Regulatory Policies and Practices of Digital Payment Systems

Yuntao Wang
Zhenxiong Fan

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September 2022
# Contents

**Executive Summary** ........................................................................................................... 8  

1. **Introduction** .................................................................................................................. 10  
   1.1 Background .................................................................................................................. 10  
   1.2 Benefits of Digital Payment ......................................................................................... 10  
      1.2.1 Reduces the Cost of Payment .............................................................................. 10  
      1.2.2 Offers More Payment Options to Producers and Consumers ......................... 10  
      1.2.3 Digital Financial Services Help Improve People’s Income-earning Potential ...... 11  
   1.3 Definitions .................................................................................................................... 11  
   1.4 Categorization of Digital Payment Systems ............................................................... 13  
      1.4.1 Business-level Digital Payment Systems ......................................................... 13  
      1.4.2 Country-level Digital Payment Systems ......................................................... 14  

2. **Three Development Phases of Digital Payment** .............................................................. 18  
   2.1 Phase 1: Transformation of Traditional Payment Systems ........................................... 18  
   2.2 Phase 2: Independent Payment Systems ..................................................................... 19  
   2.3 Phase 3: Core Infrastructure of the Future Digital World ... ....................................... 19  

3. **Overview and Analysis of the Regulatory Status Worldwide** ........................................ 21  
   3.1 Regulatory Practices of Major Countries ..................................................................... 21  
      3.1.1 USA ......................................................................................................................... 21  
      3.1.2 United Kingdom ...................................................................................................... 23  
      3.1.3 China ....................................................................................................................... 23  
      3.1.4 Japan ....................................................................................................................... 24
3.1.5 Singapore ................................................................................................................. 24

3.2 Non-bank Regulation Analysis .................................................................................. 25

3.2.1 Regulatory Requirements with Differentiated Application ........................................ 25

3.2.2 Regulatory Requirements with Uniform Application .................................................. 27

3.3 Impact of Legal Digital Currency on the Regulation of Monetary Policy .................... 30

3.3.1 Impact on the Regulation Toolbox of Monetary Policy ........................................... 30

3.3.2 Impact on the Target System of Monetary Policy...................................................... 32

3.3.3 Impact on the Transmission Channel of Monetary Policy ........................................... 33

4. Technical Architecture of CBDC .................................................................................. 35

4.1 Four Fundamental Infrastructures are Required ......................................................... 35

4.2 Classification of Legal Digital Currency Payment Systems ........................................ 35

4.3 Centralized Digital Payment System .......................................................................... 36

4.3.2 Advantages and Disadvantages of Centralized Payment System ................................. 40

4.4 Decentralized Digital Payment System ...................................................................... 43

4.4.1 Advantages and Disadvantages of Decentralized Payment System ............................. 49

5. Case Studies in China .................................................................................................. 52

5.1 Third-party Digital Payment Development in China .................................................. 52

5.2 Chinese CBDC Development ...................................................................................... 54

5.3 Development Status of China’s Digital Payment .......................................................... 55

5.4 Analysis of China’s Digital Payment Triumph ............................................................... 58

5.5 Potential Impact on CBDC that Needs Attention .......................................................... 62

5.5.1 The High-speed Development of ICT ...................................................................... 62
5.5.2 The Philosophical Impact should be Considered ......................................................... 63
5.5.3 The Social Impact should be Considered ..................................................................... 63
5.6 Future Applications and Way Forward ............................................................................ 63

6. Recommendations for Developing Digital Payment Systems ........................................... 65

6.1 Risk Management ............................................................................................................. 65
   6.1.1 Risk Management Recommendations for the Account-based Model ......................... 65
   6.1.2 Risk Management Recommendations for the Token-based Model ............................... 67
6.2 Promoting Digital Payment Systems ............................................................................... 69
# Abbreviation

