

With common features, (e.g., planning, innovation, governance, and networking) agro-food value chains have some distinctive characteristics. According to Sterling et al. (2013), there are three distinctive features of the agro-food value chain.

Volatility: The agro-food environment is more volatile, and its volatility is increasing due to climate change, among others. Weather is responsible for the variation in the production and supply of yield in the market. From the political front, volatility also derives from regulatory actions of governments, e.g. trade restrictions, push towards biofuels, or subsidized production.

Complexity: The agro-food chain is complex and is even more complex due to the diversification of crops and the more certifications from many regulatory authorities. Diversities in inputs and outputs need to maintain various levels of local and international standards. The emergence of new technologies and new markets has made AFC more complex. Furthermore, transactional and informational policies are also responsible for chain complexity (KPMG, 2019).

Scrutiny: Due to technological advancement, customers are more aware of the content and safety of the product. Everyone wants to know from end-to-end (EtoE) of a product. The actors of AFC care for the environmental footprints and social impact of products rather than only material consumption. They inspect social awareness about genetically modified products, fair price, fair trade, compliance, and overall sustainability governance (Strube et al., 2021).

Value Chain Finance

This study uses the characteristics of the supply chain in VCF. Although VCF is a well-debated topic in research, it has no common definition (Hofmann and Johnson, 2016). All studies define VCF from contextual perspectives such as the timing of financing, liquidity of financing, organizational involvement (bank/NBFI), financial engineering perspective, etc. Table 1 lists the definitions of VCF from several studies.

Table 1

An overview of definitions of VCF and participation of financial institutions

References	Description of VCF	Involvement of Financial Institutions
Hofmann and Belin (2011)	This study views VCF... namely that financial flows contrast with physical flows and their related information flow along the Cash 2 Cash cycle. Thus, optimisation of the VCF of the company can be considered equivalent to optimising working capital.	Yes
Caniato et al. (2016)	A source of short-term financing used to optimise financial flows in an inter-organizational level through a solution executed by financial institutions or technology providers where benefits rely on the cooperation among players of a supply chain.	Yes
Steeman (2014)	Financial used in collaboration with at least two supply chain partners and facilitated by the focal company to improve overall financial performance and mitigate the overall risk of the supply chain.'	Yes
Euro Banking Association (2014)	The use of financial instruments, practices, and technologies to optimise management of working capital and liquidity tied up in supply chain processes for collaborating business partners.	Differs based on instruments

Most of these studies underline the optimization of financial flows and efficient flow through factoring, trade credit, or short-term bank loans. Zhao and Huchzermeier (2018) identified three main time periods for VCF, i.e., pre-shipment finance, in-transit finance, and post-shipment finance. In contrast, the Euro Banking Association (2014) defined the same VCF instruments in terms of current assets and current liabilities. In addition, the literature of KIT and IIRR (2010) separates VCF into three categories.

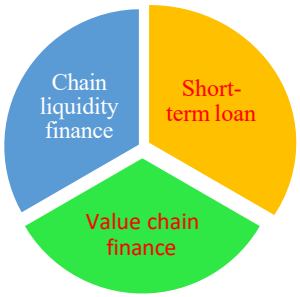

Figure 1
VCF in the agro-food supply chain in the context of the source of participation of actors: KIT and IIRR (2010)

Chain liquidity serves to facilitate short-term loans from either upstream or downstream actors in a chain. These are named trade credit, chain credit, or pre-finance for cultivation or harvesting (Klerk, 2008) and bidirectional sources of VCF. Active actors in a chain take part in liquidity financing. It is a low-cost source of VCF and ensures tailor-made chain efficiency (KIT and IIRR, 2010), but it has a danger of 'dependency'. In practice, actors use a variety of financial instruments for chain liquidity, such as operating working capital (Knauer and Wohrmann, 2013). Appendix A summarizes a few chain liquidity instruments of the VCF, drawing on previous literature and Sagar's (2020) study.

Short-term finance: Refers to formal and informal loans from commercial banks, non-bank financial institutions (NBFI), NGOs, and microfinance organizations, except direct actors of a value chain. External financing sources, such as cash loans, advances, deposits, or insurance, are identified (Swamy and Dharani, 2016). The loan agreement has a high transaction cost and limited flexibility. Most of the actors in a chain have limited access to agricultural finance. In Appendix B, common practices of agricultural financing are summarized.

