

## Tokenised Supply Chain Finance and CBDC

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### **Executive Summary**

Tokenized supply chain finance, powered by Central Bank Digital Currencies (CBDCs) and Distributed Ledger Technology (DLT) holds the potential to revolutionize global trade and financial inclusion for SMEs. The ecosystem of small and medium enterprises (SMEs) can leverage CBDCs and DLT to address longstanding pain points in the ecosystem. By leveraging these technologies, the supply chain finance ecosystem will have faster settlements, enhanced trust, and improved financial inclusion for small suppliers. Tokenization of invoices and settlement in the regulated digital money backed by the central bank also create a digital representation of receivables, enabling suppliers to access liquidity by using these assets as collateral for financing addressing the issue delayed payments, real-time verification and improving cash flow management across the supply chain.

The research's investigated tokenization of supply chain finance, CBDC within the context of supply chain finance and their integration with DLTs. The hypothesis-based research focus was on CBDC and DLT to improve liquidity, foster transparency, reduce payment delays, and mitigate risks associated with traditional financing methods.

Our findings highlight how CBDCs & DLTs enable the tokenization of invoices, transforming them into digital assets that can be seamlessly settled using CBDCs, enhancing the efficiency of supply chain finance. The role of CBDC as settlement asset and infrastructure will empower both transaction efficiency, faster payments, enhancing liquidity, reducing the need for pre-funded accounts and facilitating instant payments to suppliers. It will also enable traceability of the transactions to ensure real time and accountability for all stakeholders.

### **Five Gaps in Supply Chain** Finance Supply Chain Visibility Difficulty in obtaining visibility over the process involved in supply chain finance system Costs of Manual Updates Transactions need to be updated and constantly verified manually, generating high Late costs and **Payments** inefficiency & Credit Lending Extending payments issues, supplier issues related credit lending

Financial Flow Visibility

> Difficulty In leveraging the financial flows across international legislations

**Real-time** 

Data

Accuracy

Transactions and data are not in real time. The gap in between results in misleading communication

# Supply Chain Finance and Tokenisation

Supply chain finance (SCF) companies encounter significant hurdles in securing adequate funding and managing payment delays, especially with small suppliers. Extended payment periods from large buyers' strain cash flow and working capital, often hitting suppliers hard. Traditional financing methods, like bank loans, are typically unreachable for small suppliers due to strict credit requirements, lack of collateral, and insufficient financial history. Additionally, bureaucratic processes hinder access to finance, causing delays and adding complexities such as invoice verification and third-party involvement.

In response to the limited technological infrastructure further complicating small suppliers' adoption of SCF platforms and missing out on efficiencies, digital transformation brings emerging technologies like digital currencies to enhance SCF by enabling quicker, secure transactions, automation and programmability. Tokenisation within SCF can address traditional inefficiencies, while financial transaction governance is vital in managing complex, multi-party interactions. In sharing sensitive data, organizations risk loss of control and security—particularly with untrusted third parties.



### Supply Chain Finance Ecosystem

- The supply chain finance (SCF) ecosystem is a complex network of interconnected entities and processes that work together to optimise financial flows within supply chains. It encompasses buyers, suppliers, financial institutions, technology providers, and other stakeholders who collaborate to improve liquidity, reduce costs, and enhance efficiency in supply chain operations.
- This ecosystem leverages various financial instruments, such as trade credit, factoring, and reverse factoring, along with advanced technology platforms to facilitate early payments, extend payment terms, and manage working capital more effectively.
- The SCF ecosystem aims to create value by aligning financial flows with physical and information flows in the supply chain. It will foster stronger relationships between supply chain partners and promote sustainable business practices.
- As the SCF market grows, with projections reaching US\$5.7bn by 2032, it is increasingly recognised as a significant trend in global banking and a valuable tool for addressing sustainability challenges in supply chains.



#### **Shortfall of Funds**



Due to extended payments by powerful buyers who wish to maximise working capital

#### Limited Credit Lending



As the standards are set by the bank, small suppliers often do not qualify for credit lending

#### Lack of Visibility



Neither the buyer nor the bank is able to view clearly the chain as there is no trusted system.

