

Research on Innovative Supply Chain Finance Models Empowered by Digital RMB

Xinyin Zhang^{1,*}
Yaqin Dou²
Jiayi Zhao³
Ting Hu⁴
Hengyi Cheng⁵

*Corresponding author

¹ Nanjing Institute of Technology, Nanjing, China, 2025797821@qq.com

² Professor, NJIT Institute of Industrial Economy and Innovation Management, Nanjing, China, douyq@njit.edu.cn

³ Nanjing Institute of Technology, Nanjing, China, 2475618508@qq.com

⁴ Nanjing Institute of Technology, Nanjing, China, 2598793256@qq.com

⁵ Nanjing Institute of Technology, Nanjing, China, 2487429875@qq.com

ABSTRACT

The supply chain finance in China has gone through the traditional offline stage, online stage, and internet stage, and is currently in the digitalization stage, which has made contributions to solving the financing problems of small and medium-sized enterprises with the strong push of technology. In recent years, with the research and promotion of digital RMB in China, as well as the extensive application of digital technologies such as IoT, blockchain, artificial intelligence, and big data in supply chain finance, the new supply chain finance model powered by digital RMB has gradually attracted attention from all walks of life. The digital RMB in China has gone through the research and development stage, promotion stage, test stage, and pilot stage, and has the characteristics of unlimited legal tender, dual-layer operating system, anonymity, controllability, and offline operation. Considering the pain points of traditional supply chain finance, such as lack of technical security, insufficient network infrastructure, and lack of laws and regulations, this paper proposes three innovative models of "digital RMB + prepayment", "digital RMB + accounts payable", and "digital RMB + inventory pledge", and elaborates on the operation design of the three innovative models from the core connotation and operation process perspectives. Furthermore, in light of the current technical security shortcomings, imperfect network infrastructure, and lack of laws and regulations in the operation of digital renminbi-enabled supply chain finance models, it is proposed to strengthen the digital renminbi security system, innovate supply chain finance platform construction, and intensify efforts to improve laws and regulations.

Keywords: Supply chain finance, digital RMB, small and medium-sized enterprise.

INTRODUCTION

Research Background and Significance

Research background

In recent years, driven by relevant national policies and practices, supply chain finance has emerged as an effective financing model to address the challenges faced by small and medium-sized enterprises (SMEs) in obtaining financing, garnering widespread attention from various sectors of society. The evolution of supply chain finance in China has progressed through the traditional offline stage, the online stage, the internet stage, and, propelled by digital technology, has now reached the digital stage, contributing significantly to resolving the financing issues of SMEs. Meanwhile, digital currency, with its features of traceability, strong credit, and programmability, has become a crucial initiative in advancing the construction of a modern financial system in China. It demonstrates unique advantages in addressing challenges such as difficulties in monitoring cash flow, the low efficiency and high risk associated with manual fund settlement, and poor user experience. Applying digital currency to the field of supply chain finance can enhance the operational effectiveness of supply chain finance by reducing costs, improving efficiency, and lowering risks. The supply chain finance model empowered by digital currency is beginning to be adopted in the industry. Currently, it is particularly urgent to explore innovative applications of the supply chain finance model empowered by digital currency and to propose corresponding strategies and suggestions for the problems and challenges encountered.

Research significance

Currently, many scholars have discussed the application of digital technologies such as blockchain, the Internet of Things, artificial intelligence, and big data in supply chain finance. Some scholars, focusing on the development of a low-carbon economy and the achievement of the "dual carbon" strategic goals, have proposed green supply chain finance. However, there is relatively

little research on integrating digital renminbi with supply chain finance. This paper aims to explore the innovative model of digital renminbi empowering supply chain finance based on traditional supply chain finance models, identify the problems and challenges faced, offer recommendations, enrich supply chain finance theory and the theory of industry-finance integration, and provide theoretical support for the industry to enhance supply chain financial management practices.

On one hand, it facilitates the promotion of digital renminbi. Nowadays, mobile payments have become the preferred payment method for most consumers, and physical currency is becoming increasingly rare in daily life. Unlike third-party payment methods, digital renminbi is backed by national credit and does not incur transaction fees. Since 2014, China has actively conducted research and issuance of digital renminbi, which has been piloted in multiple locations at the current stage. Integrating digital renminbi into upstream and downstream transactions and settlements in the supply chain can significantly support the national promotion and emphasis on digital renminbi, achieving its widespread application among enterprises.

On the other hand, it reduces financing costs and risks for small and medium-sized enterprises (SMEs). The supply chain finance platform empowered by digital renminbi brings together core enterprises, SMEs, and banks. SMEs can obtain low-cost funding assistance through the credit endorsement of core enterprises. Using digital renminbi as a payment tool reduces cross-bank transaction costs. The payment method based on national credit and the use of smart contracts also lower financing risks, establishing a win-win situation for all parties involved.

Based on the elucidation and analysis of relevant theories, this study examines the pain points of traditional supply chain finance operation models, explores the characteristics of digital RMB, investigates the innovation of supply chain finance models from the perspective of digital RMB empowerment, and proposes effective countermeasures and suggestions for potential problems and challenges in integrating digital RMB into supply chain finance business, aiming to enhance the efficiency and effectiveness of supply chain finance services for small and micro enterprises.

Analysis of the Current State of Research Domestically and Internationally

The concept, essence, and function of supply chain finance

Timme and Williamite (2000) suggested that to achieve the overall goals of the supply chain, all participants, including financial service institutions such as banks and factoring companies, need to closely collaborate. Berger and Udell (2006) proposed a more comprehensive conceptual framework to analyze the credit availability issues for small and medium-sized enterprises (SMEs), suggesting that a more thorough financial assessment can be conducted before providing funds to reputable, transparent, or non-transparent SMEs. With technological advancements, many scholars have defined the concept of supply chain finance from the perspective of the application of internet and digital technologies. Additionally, with the development of the low-carbon economy, Xu, Wang, and He (2022) and He and Kuang (2023) proposed that green supply chain finance integrates green and environmental awareness into all aspects of supply chain management, representing a trend towards environmentally friendly supply chain management. Leuschner *et al.* (2023) believes that a new overall goal has emerged in supply chain management, which is to provide funding for organizations. This is achieved by leveraging cash flows and other financial support between buyers and suppliers, focusing on optimizing cash flow and ensuring liquidity. Supply chain finance can enhance supply chain transparency and reduce financing costs (Atkinson, 2008), while enabling real-time monitoring and optimization of cash flow (Wuttke, Blome, & Forest, 2013). Additionally, research has shown that supply chain finance can reduce inefficient investments (Xu, Sun, and Ao, 2023) and improve corporate innovation capabilities and performance. (Song, Huang, & Yang, 2021).