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>CBDC</td>
<td>Central bank digital currency</td>
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<tr>
<td>RTGS</td>
<td>Real-time settlement systems</td>
</tr>
<tr>
<td>DNS</td>
<td>Delayed netting systems</td>
</tr>
<tr>
<td>SWIFT</td>
<td>Worldwide interbank financial telecommunication</td>
</tr>
<tr>
<td>DLT</td>
<td>Distributed ledger technology</td>
</tr>
<tr>
<td>RMB</td>
<td>Chinese yuan or renminbi</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio-frequency identification</td>
</tr>
<tr>
<td>BIS</td>
<td>The bank for international settlements</td>
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<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>ICO</td>
<td>Initial coin offering</td>
</tr>
<tr>
<td>SEC</td>
<td>The securities and exchange commission</td>
</tr>
<tr>
<td>FCA</td>
<td>Financial conduct authority</td>
</tr>
<tr>
<td>STO</td>
<td>Security token offer</td>
</tr>
<tr>
<td>IFO</td>
<td>Initial fork offerings</td>
</tr>
<tr>
<td>IEO</td>
<td>Initial exchange offerings</td>
</tr>
<tr>
<td>IMO</td>
<td>Initial miner offerings</td>
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<tr>
<td>MAS</td>
<td>Monetary authority of singapore</td>
</tr>
<tr>
<td>AML/CFT</td>
<td>Anti-money laundering/combating the financing of terrorism</td>
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<td>MPIs</td>
<td>Major payment institutions</td>
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<tr>
<td>SPIs</td>
<td>Standard payment institutions</td>
</tr>
<tr>
<td>FTSPs</td>
<td>Funds transfer service providers</td>
</tr>
<tr>
<td>NBSPSP</td>
<td>Non-bank payment service provider</td>
</tr>
<tr>
<td>KYC</td>
<td>Know-your-customer</td>
</tr>
<tr>
<td>CDD</td>
<td>Customer due diligence</td>
</tr>
<tr>
<td>PFI</td>
<td>Personal financial information</td>
</tr>
<tr>
<td>POPIA</td>
<td>Protection of personal information act</td>
</tr>
<tr>
<td>APPI</td>
<td>Act on the protection of personal information</td>
</tr>
<tr>
<td>GDPR</td>
<td>General data protection regulation</td>
</tr>
<tr>
<td>CLS</td>
<td>Continuous linked settlement</td>
</tr>
<tr>
<td>DES</td>
<td>Data encryption standard</td>
</tr>
<tr>
<td>DHT</td>
<td>Distributed hash table</td>
</tr>
<tr>
<td>B2C</td>
<td>Business-to-consumer</td>
</tr>
<tr>
<td>DVP</td>
<td>Delivery versus payment</td>
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The scope of digital payment in this working paper is divided into two categories: centralized solutions and decentralized solutions. Centralized solutions are further divided into third-party payment and central bank digital currency (CBDC), while decentralized solutions are subdivided into cryptocurrency and digital identity.

The development of digital payment systems can be divided into three phases – (1) transformation of traditional payment systems; (2) independent payment systems; and (3) core infrastructure. Phase 1 is the digital payment system we are using now. It is comprised of four subsystems – large-value payment system, retail payment system, securities settlement system and foreign exchange settlement system, as follows:

1. The large-value payment system provides three main financial services – (1) connects banking and financial institutions nationwide and provides a channel for interbank payment and clearing for banking and financial institutions; (2) provides fund settlement services for the bond trading market, interbank lending market and other financial markets; and (3) provides fund settlement services for other payment systems such as the retail payment system and the intercity bill exchange system.

Large-value payment systems utilizing real-time settlement systems (RTGS) have been deployed in most countries since the 1990s, but face three types of risks – credit risks, liquidity risks and systemic risks. Like lighting bulbs in series, one failed node will affect the performance of the whole system.