### **CBDC Based Supply chain Finance**

Central Bank Digital Currency (CBDC) is a form of digital currency issued by a country's central bank. It is an electronic representation of a nation's official currency and is intended to be a secure and regulated digital alternative to physical cash. CBDCs could significantly reduce payment delays, facilitate instantaneous crossborder payments, benefiting global supply chains [1], CBDCs can facilitate instantaneous cross-border payments, benefiting global supply chains particularly for small and medium-sized enterprises (SMEs) [2]. It could provide a mechanism that converts the national CBDCs instantaneously, reducing risks and complexity, reduce compliance complexities, eliminating the need for currency conversions [4].

**Our Hypothesis**: CBDCs will enhance financial efficiency, reduce risks, and foster inclusion in the supply chain finance landscape. The study evaluates this hypothesis through a technical and operational analysis of CBDCs in SCF. Integrating CBDCs into SCF offers a unique opportunity to address these inefficiencies by leveraging their digital and programmable nature. Smart contracts, programmable money, and microtransaction capabilities can all be harnessed to create new ways of conducting everyday financial interactions.

CBDCs could extend financial services to remote and underbanked regions, fostering economic growth and reducing disparities by providing digital transacting. However, as depends on design and possibly the region (different regions have different underbanked populations). The potential of CBDCs to enhance financial inclusion arises from their accessibility [3]. Unlike traditional banking, CBDC accounts can be set up with minimal requirements, enabling a broader range of SME's to participate without formal identification or a physical address can engage in digital transactions, It will significant in regions where traditional banking infrastructure is limited or absent. CBDC and the DLT infrastructure would create a new Tokenised supply chain finance ecosystem [3].



<sup>1.</sup> ECB and BIS, "Central bank digital currencies: foundational principles and core features report no. 1 in a series of collaborations from a group of central banks," *Bank Int. Settlements*, no. 1, 2020, [Online]. Available: https://www.bis.org/publ/othp33.pdf.

<sup>Int. Settlements, no. 1, 2020, [Online]. Available: https://www.bis.org/publ/othp33.pdf.
H. Armelius, G. Guibourg, A. T. Levin, G. Söderberg, and C. A. Clausen, "Second special issue on the e-krona," Sveriges Riksbank Econ. Rev., 2020, [Online]. Available:</sup> https://www.riksbank.se/globalassets/media/rapporter/pov/engelska/2020/economic-review-2-2020.pdf.

<sup>3.</sup> Auer, R., Cornelli, G., & Frost, J. (2020). Rise of the central bank digital currencies: Drivers, approaches, and technologies.

<sup>4.</sup> BIS Working Papers. Bank for International Settlements. (2022). CBDCs in cross-border payments: Opportunities and risks



Tokenisation of SCF (FPO/Invoices)

> The vision of CBDCbased SCF

Liquidity Assistance / Access to Capital

> Interoperability considerations

Programmability Smart contract based Automated DVP & PVP

Payment

efficiency

### **Hypothesis-Driven Approach**

#### **CBDC Level Hypothesis**

#### CBDCs as Settlement Assets Improve Efficiency

CBDCs will significantly reduce delays in SME's domestic payments and cross border improving cash flow for suppliers.

#### CBDCs Foster Financial Inclusion for SMEs

CBDC will enhance accessibility for small and medium-sized enterprises (SMEs), providing them with faster access to working capital and reducing reliance on traditional banking systems.

#### CBDCs Enable Trust and Transparency

CBDCs will increase trust among SCF participants.



#### Distributed Ledger Hypothesis

#### Transparency Enhances Trust

Distributed ledgers, with their immutable and transparent record-keeping, will foster trust among supply chain participants by eliminating disputes over transactions and payments.

#### **Tokenization Drives Liquidity**

The tokenization of supply chain assets, such as invoices or purchase orders, will improve liquidity for suppliers by enabling faster and more secure access to working capital.

#### Programmability Reduces Delays

The programmability of smart contracts on DLT will automate key processes, such as invoice verification and payment triggers, significantly reducing delays in payments.

[1] programmability is also possible without DLT

### **Methodology of Simulation**

This simulation of tokenised money (CBDC and tokenised assets) included integrating infrastructure with traditional systems to test transactional-level interoperability.

The network was designed to issue CBDC and tokenised assets in a simulated environment. The simulation incorporated a standard messaging system to ensure interoperability between the legacy systems and the tokenised ecosystem. All processes, including issuance, distribution, processing, and settlement of CBDC and tokenised assets, were executed within the same network under a robust permissioned framework.