Innovation in supply chain finance models

He *et al.* (2020) found that blockchain technology-driven supply chain finance platforms aim to address trust issues, enhance the efficiency of capital and information flow, and provide optimized financial services to all parties in the supply chain. Natanelov *et al.* (2022) demonstrated the innovative potential of blockchain and smart contracts in supply chain finance (SCF) based on the cross-border beef supply chain from Australia to China. Through mechanism design and design-driven activities, the group buying business model was proposed as a foundation for the entire supply chain finance, which is expected to offer new avenues for SCF models. Wang (2022), from a service freedom perspective, proposed three key mechanisms to promote system construction: first, the "123 synchronization mechanism," aimed at achieving synchronized development of industry and finance; second, a risk prevention mechanism to mitigate systemic risks; and third, a power empowerment mechanism to enhance the intrinsic motivation of the ecosystem and promote the integrated development of "industry + finance".

Digital RMB and supply chain finance

From a theoretical research perspective, Bai (2022) discussed the changes that digital RMB brings to the financial system and the transformation of the roles of commercial banks in the new financial ecosystem. The study analyzed how the programmability of digital RMB affects the traditional functions and services of commercial banks. Meanwhile, digital RMB plays a significant role in many areas. Xiao (2022) explored the application of digital RMB in the power supply chain finance sector, detailing how digital RMB empowers the business processes of power supply chain finance and its effectiveness in improving financing efficiency and reducing operational costs. Supply chain finance has also innovated many applications based on digital RMB. Ou *et al.* (2023) examined the application of digital RMB in supply chain finance, including factoring financing models, bank acceptance bill financing models, and prepayment financing models. They proposed ways to empower supply chain finance by reducing transaction costs, enhancing capital utilization efficiency, and extending the industrial chain.

However, the emergence of any innovation is always accompanied by risks, and relevant scholars have conducted research on how to effectively respond. Gao (2023) using Stackelberg game theory and mean-variance theory, considered the impact of the risk attitudes of suppliers, retailers, and banks on supply chain decisions, and proposed suggestions such as increasing digital RMB subsidies and encouraging supply chain participants to adopt a positive attitude towards transaction risks arising from the use of digital RMB. Traditional supply chain finance faces challenges such as difficulty in financing, high financing costs, and information asymmetry, but digital RMB can effectively enhance its service capabilities. Zheng (2023) analyzed how digital RMB enhances supply chain financial service capabilities through technological advantages such as smart contracts, blockchain, and dual offline payments. He proposed that only by breaking the information barriers on the chain can the effectiveness of financial inclusion be improved and financial risk control capabilities be strengthened.

From a practical perspective, many large corporations are innovating supply chain financial models based on digital RMB. For example, JD Group's supply chain financial products provide lending convenience to small and medium-sized enterprises, while also actively utilizing digital RMB to address new challenges. Another example is Jinneng Holding Power Group. Ge (2023) reviewed the motivations and background for Jinneng Holding Power Group's adoption of digital supply chain finance and described in detail the key steps and methods taken during the implementation process. This distilled a model applicable to the power generation industry, providing a reference for other enterprises in the same sector, and proposed the idea of alleviating financing constraints and enhancing supply chain value. Digital RMB is also an important tool for building a financially strong nation.

Review of Current Research

Through a comprehensive analysis of existing literature, scholars both domestically and internationally have extensively explored the connotation, essence, and functions of supply chain finance. They have also examined digital supply chain finance models and green supply chain finance models in the context of the digital economy and green economy, providing a solid theoretical foundation and research methodologies for this study.

Currently, with the development and application of digital RMB in China, and its use in the field of supply chain finance, some scholars have begun to focus on "digital RMB + supply chain finance." However, there is a scarcity of literature that systematically analyzes the operational design, issues, and coping strategies of innovative models of supply chain finance empowered by digital RMB. There is also a lack of systematic research on the challenges and governance strategies faced by supply chain finance empowered by digital RMB. Therefore, this paper intends to analyze the development process and characteristics of digital RMB in China and propose innovative models of supply chain finance empowered by digital RMB, addressing the pain points and difficulties in traditional supply chain finance operations. A relatively systematic theoretical framework will be constructed for the innovative models of supply chain finance empowered by digital RMB, from the perspectives of process design, encountered issues, and governance strategies.

THEORETICAL ANALYSIS

Definition of Concepts

Digital renminbi

e-CNY, or digital Renminbi, is the digital form of legal tender issued by the People's Bank of China. It is an abbreviation for China's central bank digital currency (DC/EP), sometimes also referred to as Digital Currency and Electronic Payment (DCEP). The primary objective of this currency is to replace cash (M0) in circulation in the market. It holds the same legal status as banknotes and coins, ensuring its value attributes and the ability for mandatory circulation.

The attributes of e-CNY include its legal status, digital nature, and basic functions as a currency. He (2021) noted that in terms of issuance mechanism, e-CNY adopts a centralized management model and a two-tier operational system. Its main objective is to partially replace cash in circulation (M0), and it possesses advanced features such as dual offline payment capability, tiered limit control, and neutrality towards technical platforms. The design achieves a loose coupling with bank accounts, allowing users to create digital RMB wallets without the need for traditional bank accounts. e-CNY fully considers the convenience of user experience, the security of transaction processes, the universality of services, the protection of personal privacy, and regulatory compliance. Similar to physical RMB, digital RMB represents a liability of the central bank to the public and holds the same legal effect and economic value.

Supply chain finance

Supply chain finance refers to a model that depends on the collaborative cooperation among financial institutions, supply chain participants, and supporting service providers. Within this framework, small and medium-sized enterprises (SMEs) in the supply chain can apply for financial support from financial institutions based on the creditworthiness of core enterprises. It essentially integrates information flow, capital flow, and logistics within the supply chain, leveraging the credit endorsement of core enterprises to address financing difficulties for upstream and downstream SMEs, while enhancing the operational efficiency of the entire supply chain. Its main purpose is to enhance the circulation efficiency of funds within the supply chain and reduce transaction costs, thereby improving the overall operational efficiency and market competitiveness of the supply chain. Within the framework of supply chain finance, the key lies in unblocking and coordinating the flow of information, goods, and cash across various stages of the supply chain. By increasing the transparency and shareability of this information, financial

organizations can more accurately assess the credit status and funding needs of enterprises, enabling them to provide more flexible and cost-effective financial solutions. This mechanism plays a positive role in alleviating the financing difficulties of SMEs, given that these enterprises often face challenges such as insufficient collateral or limited credit history, making it difficult to obtain necessary loan support through traditional banking channels.