Value chain finance: Refers to the financing opportunity that arises through one or more financial institutions, leveraging the business relationship between buyers and sellers. All actors in a chain can enjoy benefits and liquidity thanks to value chain finance (Frohling, 2011). Examples of VCF are warehouse receipts, repurchase agreements, private equity, leasing, and reverse factoring. The common practice value chain financing instruments are summarized in Appendix C.

Blockchain Technology

The main technology behind Bitcoin, described as the fourth industrial revolution, is blockchain (Tieman and Darun, 2017). Blockchain is an electronically distributed ledger system that records data on transactions and other information governed by the consensus of members (Asokan et al., 2021). It primarily concerns distributed ledgers and specialized distributed databases that function in a decentralized manner (Lohmer et al., 2020). Blockchain is a technical instrument characterized by decentralization, trustworthiness, transparency, consensus protocols, and traceability (Mangla et al., 2022; Santos et al., 2024). Satoshi Nakamoto presented the foundational notion of blockchain technology in 2009. Satoshi Nakamoto introduced Bitcoin, an electronic currency system that employs blockchain technology as its foundational basis. The document "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto 2008) elucidated the mechanisms for tracking and verifying digital cash transactions.

Function and Drawbacks of Blockchain Technology

Blockchain has widespread uses in finance and capital markets (Mathew and Quadir, 2018), accounting (Wang, 2017), health (Clauson et al., 2018), supply chain (Casado-Vara et al., 2018; Tieman and Darun, 2017), food industry (Kayikci et al., 2022), and agriculture (Kamilaris et al., 2019; Lin et al., 2017). Blockchain is a giant spreadsheet to register all assets, stocks, crowdfunding instruments, and derivatives, and an accounting system to transact them on a global scale (Swan, 2015). The consensus of network actors verifies each transaction in blockchain (Crosby et al., 2016). Lazanis (2015) emphasized the distributed public ledger to store and confirm transactions held in a network. Antonopoulos (2014) asserts that the four main pillars of the blockchain are the peer-to-peer network, transaction logic, immutability of data, and consensus mechanism. The benefits of blockchain technology are robustness to IT infrastructures, transparency, regulating traceability (Donaldson A., 2022), and trackability of objects.

Moreover, blockchain integration ensures trust and commitment in new product development (Benzidia et al., 2021). Blockchain application also ensures a circular economy through information sharing and resource efficiency during disruption (i.e., COVID-19) and follows localization, agility, and digitization (L-A-D) capabilities in the value chain process (Nandi et al., 2021). On the contrary, it also has some drawbacks. The main limitations of the blockchain are limited scalability (Greenspan, 2015), disclosure of economic privacy (Goswami, 2016), unavoidable security flaws (Shrier et al., 2016), data storage constraints of the private blockchain, complexity regarding huge information, irrelevant data storage for unrelated historical transactions, large network size, regulations, and politics between countries. The stakeholders care more about safety, security, and quality than only logistical improvements. For this safety issue, traceability is a device-centric technology, and smart contract is an instrument, but the main technology overdue is blockchain. Moreover, by the intrinsic properties of blockchain and IoT smart contracts run well in the domain of blockchain.

Private and Public Blockchain

There are many similarities between public and private blockchains. Both are decentralized peer-to-peer networks and maintain consensus. They also have dissimilarities. Jayachandran (2017) highlights the main differences in network participation, consensus protocol execution, and shared ledger maintenance. The public blockchain is an open network, and anyone can participate in it. Ethereum is a public blockchain application that allows users to build and run their own smart contracts without building their own ecosystem (Bennett, 2018), but the private blockchain requires an invitation and validation by a network starter or a set of rules in the network. IBM-Hyperledger is an example of a private blockchain, which is generally set up as a permissioned network.

Public blockchain may be considered the internet (open access), and private blockchain is about the intranet (restricted access), and the speed of a transaction on public blockchain is a bit slow compared to private blockchain. In cases of security purposes, the public blockchain needs proof of work, proof of stake, and other consensus mechanisms, but the private blockchain needs only pre-approved participation. For identity, the public blockchain is anonymous and pseudonymous, but in the private blockchain, we know each identity. Each node of the public blockchain has equal transmission power, but in the private blockchain, only certain nodes can create new transactions. Due to the large number of nodes, each transaction cost in a public blockchain is higher than in a private blockchain. Private blockchain is the preferred platform for business-to-business (B2B), but public blockchain is the platform for business-to-consumer (B2C).