The simulated nodes recorded and processed transactions of both CBDC and tokenised assets and managed CBDC transactions related to tokenised assets. In the simulated nodes of central banks that issued CBDC tokens, commercial bank nodes act as distributors for distributing the CBDC tokens issued by the central bank under **the Proof-of-Authority** (PoA) consensus.

The simulated invoices were tokenised within the same network, represented through tokens, tracked, and governed on-chain. The enforcement of ownership transfer was linked with the smart contracts based on the atomic settlement of the CBDC and tokenised invoices.

Interoperability between on-chain and off-chain transactions was achieved through the communication bridge standard under ISO 20022, which integrated legacy systems with distributed networks. The API gateway facilitated interaction between external platforms and the CBDC/tokenised asset ecosystem.

#### Portdex



### Impact on Asset & Infrastructure

- CBDC could play a critical role in tokenised supply chain finance, including acting as a settlement asset and streamlining transactions through the infrastructure for tokenised asset issuance, processing, and settlement.
- The hybrid model will enable faster payment settlement and will facilitate the issuance and trading of tokenised assets like invoices and receivables.
- It will transform supply chain finance by addressing inefficiencies, reducing risks, and fostering financial inclusion for all participants in the ecosystem.



### Impact of Tokenisation on SMEs

- Organisations can use a CBDC infrastructure to create CBDC-based supply chain financing programs that allow on-demand financing options, such as purchase order financing, dynamic discounting, or forward payment obligations. FPOs with CBDCs may enable these obligations to be digitised and managed on a distributed ledger, making them easily verifiable. Trusted network powered by CBDC companies in future to tokenise their FPOs through retail banks' infrastructure for digital tokens representing a fraction of the payment obligation. Fractional ownership of the tokens will enable the investor to gain a share in the future payment return, providing companies with upfront liquidity.
- ✓ Tokenisation of assets such as receivables/inventory and using them as a collateral represent a paradigm shift in how tokenised financial systems will empower small suppliers, promoting economic resilience, and driving financial inclusion and providing suppliers with easier access to capital based on their real-time asset values.
- Our investigation reveals that CBDCs can transform supply chain finance by enhancing efficiency, transparency, and security. However, realising this potential depends on addressing several technical challenges, including scalability, interoperability, and regulatory compliance. Future efforts should focus on developing unified frameworks for CBDC implementation in SCF, fostering collaboration between central banks, technology providers, and industry stakeholders. With continued innovation, CBDCs could become a cornerstone of a more inclusive and efficient global SCF ecosystem.



### **Distributed Ledger and Supply Chain Finance**

Distributed ledger technology is commonly proposed for tokenising assets and governance at a more granular level of control without central authority for verification for companies partnered with external collaborators such as vendors, industry peers, and public-sector organisations [1]. Adopting distributed ledger technology for tokenising assets and CBDCs represents a transformative opportunity for the global financial ecosystem. By enabling secure, transparent, and efficient transactions, DLT has the potential to reshape supply chain finance, enhance liquidity, and foster financial inclusion[1][2]. However, achieving these benefits will require concerted efforts from stakeholders to overcome existing challenges and build a unified, interoperable framework for digital finance.

The current supply chain stakeholders cannot handle complex data relationships with many participants regarding complex relations, access, updates, and controls. Blockchain distributed processing and distributed trust model enable transparency, traceability, and accountability through an underlying consensus model among parties with no direct relationship. Smart contract "Data with rules" facilitates storing and manipulating data, only calling the approved functions compared to the stored procedure in the database. In the context of financial data governance distributed ledger and smart contract will enable user to part of the network, where the user could monitor transaction processing and governance [3][4]. The research investigated and analysed distributed ledger protocols including Blockchain frameworks like Hyperledger, Activeledger, Ripple for tokenisation, decentralised and immutable record-keeping systems, programmability via smart contracts, and interoperability of tokenised assets and CBDCs with third party platform to enable seamless and secure financial transactions.

- Distributed database that is spread across multiple organisations, eliminating the need for an intermediary to process, validate or authenticate transactions.
   Each party is represented by a node, and a node keeps its own copy of all transactions on the
  - network. Each of these transactions is encrypted and sent to every node on the network to be **verified** and

grouped into timestamped blocks of transactions.