Theoretical Foundation

Integration of industry and finance

The integration of industry and finance refers to the organic combination of industrial capital and financial capital, aiming to achieve the optimal allocation of resources and synergy effects. (Hong, 2025). Such integration is achieved through financial means to drive the growth and innovation of the real economy. The implementation pathways of industry-finance integration are diverse, including financial institutions providing capital support to enterprises and collaboration between the industrial and financial sectors to jointly develop new financial products and services to meet the development needs of industries. Its goal is to achieve efficient allocation of capital, promote sustainable economic development, and enhance the competitiveness of industries.

Supply chain finance is a key implementation method in the strategy of integrating industry and finance. It provides financial assistance to enterprises upstream and downstream of the supply chain through financial institutions, thereby promoting the optimization of capital flow and the improvement of cooperation efficiency. Additionally, supply chain finance helps enterprises mitigate potential issues in the supply chain, such as payment delays and excessive inventory risks. By offering services such as financing and insurance, supply chain finance aids in reducing operational risks for enterprises, stabilizing supply chain operations, and further promoting the deepening development of industry-finance integration. In this article, digital renminbi is introduced as a new payment method into supply chain finance, achieving innovation in industry-finance integration. This not only aligns with the national policy of promoting digital renminbi pilot projects but also reduces the financing costs for small and micro enterprises and enhances financing efficiency.

Digital ecosystem

The digital ecosystem is primarily composed of the following three core elements, which synergize with each other to build the economic ecosystem in the digital era: industrial ecology, producer services, and big data. Its essence lies in leveraging big data to inject productive services into the industrial ecosystem. The formation of a digital ecosystem relies on the digital restructuring of the economy, where the key is a unified trading market, financial services flowing with transactions, and a consistent ecosystem operation platform. A unified trading market is a centralized, standardized trading platform that allows participants to buy and sell goods, services, or financial assets under common rules and standards. Such a market can enhance trading efficiency, reduce costs, increase liquidity, and promote price transparency. Financial services flowing with transactions represent the transfer of financial assets such as funds, securities, and derivatives during transactions in the real economy. Through bank loans and supply chain finance, cash flow can be achieved, effectively alleviating the financing difficulties and high costs faced by small and medium-sized enterprises. The same supply chain finance ecosystem operation platform can resolve the information asymmetry issues among banks, industries, and service organizations. It is an integrated, standardized system or framework that supports industrial enterprises in achieving efficient and coordinated operational activities. The supply chain finance ecosystem operation platform can facilitate the optimal allocation of resources, automation of processes, intelligent decision-making, and improve overall operational efficiency. In this paper, the supply chain finance ecosystem operation platform empowered by digital renminbi can realize the use of digital renminbi as a payment tool for supply chain transaction flows, utilizing intelligence to achieve full-process online operations of the supply chain, thereby reducing process costs and ensuring fund security.

THE DEVELOPMENT OF DIGITAL RMB AND ITS BASIC CHARACTERISTICS

The Development of Digital RMB

Research and development phase (2014-2016)

Since 2014, China has initiated research on the central bank's legal digital currency, known as the digital RMB (e-CNY). This research project, led by the People's Bank of China (PBOC), involved the formation of a dedicated research team. The team conducted in-depth studies on the operational model, technological foundation, circulation conditions, legal challenges, and international practices of other central banks in issuing digital currencies. (Zhou and Li, 2023). This initiative marked the digital RMB as potentially the world's first digital currency issued by a national bank.

Advancement phase (2016-2020)

In 2016, the PBOC established a digital currency research institute, successfully developing the first prototype system for a legal digital currency. In the same year, the central bank also developed a blockchain-based digital bill trading platform prototype and conducted sandbox testing for the legal digital currency. (Wang & Jia, 2020). In 2017, the PBOC's Digital Currency Research Institute was established in Shenzhen, signaling the transition of China's digital RMB from theoretical research to practical application. China's digital currency follows a two-tier distribution system tailored to the country's developmental stage, currently primarily adopting a centralized management model, with cautious use of smart contracts. In October 2019, to align with the needs of fintech development, China actively advanced the research and development of its legal digital currency, and had already achieved significant progress. (Hu & Xie, 2022).

Testing phase (2020-2022)

From 2020 to 2022, China's digital RMB made notable progress in research and development, gradually entering the testing phase. The PBOC adhered to the principles of safety, controllability, and innovation, comprehensively evaluating the theoretical reliability, system stability, functional usability, operational convenience, scenario applicability, and risk control capabilities of the digital RMB. These relevant evaluations were conducted in regions such as Shenzhen, Suzhou, Xiongan New Area, Chengdu, and the venues for the 2022 Beijing Winter Olympics. In November 2020, pilot areas were expanded to include Shanghai, Hainan, Changsha, Xi'an, Qingdao, and Dalian. Considering national development strategies, regional coordination plans, and the industrial and economic characteristics of different areas, pilot programs were also extended to regions like the Yangtze River Delta and the Pearl River Delta, enabling a broad assessment of the digital RMB's nationwide application potential. In July 2021, the PBOC announced further efforts to advance the digital RMB pilot program and improve related policies and institutional frameworks.

Pilot phase (2022-Present)

In January 2022, residents in 11 pilot regions, including Beijing, Shanghai, and Shenzhen, could use the digital RMB to pay for food delivery. The Digital RMB (Pilot Version) app was made available for download on Android and Apple app stores. On February 17, 2022, China's digital RMB broke Visa's 36-year monopoly on payment services at the Olympics. The Digital RMB app supports a wide range of scenarios. During 2023, it has enhanced service experiences in both personal and corporate services—such as salary payments, financing, and green finance—as well as government services, including fiscal revenue, tax payments, and public utilities, thereby supporting the real economy. Data indicates significant growth in the number of digital RMB wallets, transaction volumes, and merchant outlets, reflecting strong public adoption. Notably, many regions have highlighted innovative use cases. For example, the digital RMB has improved accessibility for the elderly, with services like the "Longevity Card" digital wallet in Huzhou, Zhejiang. In Hangzhou and Shaoxing, Zhejiang, the integration of the "Ride Code" with the digital RMB allows quick access by scanning the Digital RMB app. These examples demonstrate the digital RMB's deep integration into daily life, offering diverse and convenient services.

Basic Characteristics of Digital RMB***Unlimited legal compensation***

Legal compensation means that digital RMB must be accepted by any merchant at any time without refusal, equivalent to paper currency and coins. Unlike Bitcoin or Libra, which lack this feature and thus have limited application scenarios, digital RMB is not affected by the bankruptcy of enterprises or banks. While commercial bank deposits are insured (with full coverage for amounts under ¥500,000), this does not constitute unlimited legal compensation. Third-party payment methods, lacking deposit insurance, expose users to significant risks in case of failure. However, digital RMB, backed by national credit, is more secure. In 2020, the revised draft of the "Law of the People's Republic of China on the People's Bank of China" recognized digital RMB as a form of legal tender, providing a legal basis for its unlimited legal compensation. (Feng, 2022).