Use and Scope of Blockchain

Blockchain confirms the accuracy of a transaction and reduces intermediary cost and transaction cost (Mainelli and Smith, 2015). Catalini and Gans (2016) anticipate that the cost of market entry will likely be minimal. Trade finance promises to enhance efficiency in the transformation of global trade networks (Meijer et al., 2006) and has a significant impact on business and commerce (Guo and Liang, 2016). The private blockchain also explores efficiency in logistic, storage, and processing units (Groenewegen, Heijmerikx, and Kalf, 2017). Furthermore, governments are exploring blockchain to support asset registration such as land and corporate shares (AICPA, 2017) and to improve the logistics of digital ports (Weernink et al., 2017). Many blockchain applications are already used in markets, such as Skuchain (trade finance), Provenance (traceability), Tallysticks (invoicing), Chain of Things (IoT), and SolasVGM (documentations). Table 2 lists a few examples of blockchain applications.

Table 2
List of available blockchain applications and execution mechanism

Name of private blockchain	Application	Smart contract execution	Smart contract language	Consensus mechanism	VCF involvement
BigChainDB https://www.bigchaindb.com	Blockchain data base	N/A[1]	N/A	Federated Voting	✓
Corda https://www.corda.net	Smart Contract	JVM[2]	JAVA, Kolin	Pluggable (RAFT, BFT)[4]	✗
Dfinity https://dfinity.network	Smart Contract	EVM[3]	Solidity, Serpent, LLL	'Blockchain Nervous System' Randomised POS[5]	✗

Note. N/A = Not available, JVM = Java Virtual Machine, EVM = Ethereum Virtual Machine, RAFT and BFT = consensus protocol, POS = Proof of stake

In the energy and agriculture sectors, blockchain has the largest transformative and disruptive impact in the immutable and distributed ledger system that ensures record management (Lin et al., 2017), but it has many uncertainties in combinations of regulations, technologies, and practical challenges (WEC, 2017).

Relationship between Blockchain and Value Chain Finance

Since Adam Smith, economists have recognized VCF, or working capital, as an important part of a firm's capital stock (Fazzari and Petersen, 1993), and its importance has boomed since the financial crisis in 2008 (Pirttila, 2014). VCF has an influence on financial health, profitability, earnings before interest and taxes (Ramachandran and Janakiraman, 2009), and the liquidity of a company (Sagner, 2014). VCF is a process that involves planning, controlling, and financing the level of current assets (Bhalla, 2014). In the USA, a firm uses 30% of its book value of assets in VCF to balance profitability and risk (Chen et al., 2019), but substantial portions of VCF are not necessary (Ek and Guerin, 2011). Therefore, there is a capacity to improve the efficiency of VCF in most companies (Ernst and Young, 2012).

Moreover, a high inward VCF signifies a reduced return on investment (ROI) for a company, impacts its corporate performance (Vishnani and Shah, 2007), and correlates with the efficiency of VCF (Omran et al., 2017). Recent research has given significant attention to this VCF, yet it was viewed as distinct from product flows (Zhang and Dhaliwal, 2009). The financial sector first used blockchain technology to reduce separate streams in a supply chain (Azaria et al., 2016), as well as to reduce regulatory compliance costs and increase transparency requirements (IFC, 2017). The literature by Bogucharskov et al. (2018), Casado-Vara et al. (2018), Hofmann et al. (2017), and Nakasumi (2017) also demonstrates how blockchain technology can enhance the efficiency of a supply chain. There are many examples of smart contracts, traceability, and private blockchain podiums that are used in corporate business for efficient VCF. Table 3 lists a few examples of case studies outside the AFC.