- 1. Choi, T.M., Guo, S. and Luo, S., 2021. Blockchain-enabled supply chain finance: A literature review and future research agenda. *International Journal of Production Economics*, 231, p.107859.
- 2. Kamble, S.S., Gunasekaran, A. and Dhone, N.C., 2021. Blockchain technology for sustainable supply chain management: A systematic literature review and future research agenda. *International Journal of Production Research*, 59(11), pp.3509-3534.
- 3. Queiroz, M.M., Telles, R. and Bonilla, S.H., 2020. Blockchain and supply chain management integration: A systematic review of the literature. *Supply Chain Management: An International Journal*, 25(2), pp.241-254.
- 4. Xu, L., Chen, J., Gao, Z., Chang, E. and Li, S., 2020. Blockchain in supply chain finance: Architecture and implementation. *IEEE Access*, 8, pp.183255-183267.

### **DLT & Smart Contracts**

**Distributed Ledger Technology** and **smart contracts** may reshape industries by providing secure, transparent, and automated solutions. It will enable liquidity for suppliers by allowing them to sell their invoices to financiers instantly and reducing manual intervention through smart contracts [3]. The investigation focused on the smart contract in the context of Supply chain finance, particularly in its tokenized form for seamless interactions between various stakeholders, such as suppliers, buyers, financiers, and intermediaries. Traditional SCF processes often involve complex paperwork, time-consuming procedures, and a lack of visibility into the status of transactions. Through smart contracts, blockchain systems can enforce complex financial agreements in an automated and tamper-proof manner, thereby reducing the risk of fraud and human error [5].

Challenges in Supply Chain Industry		Distributed Ledger/Blockchain <b>Solution</b>	
>	Invoice delays and payment issues to limited access for small suppliers—highlight systemic inefficiencies	~	Leveraging DLT for tokenized assets and CBDCs for settlement, this dual approach creates a more inclusive, efficient, and resilient financial ecosystem.
>	Disconnected data, large volumes of repetitive data held in email, phone logs, text messages, multiple instant messaging tools, proposals and agreements, terms and conditions, legal and regulatory requirements.	~	Point-to-point communications with multi-party visibility overlay for information and event flows. Shared, secure record of immutable transactions and single point of truth for information flows.
>	Companies with complex supply chains find it difficult to pinpoint issues due to lack of transparency and limited visibility of supply chain data.	V	Distributed ledger technology makes transactions processing visible in real time. Permissioned users, processes and devices can monitor and react to transactions and changes in state.
>	Manual human activities.	V	All processes reliably managed by smart contracts. Smart contracts help eliminate uncertainty and delay, they are autonomous and automatic. Eliminating middle-men friction, delays and costs. [2][3]
>	High cost and payment processing delays.	~	Transactions are pre-agreed secure and instant and happen when preconfigured events occur.

- 1. Choi, T.M., Guo, S. and Luo, S., 2021. Blockchain-enabled supply chain finance: A literature review and future research agenda. *International Journal of Production Economics*, 231, p.107859.
- Kamble, S.S., Gunasekaran, A. and Dhone, N.C., 2021. Blockchain technology for sustainable supply chain management: A systematic literature review and future research agenda. *International Journal of Production Research*, 59(11), pp.3509-3534.
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- 4. Xu, L., Chen, J., Gao, Z., Chang, E. and Li, S., 2020. Blockchain in supply chain finance: Architecture and implementation. *IEEE Access*, 8, pp.183255-183267.
- 5. Buterin, V. (2014). Ethereum White Paper. Ethereum Foundation

### **Centralised versus Decentralised Ledger Technologies**



#### Governance

Supply chain has an interconnected and multiparty complex data transaction environment. In a collaborative environment organization shares data with multiple stakeholder's, partners, and some time the sharing involves untrusted stakeholders including third party tools to share information in an inter-organisational environment companies share data with different partners, external collaborators sometimes result in loss of control on data. Blockchain technology was proposed for data governance between multiple participants. Distributed processing for multiparty stakeholder environment that would enable transparency and accountability at the transaction level. One of the objective of the research was to analyse distributed ledger technology for transaction-level insight, which may eliminate the lengthy internal audit processes, which take days, weeks, and months.