Two-tier operating system

The digital RMB adopts a two-tier operating system, an innovative design suited to China's conditions, aimed at effectively managing the issuance and circulation of the digital currency. The PBOC does not directly issue or exchange the central bank digital currency with the public. Instead, it distributes the digital RMB to designated operating institutions (e.g., commercial banks or other financial institutions), which then exchange it with the public. Meanwhile, these operating institutions are required to deposit 100% reserves with the PBOC, ensuring a 1:1 exchange process. (Feng, 2022). The core advantage of this two-tier model lies in its risk dispersion and stability. It avoids potential financial disintermediation under a single-tier system, reduces the crowding-out effect on commercial bank deposits, and safeguards the lending capacity of commercial banks and the healthy development of the real economy (as shown in Figure 1).

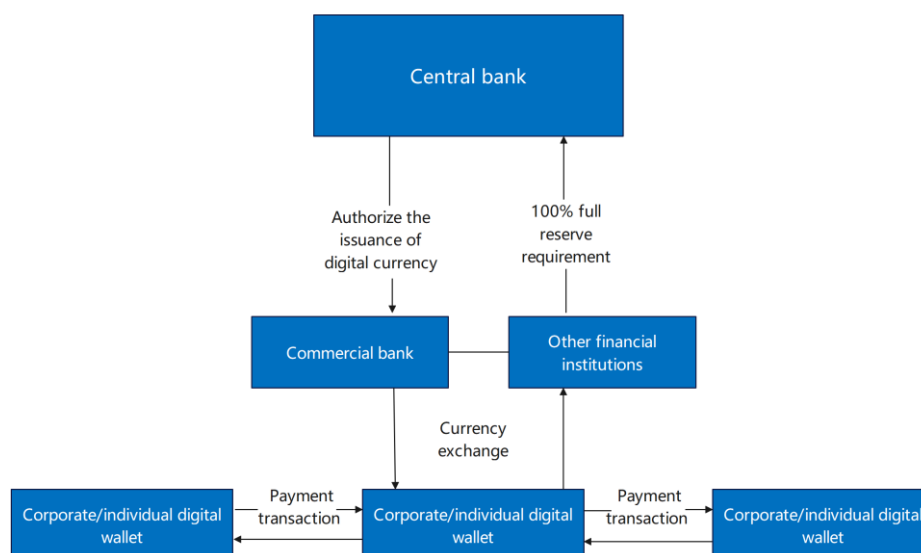


Figure 1: Two-Tier Operating System of Digital RMB

Anonymity

Anonymity aims to meet reasonable demands for private payments and privacy protection, offering limited rather than complete anonymity. Small transactions can be conducted using anonymous wallets, requiring only a mobile number for activation, thus protecting user privacy. Regulations stipulate that customer information must not be disclosed by mobile or telecom operators to third parties, ensuring anonymity for wallets linked to phone numbers. Unlike other payment methods used in platform shopping, e-CNY is pushed through sub-wallets without requesting user information permissions, satisfying most users' privacy needs. Additionally, hardware wallets resembling "prepaid cards" can be used without ID or bank information registration. Limited anonymity applies to large transactions, which require personal information.

Controllability

Controllability means protecting reasonable anonymity while maintaining the ability to combat illegal activities. The anonymity of digital RMB must be risk-controlled, as fully anonymous digital currencies are impractical. While full anonymity protects privacy, the PBOC's moderate access to personal information aids in tracking financial crimes, improving efficiency, and reducing risks like money laundering and terrorist financing. Users generally trust central authorities to safeguard their basic information. Thus, balancing convenience and traceability is essential, aligning with anti-money laundering and counter-terrorism financing obligations for central banks, financial institutions, and virtual asset providers.

Dual offline capability

The "dual offline" payment feature of digital RMB is an innovative technology enabling transactions between payers and recipients without an internet connection, using NFC technology. This is particularly useful in areas with poor signal coverage, such as basements, parking lots, remote mountainous regions, or during natural disasters, ensuring payment system stability. E-CNY wallet primarily comes in two forms: APP wallets and hardware wallets. Among them, hardware wallets are embedded with secure chips and serve as the core enabler of "dual offline" payments. These "dual offline" payments are primarily conducted through the "touch-and-go" method, which relies on NFC technology to facilitate information exchange and payment functions between devices. However, while this payment method can be completed without an internet connection, the receiving device still requires a power supply. The White Paper on the Progress of e-CNY Development highlights that the offline functionality of the digital yuan addresses the needs of elderly individuals, people with disabilities, and those who do not use smartphones, underscoring the necessity of this feature.

ANALYSIS OF PAIN POINTS IN TRADITIONAL SUPPLY CHAIN FINANCE MODELS

Traditional supply chain finance relies on the credit guarantees of core enterprises, providing financing to upstream and downstream SMES based on genuine trade relationships. Initially, this model alleviated financing difficulties for SMES by closely integrating with industrial chains. However, with the rapid development of information technology and e-commerce, traditional supply chain finance faces significant challenges in addressing information asymmetry, data sharing, risk mitigation, and credit transparency (as shown in Figure 2).

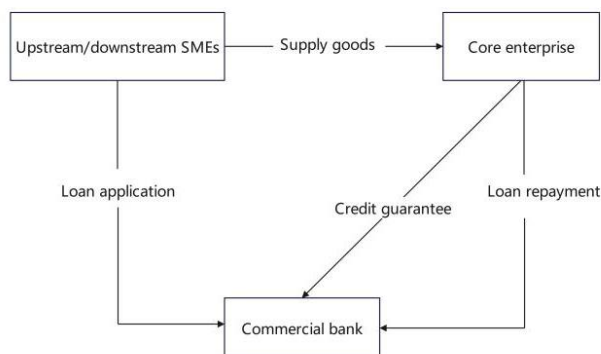


Figure 2: Traditional Supply Chain Finance Operation Model

Information Opacity Between Lenders and Borrowers

Traditional supply chain finance, especially early offline models, primarily assessed risk based on client credit, requiring comprehensive borrower information. However, information asymmetry leads to incomplete transparency, particularly in Dynamic movable property pledge behavior using inventory as collateral, which is harder to monitor than traditional collateral like real estate. Frequent asset and fund changes make inventory tracking difficult, and unclear supervisor in charge hampers effective communication with financial institutions. Without IoT or cloud-based internal information-sharing platforms, financial institutions struggle to resolve internal information asymmetry, impairing risk management.