Table 3

Blockchain-based case studies in value chain finance

References	Instruments	Outcome
CRX MARKETS (www.crxmarkets.com)	Blockchain, ERP system, and full integration	Seamless VCF. Full automation in financing and internal management.
Kyriba (www.kyriba.com)	Private blockchain as SAAS and integrated platform	Less costly VCF and efficient working capital management.
OILIBYA (www.oilibya.com)	Cloud-Based Ecosystem	80% operational efficiency in working capital management. 20% cost reduction of VCF.
Prime Revenue (www.primerevenue.com)	Traceability and Smart Contracts	Continually measure cash flow to keep performance on track.
TradeLens (www.tradelens.com)	Blockchain through Smart contract	Financial asset management and real-time information sharing.
Tower Trade (www.towertradegroup.com)	Private Blockchain	Favourable CCC and improve working capital.
Orbian (www.orbian.com)	Web-based system	Efficient receivable monetization, real-time invoice, and electronic payment settlement
Tungsten (www.tungsten-network.com)	Industrial Internet of Things (IIOT) and Blockchain	Enhance the VCF network and reduce the cost of financing.

Note. ERP = Enterprise Resource Planning, SAAS = Software as a Service

These companies provide platforms and connect all parties, facilitating the reconciliation process of their trade credits, invoices, product deliveries, and payments (Del Prete, 2014).

Collaborative Cash Conversion Cycle of the Agro-Food Chain

This AFC comprises four layers of stakeholders. The cash-to-cash (C2C) and net working capital of each actor vary in terms of size, influence, and financial performance. At the company level, an actor may be more efficient in managing cash conversion time, but it has a reverse impact on another actor in the chain.

This individual efficiency leads to better performance for a particular company, but chain-level efficiency depends on the decrease in the total CCC of the entire chain. Figure 2 expresses the chain-level CCC.

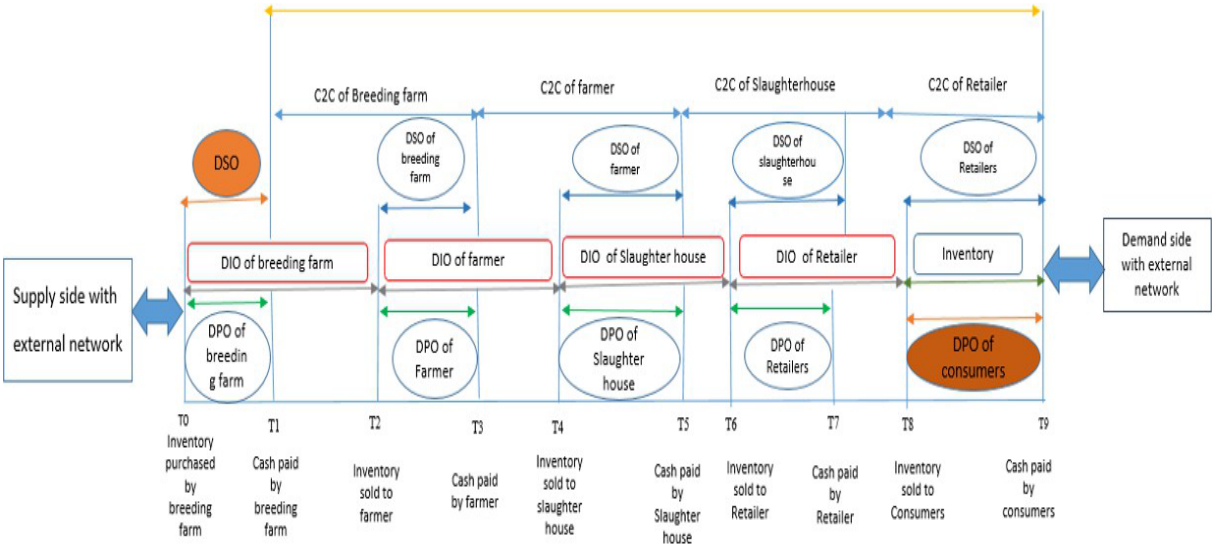

Figure 2
Collaborative cash conversion cycle within value chain finance

Figure 2 explains the CCC at the chain level of an AFC by summarizing all the cash conversion times of the actors. This study considers the entire supply chain as a single corporate quasi-entity (Blois, 1972). This figure shows that there are two ways to optimize its CCC.