The research findings in the context of governance of financial transactions in supply chain finance through distributed ledger technology (DLT) have concluded that distributed governance at the transaction level will automate processes and enhance financial transaction governance by streamlining processes and reducing errors and fraud. Distributed technology can store and enforce conditions through a smart contract. The blockchain enable verifiability auditability, provenance, transparency, and consistency at the transaction level and automated conditions enforcement, management will improve the multiparty transactional engagement process.



Depending on the need and the design, permissioned blockchain can offer more granular level control over the management and distribution of data. The smart contract can automate the enforcement of the terms and can act as a tool of governance. Companies often collaborate with partner, and other ecosystem stakeholders that collaboration often involve information sharing and need a common governance framework. A governance framework which could enable the ecosystem stakeholders to control unauthorized information access.

 Verifiability, transparency, auditing, consistency of transaction enforcement, management, and monitoring is a challenging task when data is shared with a third-party provider in a multi-organisation environment. The collaboration based on data sharing agreement in a centralized system struggles to handle automated processing where purpose and the context changes.

In the context of supplychain finance data governance establish level of trust about the authenticity, origin, data creation, data modifications of the transaction, who initiated them, and when and how in an immutable and tamper-proof way. A high level and low-level provenance, parallel provenance where multiple records will be a critical success factor for the whole supplychain eco-system.

<sup>1.</sup> Kim, H. Y., & Cho, J. S. (2018). Data governance framework for big data implementation with NPS Case Analysis in Korea. Journal of Business and Retail Management Research, 12(3).

<sup>2.</sup> Laoutaris, Nikolaos. "Data Transparency: Concerns and Prospects [Point of View]." Proceedings of the IEEE 106.11 (2018): 1867-1871.

<sup>3.</sup> Khatri, V., & Brown, C. V. (2010). Designing data governance. Communications of the ACM, 53(1), 148-152.

Neisse, R., Steri, G., & Nai-Fovino, I. (2017, August). A blockchain-based approach for data accountability and provenance tracking. In Proceedings of the 12th International Conference on Availability, Reliability and Security (pp. 1-10)

<sup>5.</sup> Liang, X., Shetty, S., Tosh, D., Kamhoua, C., Kwiat, K., & Njilla, L. (2017, May). Provchain: A blockchain-based data provenance architecture in cloud environment with enhanced privacy and availability

### Active ledger Based Tokenisation

Activeledger is an open-source distributed ledger technology platform designed for enterprise applications. Unlike traditional blockchains, it employs a choreographed consensus model, ensuring lightweight and efficient transactions. Its ability to integrate with existing enterprise systems and facilitate data tokenisation makes it suitable for SCF use cases (Activeledger Documentation, 2021).

- Programmable Workflows: Smart contracts facilitate automated business processes.
- Choreographed Consensus: Ensures scalability and reduces energy consumption.
- Data Tokenization: Converts assets like invoices and trade credits into secure, tradable tokens.
- Interoperability: Seamlessly integrates with legacy systems and other blockchain networks.

The Activeledger tokenisation model can turn digital assets that can be traded or used as collateral for financing. and reduces the risk of fraud through real-time verification. The payment terms can be encoded into the smart contracts, automating settlement once pre-defined conditions are met. Real-time sharing of transaction data among buyers, suppliers, and financiers. This transparency fosters trust and allows for better decision-making. Activeledger was used to tokenise trade finance instruments, enabling seamless digital issuance, tracking, and redemption.



#### Activeledger Proposed SCF Model – (APO's)

Advanced Payment Obligations are created aiming to conquer challenges within a supply chain system where extending payments affects financial positions and credit lending issues. They are created when a supplier accepts an order and can be redeemed after an invoice is approved by the buyer and reaches the agreed terms (such as 90 days). APOs represent a guarantee of cash flow automation on a specified date. A participant in a supply chain can sell APOs at a discount for emergency funds; a supplier can also use APOs to buy from their downline suppliers, and so on. This application flattens the supply chain and enables small suppliers to return to supply chains and compete once again for the business they have lost to open accounting. It removes the limitation to who can be involved in the supply chain and make management tasks easier and more transparent.