Data Gaps

In traditional supply chains, insufficient IT adoption results in data gaps between investment and financing entities. For instance, without block-chain, supply chain finance lacks a shared ledger, increasing auditing and reconciliation costs. Data from financial institutions, SMES, and regulators remains siloed, preventing the formation of accessible big data centers. Sensitive information like assets cannot be selectively shared, eroding trust and security. Similarly, without IoT, financial institutions cannot monitor movable property in real-time, failing to adequately prevent risks including false collateralization and double-pledging of movable property, which limits BD (business development) and risk control.

Inadequate Risk Management in Financing

Risks arising from information systems or internal controls can be divided into two main phases. The first occurs during the investigation phase, where verifying the authenticity and validity of accounts receivable bills or warehouse receipts between core enterprises and suppliers requires specialized expertise. The second phase involves operational model design, where the robustness of process design determines whether such risks exist. Every step—from verification to supervision—must be strictly enforced to prevent procedural loopholes. Additionally, internal fraud risks may arise if employees violate professional ethics. Unethical staff may exploit their positions to engage in fraudulent activities, such as tampering with transaction records or impersonating others to conduct unauthorized transactions, leading to financial losses and a crisis of trust. Such risks stem from inadequate internal risk management, enabling collective "collusion" and "fraudulent cash-outs" among supply chain firms, ultimately exposing commercial banks to financial hazards. For example, LuoJing, the major shareholder of Noble Century International, was detained by police on suspicion of fraud after the company allegedly fabricated trade contracts and accounts receivable with major corporations like JD.com to defraud financial institutions, involving billions in funds.

Corporate Credit Crises

In supply chain finance, small and medium-sized enterprises rely on the strong creditworthiness of core enterprises to obtain financing services. However, if the core enterprise's credit deteriorates, it can deal a fatal blow to the entire supply chain. Therefore, it is essential to conduct not only credit assessments of the financing entities themselves but also entity credit ratings and obligation credit ratings for the core enterprises. During the specific review process, it is necessary to evaluate not only the enterprise's operational status, development prospects, and financial health but also to assess the transaction risks—known as obligation credit rating—since the creditworthiness in supply chain finance depends not only on the borrower but also on the supply chain's operational environment, industry dynamics, business activities, and task-specific factors. In contrast, financing methods secured by real estate or land primarily or entirely rely on entity credit ratings, highlighting the more stringent requirements of supply chain finance. On the other hand, financial institutions typically gain indirect insights into upstream and downstream suppliers and customers through core enterprises, leading to information asymmetry. Many of these supply chain partners operate in emerging industries or are small-scale enterprises with less standardized management, making data collection more challenging. The lack of reliable historical transaction data prevents financial institutions from fully assessing the creditworthiness of borrowing firms, thereby exacerbating credit constraints.

SUPPLY CHAIN FINANCE INNOVATION MODEL EMPOWERED BY DIGITAL RMB

"Digital RMB + Advance Payment" Model

The "Digital RMB + Advance Payment" model is primarily used in corporate procurement, focusing on downstream distributors (i.e., small, medium, and micro enterprises seeking financing) signing repurchase agreements with upstream core enterprises. Warehouse receipts confirmed by logistics agencies designated by the supply chain finance platform are used to apply for loans from commercial banks. The repayment source will be the future sales revenue of the downstream distributors. All fund transfers and settlements are fully conducted through digital RMB wallets (as shown in Figure 3).

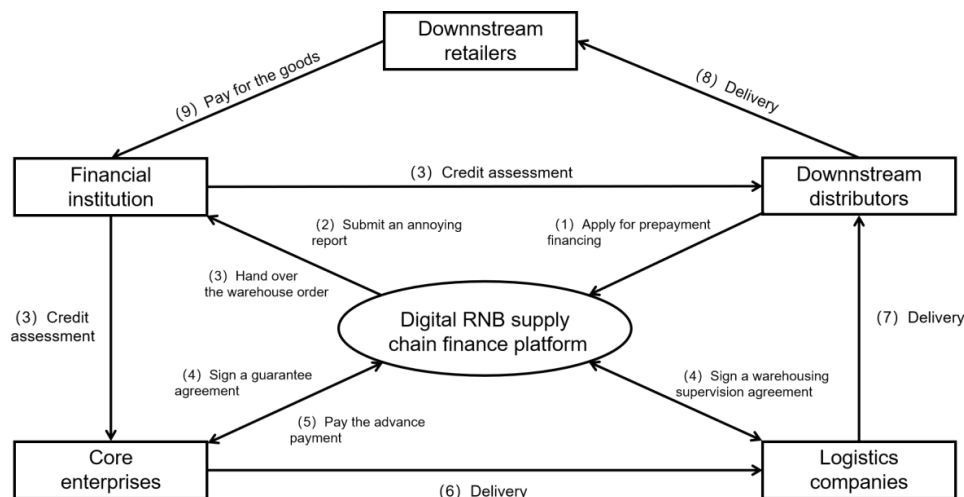


Figure 3: "Digital RMB + Prepaid Accounts" Model

During the loan application and credit review stage, downstream distributors are required to prepay funds to purchase goods from core enterprises. They sign purchase and sale contracts with these core enterprises, using the contracts as credit guarantees to apply for financing from financial institutions. Meanwhile, the digital RMB supply chain platform creates a smart contract-enabled digital wallet for each enterprise on the chain and sets up public wallets. Leveraging the traceability of digital RMB, the platform monitors the transaction amounts and purposes between core enterprises and downstream distributors. By utilizing the controllable anonymity feature of digital RMB, it verifies the legality and reasonableness of historical large transactions, screens out risks of malicious money laundering, terrorist financing, and coordinated fraud, and generates credit assessment reports to be shared with financial institutions. Financial institutions evaluate the operational performance, growth potential, and financial health of core enterprises and downstream distributors to assign credit ratings and assess the safety of providing financing and ensuring fund recovery. They also examine digital RMB-based transactions to rate relevant credit items and identify potential debt default risks. At the same time, by harnessing the programmability of digital RMB, the platform establishes buyback and quality assurance agreements with upstream suppliers through smart contracts, as well as warehousing supervision agreements with logistics providers. Separate smart contract modules are developed to enable conditional payments and the automatic execution of contractual terms. Based on cooperation terms between financial institutions and enterprises—such as delivery schedules, financing amounts, payment conditions, supervisory roles, and timelines—these parameters are pre-coded into smart contracts to generate electronic contracts and signatures. The platform submits warehouse receipts to financial institutions, and the smart contract automatically verifies whether the receipts meet the execution criteria. Upon confirmation via electronic signatures, the disbursement of digital RMB is executed automatically.