The breeding company extends its payment period to include external intersections on its supply side. This extension of the payment period is assumed to not affect the price, quality of the goods, the trade relationship, or the trade services between the suppliers and the breeding company. The stretching out of the account's payables period of the breeding company and reducing the accounts receivable period of the retailer on its demand side with external interactions. Similarly, the retailer uses hits market power to manage accounts receivable periods in the shortest possible time without affecting the quality of the goods, the price, the services, or the relationship between the customer and the retailer. Through optimization of the collaborative CCC of the supply chain. For instance, because of the inverse relationship between the chain's actors, the breeding company's accounts receivable period corresponds to the farmer's accounts payable period, while the farmer's accounts receivable period corresponds to the slaughterhouse's accounts payable period. Therefore, the collective CCC of the chain is the total of the inventory periods for each of the four actors, accounting for their respective sales revenue and costs of goods sold. Moreover, the reduction of inventory period has a positive impact on the cash conversion time for both individual actors and the chain.

CONCLUSION AND FUTURE RESEARCH DIRECTION

This paper comprehensively describes VCF by characterizing the costs, relationships, and limitations. It reveals blockchain from several aspects. The analysis and results are structured into three perspectives: the experiences of VCF and blockchain in the food value chain, the blockchain-based VCF model, and the creation and comparison of the conceptual frameworks of conventional and blockchain-based AFC. Moreover, this study is conceptually the first study considering CCC through blockchain in the AFC. It shows the blockchain platform shares economic resources and shows more integration compared to the conventional value chain model. This study also discusses the findings of many case studies of VCF where

actors use blockchain, smart contracts, and software as a system (SaaS) for integrating financial metrics through blockchain architecture. However, the cost-benefits and feasibility of using blockchain in AFC are still perplexing. Therefore, the findings of the empirical analysis and blockchain performance assessment of VCF in the AFC were not explored in the reviewed literature.

In fact, the literature, application of blockchain, conceptual framework, and comparative study of conventional and blockchain-based value chains show a positive effect on VCF performance. This conceptual framework guides the assessment of blockchain's risk in the agro-food chain. The blockchain-based VCF solution contributes to liquidity and profitability in the chain. However, the agro-food industry's use of blockchains only demonstrates the transparency of product flow (Hu, X. 2022). To understand the impact of blockchain on the CCC and net working capital through a dynamic model, more research is required. It has been declared that the framework outcomes are not rigid for all chains, as illustrated by this study. The study's outcome is contingent upon the assumptions it adheres to.

The conversion of VCF instruments into financial derivatives introduces a new dimension to the AFC, potentially opening new avenues for future research. For example; how does blockchain affect financial derivatives of the AFC that are traded on many stocks? What impact does blockchain have on managing the inventory of the agro-food chain using a dynamic model? Finally, what disparities exist in the case of the application of blockchain to support sustainability? AFC diverges from developing and developed countries. Divergent research outcomes exist regarding the impact of blockchain on the enhancement of VCF within the AFC. In this case, does this impact moderate or mediate the relationship between VCF and blockchain for chain performance? However, this study has several limitations; first, the paper does not follow a systematic literature review (SLR) process, and the selected articles have not been explored from the 'Scopus' or 'Web of Science data bank with some strings through a single click. Second, this paper does not follow any exclusion criteria, filtering approach, or PRISMA protocol (Asante et al., 2021) to come up with a conclusion.

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Appendix A

Instruments of chain liquidity as a source of value chain finance

References	Instruments	Description	Bottleneck	Cost	Relationship	Benefits
Swamy and Dharani (2016), Wuttke et al. (2013), and Wu and Zhao (2016)	Trade credit	An arrangement of deferred payment between seller and buyer in which the seller allows the deferred payment to increase sales and profits, which in turn have default risk (Grau and Reig, 2018)	▪ High default risk ▪ Overdue and Bad Debts	▪ Financial transaction cost in the form of trade discount	▪ Long-term trade relationships between the buyer and the seller are needed.	▪ Easy transaction at the door steps for actors ▪ Traditionally accepted and well known by all actors in a chain.
De Boer et al. (2015), European Union Accounting Rule 5 (2015), and EBA (2014)	Pre-finance credit (purchase order)	A cash in advance or a payment intended to provide to a supplier with a float. Pre-finance credit manages working capital needed for suppliers.	▪ Depend on the buyer's willingness	▪ Weighted Average Cost of Capital (Hofmann and Kotzab, 2010; Steeman, 2014)	▪ Buyer and seller trading relationship	▪ Low transaction cost ▪ No third-party commission ▪ More assured
Chauffour and Malouche (2011) and Michalski (2008)	Factoring	A financial service that trades invoices or accounts receivables at a discounted price. Factoring is used to manage liquidity and mitigate the risk of default.	▪ High discount rate ▪ Seller-centric ▪ Less customer bond	▪ 2%-5% of turnover.	▪ Buyer-factor-seller relationship with recourse or without recourse (Zhao and Huchzermeier, 2018)	▪ Reduce the cost of collection from account receivables