2. The retail payment system needs to meet the specific demands of high business volume and low cost of the societies’ diverse needs. Unlike large-value payment systems, national micro-payment systems still mostly use delayed netting systems (DNS) that send payment instructions in bulk and roll them in real time. Compared to RTGS, DNS are more liquid, but have greater settlement risk. A netting system settles at the end of a business day, meaning that one party to the transaction needs to provide day-to-day credit to the other party, and the settlement interval is lengthened leading to higher settlement risk.

3. The securities settlement system mainly handles securities transaction settlement and clearing operations. After the securities transactions are completed, the securities settlement system approves and calculates the price of the securities receivable and payable by both parties to the transaction, transfers the securities from the seller to the buyer, and transfers the funds from the buyer to the seller. Securities settlement is divided into two methods – full settlement and net settlement, which have the characteristics of both RTGS and DNS models.

4. The foreign exchange settlement system has two levels of markets – (1) retail market, including foreign exchange dealers and customers; and (2) wholesale market, also known as the interdealer market or interbank market. The three types of subjects are customers, foreign exchange brokers and foreign exchange dealers. The most widely used foreign exchange settlement system is the Continuous Linked Settlement, which is a multi-currency foreign exchange clearing bank. The standard format of messages introduced by the Society for Worldwide Interbank Financial
Telecommunication (SWIFT) provides a standard language for international interbank data exchange.

The advantages of centralized payment systems are their solidity, security, and trustworthiness. Authoritative institutions coordinate and manage the system, and the system operates on a more solid basis. The structure of the payment system is complete, and the settlement system is consummate. They have sound relevant regulations and systems, and adequate legal support for payment and settlement. The disadvantages of centralized payment system are inefficiency and discrimination. Funds cannot be directly transferred between systems and the turnover of funds is slow. Cross-border interconnection of national payment systems suffers high risk contagion potential and may weaken the financial inclusion of legal digital currencies.

In the near future (Phase 2), independent digital payment systems that do not rely on existing payment systems will likely emerge. These independent digital payment systems can be viewed as pilot experiments to innovate and disrupt traditional payment systems. For instance, decentralized payment systems are already experimenting with blockchain and smart contracts. The advantages of decentralized payment systems are their simplicity, robustness and low cost.

The number of money circulation links is significantly reduced and the efficiency of financial operation is improved. Decentralized payment systems create a decentralized credit mechanism and provide an opportunity for financial transaction model innovation. They also enhance payment system liquidity and reduce transaction funding costs. The disadvantages of decentralized payment systems are vulnerability, inflexibility and instability. They still face certain technical risks and the security of decentralized payment systems account has hidden dangers. Decentralized payment systems are automated and programmed, and are less flexible as they cannot be changed after operation. Distributed payment technology may also have an impact on financial stability.

In the far future (Phase 3), digital native assets will create a far larger markets than expected, and digital payment systems will be seamlessly integrated as an infrastructure. The independent digital payment systems will become the core infrastructure in the digital world as these digital-born payment systems become more effective than traditional payment systems.

Regulations on digital payment systems worldwide mainly differ in the area of decentralized payment systems, but most countries have issued policies to promote deployment of centralized digital payment systems. Regulations can be divided into two categories based on the functionalities of digital payment systems, which are uniform applications as the common foundation of digital payment systems, and differentiated applications based on uniform applications.

Regulations on uniform applications mainly focus on four areas – anti-money laundering/combating the financing of terrorism, risk management and cybersecurity, data protection, and consumer protection. Regulations on differentiated applications mainly focus on three areas – licensing and registration, minimum capital and safeguarding of funds, and interoperability. What’s worth mentioning is that digital currency itself has impacts on existing monetary policies, including but not limited to, the regulation toolboxes of monetary policy, target system of monetary policy and the transmission channel of monetary policy.