The loan disbursement phase. The digital RMB supply chain platform transfers the prepayment requested by downstream distributors into its public wallet in the form of digital RMB. At the same time, it routes the funds to the core enterprise's public wallet via the transaction module, completing the entire digital RMB financing process. After depositing the prepayment into the core enterprise's public wallet as digital RMB, the platform secures the right to withdraw goods, instructs the core enterprise to ship the goods to a designated logistics warehouse, and the logistics provider collects goods data using IoT technology to generate electronic warehouse receipts, sharing information with financial institutions around the clock. Downstream distributors then submit a deposit for goods withdrawal, prompting financial institutions to issue online instructions to logistics providers, releasing the corresponding amount of goods release rights to the downstream distributors.

The loan recovery phase. Downstream distributors subsequently deliver the goods to downstream retailers, who pay part of the invoice directly into the financial institution's public wallet in digital RMB according to the terms of the smart contract. The digital RMB-enabled smart contract automatically executes relevant instructions until both payment and delivery are fully settled.

"Digital RMB + Accounts Receivable" Model

Under the "Digital RMB + Accounts Receivable" model, upstream suppliers pledge accounts receivable as collateral to apply for loans, securing funds for subsequent production. The platform evaluates the repayment capacity of supply chain enterprises

individually and assesses their creditworthiness. This scenario typically arises during the sales phase and is most suitable for enterprises with strong credit profiles. All financial transactions and settlements are conducted exclusively through digital RMB wallets (as shown in Figure 4).

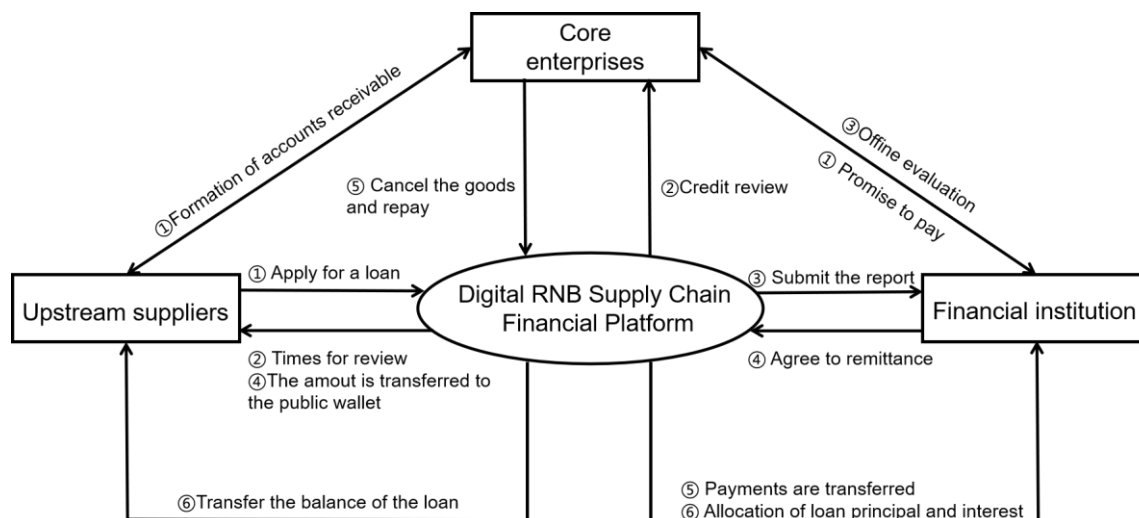


Figure 4: "Digital RMB + Accounts Receivable" Model

During the loan application and credit review stage, the core enterprise needs to purchase goods from upstream suppliers and sign sales contracts. However, since the upstream supplier has not yet received payment but requires cash flow, they pledge accounts receivable notes as collateral to apply for a loan from financial institutions. The core enterprise commits to timely repayment, forming an accounts receivable pledge contract with the financial institution, contingent upon the validity of the accounts receivable. Meanwhile, the digital RMB supply chain platform creates a smart contract-enabled digital wallet for each enterprise on the chain and issues public wallets. Leveraging the traceability of digital RMB, the platform tracks the transaction amounts and purposes between the core enterprise and upstream suppliers using digital RMB. Utilizing the controllable anonymity feature of digital RMB, the platform verifies the legality and reasonableness of historical large transactions, rules out risks of malicious money laundering, terrorist financing, and coordinated fraud, generates a credit assessment report, and shares it with financial institutions. Financial institutions evaluate the enterprises' credit ratings offline based on their operational status, growth prospects, and financial health, assessing the safety of providing financing and ensuring capital recovery. They also review the transaction history between the two parties conducted in digital RMB, rate relevant credit items, and assess potential risks of debt default.

During the loan disbursement stage, the financial institution's smart contract automatically executes terms once the accounts receivable are confirmed to be valid. It grants credit to the upstream supplier through the digital RMB supply chain platform, directly transferring the loan in the form of digital RMB into the upstream supplier's public wallet for subsequent fund circulation.

During the loan repayment stage, after the core enterprise sells the goods and receives payment in digital RMB, the amount is deducted from the core enterprise's credit limit and transferred into the platform's public wallet. The platform transfers the principal and interest of the loan to the financial institution's public wallet, with the remaining balance, representing the difference between the loan and accounts receivable, transferred to the upstream supplier's public wallet. Upon receiving the principal and interest of this financing, the digital RMB accounts receivable pledge contract automatically terminates through the execution of relevant instructions.

"Digital RMB + Inventory Pledge" Model

The "Digital RMB + Inventory Pledge" model involves the platform utilizing the Internet of Things and cloud computing to dynamically monitor movable property pledges for small and medium-sized enterprises (SMEs). SMEs pledge their inventory as collateral to obtain financing from financial institutions, with future sales revenue from the inventory serving as repayment source. This model applies to the production processes of SMEs possessing eligible inventory pledges, with all fund settlements conducted exclusively through digital RMB wallets (as shown in Figure 5).