Appendix B

Instruments of short-term finance as a source of VCF

References	Instruments	Description	Bottleneck	Cost	Relationship	Benefits
Ekka et al. (2010) and Miller and Jones (2010)	Loans and advances	A formal loan disbursement by financial institutions in the form of cash or others at a specified interest rate as a term loan that is backed by collateral or security.	▪ Not easy access for marginal farmers or traders. ▪ More formalities and demonstration of documents	▪ High interest rate compared to chain liquidity (Miller and Jones, 2010)	▪ Lender and borrower relationship through a formal agreement.	▪ Uses as start-up capital ▪ Low flotation cost and high speed of loan transaction (Brigham and Houston, 2013)
Brigham and Houston (2013), Demiroglu and James (2010) and Lins et al. (2010)	Line of credit	An informal financial arrangement of a customer and a bank in which the bank honours the maximum amount of loan a client can borrow, which is secured, unsecured, or demand basis.	▪ Limited to premium customers ▪ Informal agreement (Brigham and Houston, 2014)	▪ Flexible interest rate in terms of relationship and designated period	▪ Long-term client-bank relationship	▪ Dominant source of liquidity ▪ Lower interest rate and less formalities
Sanchez-Barrios et al. (2016) and Vijaykumar et al. (2016)	Revolving credit	A special type of line of credit committed by bank where the client needs to pay the commitment fee for unused loan and is charged interest on the used loan.	▪ Only for large firms which have huge cash inflows and outflows	▪ Interest and a certain commitment fee	▪ Continues the transactional relationship between the corporate firm and the bank.	▪ Continues liquidity for firm by a legal obligation for a bank to honour funds (Hofmann and Belin, 2011)

Appendix C

Instruments of value chain finance

References	Instruments	Description	Bottleneck	Cost	Relationship	Benefits
Liebl et al. (2016), Seifert and Seifert (2011), and Wuttke et al. (2013)	Reverse Factoring	An arrangement in which the buyer provides/manages a discounted financing from the third party for the supplier by grounding the buyer's credibility instead of the supplier's creditworthiness. Reverse factoring guarantees a longer payment term without affecting the long-term relationship between actors.	▪ Depend on the credibility of the buyer.	▪ The average discount is 6% (Lekkakos and Serrano, 2016) ▪ Different Tax Regulations	▪ Buyer-initiated relationship among buyer-bank-seller	▪ Short Cash Conversion Cycle ▪ Extra financing source for the supplier
Gelsomino et al. (2016) and Handayati et al. (2015)	Dynamic discounting (daily discount)	An elastic discounted financing source where the buyer pays early using his excess cash, in return the supplier charges overall lower cost of product or provides goods at a discounted price. This discount rate is not static for the entire credit term.	▪ Used only in post-sale financing ▪ The discount rate depends on the supplier (Zhao and Huchzermeie, 2018)	▪ Discount = face value - trade/market value	▪ Simple buyer-seller relationship	▪ Early recovery for seller and short CCC ▪ Reduced price or higher discount for buyer by early payment
Marquès et al. (2010) and Mangiaracina et al. (2012)	Vendor Managed Inventory (VMI).	A collaborative arrangement in which a supplier makes inventory replenishment decisions for its buyer, monitoring its inventory levels and making periodic resupply decisions regarding order quantities, shipping and timing (Caniato et al., 2016; Waller et al., 1999)	▪ Lead time-based delivery ▪ Variability of Market Demand	▪ Vendor bears retailer's ordering cost, while retailer bears holding cost (Bazan et al., 2014)	▪ Close partnership between the buyer and supplier based on trust and power (Raghunathan and Yeh, 2001)	▪ Lower inventories cost ▪ Higher customer service ▪ Common replenishment period