<b>Transparency</b> The ability to let everyone in the chain see every actions performed toward the moving assets	<b>Anonymity</b> The potential to transact anonymously and to keep aggregate portfolios anonymous	<b>Traceability</b> The ability to trace the full chain of ownership of an asset, if and when required by contract or law	<b>Flexibility</b> The capability to be agnostic both to the type of asset transacted, and to the contract terms entered into by the any party
Workflow Automation Asset movement control can be pre- defined using Smart Contracts	<b>Immediacy</b> The characteristic of any counter party check or subsequent transaction to be immediate and final	<b>Non-Duplication</b> The impossibility to "double spend", that is, transfer a right to one party and then transfer the same right to another	Interoperability ActiveLedger allows to work side-by-side with current operations

### Active ledger Proposed SCF Model – (APO's)



### Hyperledger Based Tokenisation

Our analysis concluded that a network built on Hyperledger for both CBDCs and tokenized asset such as tokenized invoices and forward payment obligation (FPOs) will revolutionise supply chain finance (SCF). By enabling the tokenization of supply chain assets, such as invoices, purchase orders, and inventory, It will bridge the gap between traditional financial systems and tokenised assets by unlocking the full potential of digital innovation in SCF. The dual application of Hyperledger for both CBDC issuance and tokenized assets introduces a network effect that will fundamentally change supply chain finance. Hyperledger fabric would enable suppliers to tokenize receivables and settle them through CBDC, accelerating payments and minimizing costs. Hyper ledger's Fabric transactional governance ensures all transactions are traceable and secure, fostering trust among supply chain participants.

A complete end-to-end organisational framework based on Hyperledger Fabric enable verifiability, auditability, consistency, provenance, enforcement, and governance monitoring.



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- Hyperledger. (2023). "Hyperledger Fabric Documentation." <u>hyperledger.org</u>.
- Sharma, V., et al. (2021). "Blockchain in Supply Chain Finance: Applications and Case Studies." *Journal of Financial Technology*, 8(3), 45-67.
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### Hybrid Model – Distributed Ledger & CBDC

A distributed ledger will maintain a continuously growing linked list of attested transactions delivering:

Trust

- Tokenisation
- Immutability
- Transaction Governance
- Resilience







### **Tokenisation Of SCF**



#### Tokenisation

Tokenization will allow supply chain assets such as invoices, purchase orders, and receivables to be transformed into digital assets, while CBDCs provide instant, secure, and transparent settlement mechanisms.



#### **Non-Duplication**

The impossibility to 'doublespend', that is, transfer a right to one party and then transfer the same right to another.



#### Instant Multilateral transactions

Enabling simultaneous multilateral transactions



#### Traceability

The ability to trace the full chain of ownership of an asset, when required by contract or law.



#### Workflow automation

Smart contracts automate the disbursement of funds based on real-time conditions. Asset movement controlled by customised term and conditions.



#### **Real-Time Invoice Factoring**

Fractional tokenization of invoices/multiple financiers to participate/ Suppliers tokenization their invoices and selling them to financiers instantly in exchange for CBDCs.

Our hypothesis-based investigation concluded that CBDCs are technically and operationally feasible for adoption in supply chain finance

### Conclusion

A hypothesis-based approach was adopted to evaluate the transformative potential of Central Bank Digital Currencies (CBDCs), Distributed Ledger Technology (DLT), and smart contracts in supply chain finance (SCF). The hypothesis focused on the core features of transparency, tokenisation, automation, payment delays, lack of liquidity, and inefficiencies in traditional processes.

The simulation process was performed in a permissioned environment to create a trusted and efficient ecosystem that benefits all supply chain participants, addressing regulatory barriers to realise the full potential of DLT-powered supply chain finance. The technology feasibility of CBDC, DLT, and smart contracts concluded that the central bank's digital currencies could transform supply chain finance, eliminating payment delays and liquidity shortages by tokenising receivables and enabling seamless settlement through CBDCs.

The analysis of payments through smart contracts concluded that suppliers receive payments automatically once predefined conditions, such as invoice approval, integrated with distributed ledger technology (DLT). The tokenised assets can be traded, financed, and settled seamlessly using CBDCs. The simulated environment demonstrated the transformative potential of CBDCs, DLT, and smart contracts in supply chain finance and how CBDCs and DLT are well positioned to address the traditional supply chain finance system's regulatory barriers and key inefficiencies.