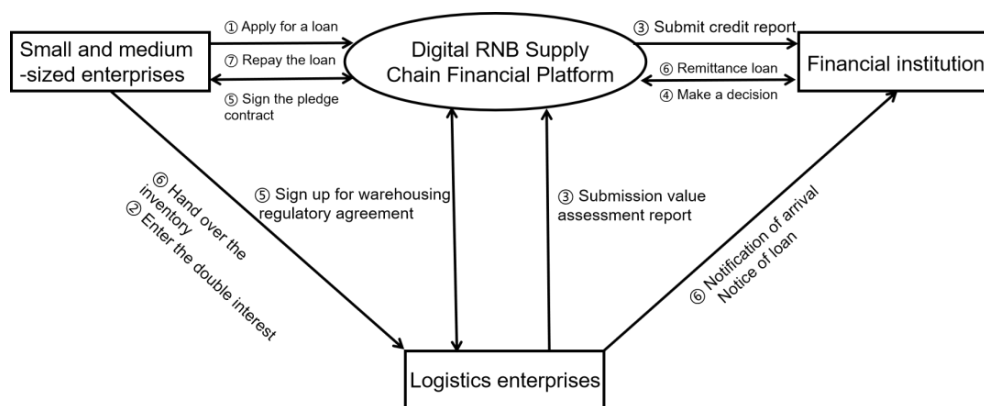


Figure 5: "Digital RMB + Inventory Pledge" Model

During the loan application and credit review stage, small and medium-sized enterprises (SMEs) use their inventory as collateral to apply for inventory-backed loans from financial institutions via the platform. Simultaneously, the digital RMB supply chain platform creates a smart contract-enabled digital wallet for each enterprise on the chain and sets up a public wallet. Using IoT electronic tag technology and standardized interfaces, the platform inputs the inventory information of SMEs into the system. The value of the SMEs' inventory is assessed through IoT and big data technologies and then submitted to financial institutions via the digital RMB supply chain finance platform. Offline, financial institutions evaluate the credit rating of SMEs based on their operational status, growth potential, and financial health to assess the safety of providing financing and ensuring capital recovery. By leveraging the traceability of digital RMB, financial institutions review the transaction history of SMEs using digital RMB, rate relevant credit items, identify risks of debt default, and decide whether to provide financing. Utilizing the programmability of digital RMB, the platform signs inventory pledge contracts with SMEs and storage supervision agreements with logistics companies. Separate smart contract modules are developed to enable functions such as conditional payments and automatic execution of contract terms. Based on the cooperation terms between financial institutions and SMEs—such as inventory quality compliance, delivery timelines, loan amounts, payment recipients, inventory supervisors, and timeframes—these details are pre-coded into smart contracts to generate electronic contracts and signatures. Meanwhile, the platform requires SMEs to transfer their inventory to designated logistics companies. Logistics companies inspect the inventory according to the smart contract terms and monitor the goods 24/7 using big data, sharing real-time inventory data with financial institutions to ensure its safety.

During the loan disbursement phase, the proceeds from small and medium-sized enterprises selling their inventory are deposited into a public wallet in the form of digital RMB. The smart contract's repayment terms are automatically executed via the digital RMB supply chain platform, transferring the funds to the financial institution's public wallet. The digital RMB inventory pledge contract is then automatically terminated, and the relevant instructions are carried out.

CHALLENGES FACING THE INNOVATION OF SUPPLY CHAIN FINANCE MODELS EMPOWERED BY DIGITAL RMB

Insufficient Technical Security

First, small transactions can result in ambiguity in identity verification. The standout advantage of the digital RMB's loosely-coupled feature is its exceptional accessibility, enabling transfers without relying on banks. This has greatly advanced the progress of inclusive finance, and its significance cannot be overstated. Any account linked to a legitimate document capable of verifying personal identity holds the potential to function as a digital currency wallet. Beyond the traditional banking system, other systems like social security, driver's licenses, and identification cards may lack the online risk control capabilities required by banks. Consequently, this introduces new challenges for the security and risk management of supply chain finance platforms. While the loosely-coupled feature permits small payments to bypass traditional bank accounts, large-value transactions in supply chain finance still necessitate binding to a bank account. In cases involving cross-bank transactions, it becomes imperative to clearly identify user identities to prevent transactional confusion. This requirement for identity verification ultimately ties back to the definition of the concept of an "account".

Secondly, there is a risk of money laundering. Despite measures to impose limits on anonymous accounts, criminals may abuse numerous anonymous accounts to launder money via small-value transactions. Prosecutor Li Boyu noted that digital RMB payments require users to open a personal digital wallet via an app and make purchases by scanning a code. At present, services and regulations remain underdeveloped, allowing criminals to exploit these gaps for money laundering. Similar issues could emerge if digital RMB is adopted in supply chain finance. For instance, in 2023, a man, following instructions from an online "friend", traveled to Kunming and used illegal software to remotely operate a phone. He employed payment codes and facial recognition data to make payments, posing as a fraud victim using digital RMB for consumption in order to facilitate money laundering.

Third, the risks of internal technical flaws and external attacks. Internal technical issues include challenges related to compatibility and system upgrades. Given that the operation of the digital RMB involves multiple institutions and technology platforms, compatibility problems could lead to delays or failures in transaction processing. Additionally, with the rapid advancement of technology, system upgrades and maintenance may present significant challenges. External threats, such as hackers compromising suppliers' software or hardware, can indirectly harm financial institutions. Both banks and small and medium-sized enterprises (SMEs) involved in supply chain finance must have robust risk management capabilities. Mishandling these risks could disrupt normal digital RMB transactions, necessitating further enhancements in technical design to ensure secure currency operations.

Inadequate network infrastructure

First, platform monopolies may arise emerge. The integration of the digital RMB into supply chain finance imposes stringent requirements on platform qualifications. Consequently, only a handful of companies can build digital RMB-enabled supply chain finance platforms, preventing the development of a competitive ecosystem with diverse participants. This raises the possibility of a single dominant player, leaving SMEs in regions with weaker network infrastructure with limited options. This significantly hinders the broader adoption of the digital RMB and risks stifling its innovative potential in the supply chain finance sector. Practical implementation in both online and offline scenarios becomes challenging, undermining the widespread applicability of supply chain finance.

Second, there is a lack of network infrastructure with strong technical integration capabilities. Establishing digital RMB supply chain finance platforms in areas with insufficient network coverage or subpar network quality could hinder the effective use and circulation of the digital RMB. The application of digital RMB in supply chain finance encounters various challenges and requirements, including network stability and coverage quality, the flexibility and adaptability of cloud computing resources, the profound analytical insights from big data, the improvements in processing speed and accuracy brought by artificial intelligence, the security and transparency ensured by blockchain technology, the real-time monitoring capabilities of IoT devices, the rapid information exchange enabled by mobile communication technologies, the multi-layered protection provided by cybersecurity measures, and the role of banks in data sharing and service innovation.

Absence of Legal Frameworks

The emergence of digital RMB has significantly impacted the existing financial system and monetary framework, necessitating effective legal regulation and oversight. In this context, it is imperative to refine the legal framework for digital RMB to mitigate uncertainties and potential risks associated with innovations in supply chain finance models.

Firstly, there is an absence of national legal safeguards. According to the White Paper, digital RMB constitutes a liability of the People's Bank of China to the public, supported by national credit. However, its status as legal tender is not explicitly established by law. Currently, Article 16 of the Law of the People's Republic of China on the People's Bank of China states that the legal currency of the People's Republic of China is the RMB. Article 2 of the Regulations on the Administration of the Renminbi specifies that the RMB exists in the forms of coins and banknotes, without acknowledging its digital form (Gao, 2022). It is noted that the 2020 draft revision of the Law of the People's Republic of China on the People's Bank of China (Draft for Public Comment) proposed including both physical and digital forms of the RMB, thereby providing a legal foundation for the issuance of digital RMB. This provision indicates that digital RMB will attain the status of legal tender and will be issued and managed by the People's Bank of China. Although this revised draft has some reference value, it still lacks legal binding force concerning the use of digital RMB in supply chain finance (Lu, 2022).

Secondly, there is no dedicated legislation or regulation for digital RMB, and its operational framework remains vague. There is no systematic effort to consolidate lessons learned from pilot programs integrating digital RMB into supply chain finance, nor is there an analysis of issues identified during these trials, preventing the creation of case studies to guide the operation of future digital RMB-based supply chain platforms. Additionally, there are no corresponding laws that specify the functions and scope of digital RMB wallets, including but not limited to wallet setup, fund storage, transfers, and inquiries, while clarifying the rights and obligations of banks and small- and medium-sized enterprises (SMEs), such as banks' disclosure obligations and SMEs' responsibilities for transaction security.

Finally, there is a lack of regulatory systems governing smart contracts for digital RMB. Given that digital RMB serves as a payment instrument in supply chain finance and its smart contract capabilities are used to establish agreements and facilitate subsequent transactions, there is an urgent need for legal safeguards to ensure its accessibility.

DIGITAL RMB EMPOWERING SUPPLY CHAIN FINANCE MODEL INNOVATION

Governance Strategies Strengthen the Security Framework of the Digital RMB

First, enforce strict market access supervision. Core enterprises and banks utilizing the Digital RMB as a payment tool in supply chain finance must secure approval from national regulatory authorities and undergo regular inspections by regulators or third-party risk assessments. Simultaneously, the credit reporting system for small and medium-sized enterprises on the chain should be enhanced to standardize the use of the Digital RMB, preventing companies with poor credit from overextending or overspending, while ensuring the traceability of account identities during large Digital RMB transfers on supply chain finance platforms.

Second, reinforce anti-money laundering technical support for the Digital RMB. On one hand, leverage financial technology to improve the accuracy and completeness of data provided by anti-money laundering reporting agencies, thereby driving the standardization of anti-money laundering information systems and regulatory processes. On the other hand, conduct research into embedding regulatory mechanisms within smart contracts. This mechanism preserves the anonymity of transaction participants while strengthening the security audit of smart contracts through additional verification layers, establishing and refining an audit registration system to prevent tampering in the application of Digital RMB smart contracts.

Finally, actively advance security technology upgrades. In its 2022 Two Sessions proposal, the Central Committee of the China Democratic recommended accelerating innovation in Digital RMB data storage technology, establishing a robust data preservation system, developing high-capacity data storage devices, properly managing and storing relevant transaction data, and rigorously preventing data loss caused by technical failures or network disruptions. (Gao, 2022). With expanded data storage capacity, technologies on supply chain finance platforms will avoid compatibility-related transaction failures, leaving room for system maintenance and upgrades. To effectively address external information security and cyber risks, banks should actively harness financial technology to build a comprehensive, end-to-end online fund monitoring system. Additionally, they must enhance the precision and enforceability of operational protocols to safeguard digital yuan transactions within supply chain finance.

Innovating the Development of Supply Chain Finance Platforms

First, explore collaborative models between core enterprises and commercial banks. Under the oversight of the People's Bank of China, commercial banks are tasked with managing the circulation of the digital yuan and overseeing its usage to ensure secure and efficient operations. To achieve this, a variety of services can be offered, including the design of innovative payment solutions, expansion of application scenarios, market promotion, system development, business process management, and routine system maintenance. As a payment instrument, the digital yuan plays a pivotal role in the digital yuan supply chain finance platform. Internet technology companies in pilot regions have set benchmarks for other areas, primarily focusing on scenario innovation. For example, JD Digits has advanced the development of mobile foundational technology platforms and blockchain infrastructure under the digital yuan initiative. Furthermore, efforts have been made to strengthen the digital yuan ecosystem by introducing innovative mobile application features that bridge online functionalities with offline implementations, laying the groundwork for the growth of the digital yuan supply chain finance platform.

Second, accelerate the development of network infrastructure to expand coverage and improve quality. In the realm of supply chain finance, integrating elastic computing resources from cloud platforms, deep analytical insights from big data, automated processes enabled by artificial intelligence, immutable records from blockchain, real-time monitoring through IoT devices, swift information exchange via mobile communication technologies, multi-layered cybersecurity defenses, and seamless open banking integration can establish a robust and versatile digital infrastructure. Such infrastructure can not only improve the efficiency and security of digital RMB transactions but also offer personalized and precise solutions to small and medium-sized enterprises within the supply chain finance ecosystem through real-time data analysis and intelligent decision-making support.

Strengthen and Refine Laws and Regulations

First, the legal status of the digital RMB must be clearly defined. Its recognition as legal tender should be firmly established, with the People's Bank of China designated as the issuing authority. Currently, the precise definition of the digital RMB largely relies on the content outlined in the White Paper. During the 2022 National People's Congress and Chinese People's Political Consultative Conference, Wang Jingwu, a national deputy and vice president as well as chief risk officer of the Industrial and Commercial Bank of China, proposed revising the "Regulations on the Administration of the Renminbi of the People's Republic of China" to clarify the legal attributes of the digital RMB. Additionally, it is anticipated that the draft revision of the "Law of the People's Bank of China of the People's Republic of China (Draft for Soliciting Opinions)" will legally recognize both physical and digital forms of the RMB in the future. This would provide greater assurance for using the digital RMB as a payment tool in supply chain finance.

Second, relevant regulations or rules should be developed to standardize the operational framework. Lessons learned from pilot programs integrating the digital RMB into supply chain finance should be summarized, clarifying the legal roles of small and medium-sized enterprises and banks, along with their respective rights and obligations. The functions of digital RMB wallets should be clearly defined, with classifications based on the credit ratings of supply chain enterprises, specifying their purposes, usage scenarios, and transaction limits. A wallet system distinct from traditional bank accounts should be constructed to highlight its advantages in supply chain finance.

Thirdly, it is recommended to establish clear usage standards for smart contracts. On one hand, specify that the users encompass small and medium-sized enterprises (SMEs) and banks within the supply chain finance ecosystem, ensuring the broad application of smart contracts in transactions to showcase the unique advantages of the digital RMB. On the other hand, delineate the authority for creating and modifying smart contracts, with the People's Bank of China developing standardized templates and formal amendment procedures. This ensures that neither SMEs nor banks can make arbitrary changes during transactions, thereby

maintaining the transparency, compliance, and integrity of smart contracts while safeguarding the legitimate rights and interests of all parties involved.

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