Keywords: Digital Payment System, CBDC, Centralized, Decentralized
1. Introduction

1.1 Background

The COVID-19 pandemic has disrupted every aspect of how societies function, forcing governments, businesses, educators and regular citizens to adapt to a “new normal” way of conducting daily activities. More specifically, the current health crisis has accelerated the digital transformation already taking place across geographies in areas such as e-government, remittances and e-commerce. Stay-at-home orders and social distancing measures have forced brick-and-mortar retailers to close or reduce their activity, accelerating e-commerce sales. Digital payment, as the essential component of e-commerce, has been developed rapidly, together with non-bank payment services and central bank digital currencies (CBDCs).

1.2 Benefits of Digital Payment

1.2.1 Reduces the Cost of Payment

A test conducted by IKEA at its Gävle, Sweden, branch showed that employees spend 15 per cent of their working time counting and depositing cash, even though less than 1 per cent of customers use cash.\(^1\) It is estimated that Japan currently spends about JPY8 trillion annually on cash circulation and management. The use of digital payments can greatly improve the efficiency of social operations. Many countries have therefore adopted incentives for digital payments: Japan’s Ministry of Economy, Trade and Industry released its “Cashless Vision” last year with a goal to increase the proportion of cashless payments by 40 per cent by 2027;\(^2\) and Singapore’s Prime Minister, Lee Hsien Loong, has encouraged the country’s institutions to learn from China’s leading mobile payment experience.

1.2.2 Offers More Payment Options to Producers and Consumers

With the rapid evolution of digital payments, producers can provide more options between businesses and attract more consumers through various financial options. Consumers are also gaining more payment options. Consumers expect payments to meet their needs and empower them to exchange value anytime, anywhere, regardless of the channel or method they use to transact.

However, the current business environment can be described as increasingly fragmented, with fragmented transaction channels expanding. Therefore, ensuring that consumers can pay conveniently and securely anywhere, anytime is key to realizing the true value of digital payments and is the mission of payments ecosystem practitioners.

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1 The Local, "Ikea to test cash-free store in Sweden", 30 August 2018. Available at https://www.thelocal.se/20180830/ikea-to-test-cash-free-store-in-sweden/.

1.2.3 Digital Financial Services Help Improve People’s Income-earning Potential

In the long run, studies have shown that digital financial services can help improve people’s income-earning potential, increase women’s economic participation and lead to more inclusive societies. Since 2014, digital financial services have brought more than 240 million women worldwide into the formal financial services sector. However, digital financial services have yet to reach another one billion women who still lack access to the formal banking system. In Kenya for example, the spread of mobile money from 2008 to 2014 lifted one million people (2 per cent of the population) out of extreme poverty.

1.3 Definitions

A payment system is a system established and led by the central bank that enables the function of debt settlement and funds transfer between traders. It usually consists of a combination of rules for transferring funds, institutions that provide payment services, and instruments that enable the transmission of payment instructions and the clearing of funds. The payment system, in a broad sense, includes a set of instruments, procedures and rules for the transfer of funds. It is the basis for funds transactions, covering payment operations such as fund settlement and non-payment operations such as deposit reserve payment. Legal digital currencies and the distributed ledger technology (DLT) behind them are considered to have the potential to reshape the global payment system and will bring profound changes to the traditional payment and settlement system.

In this connection, the paper defines the digital payment system in a narrow sense, as a combination of digital systems for transferring funds and providing payment services, and instruments that enable the transmission of payment instructions and the clearing of funds. Based on this definition, the digital payment system is comprised of four essential subsystems – large-value payment system, retail payment system, security settlement system and foreign exchange settlement system.

As shown in Table 1-1, transaction, clearing and settlement are three main standardized processes in payment clearing. Taking the retail payment business as an example, the transaction link is the front-end link of the whole payment process, which mainly completes the generation, sending and determination of payment instructions, and the participants are buyers and sellers. The clearing is the middle part of the payment process, mainly completing the exchange of payment instructions between the two

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parties, as well as the calculation and clearing of unsettled claims and debts, with the participants being the institutions where the accounts of both parties are located and the clearing intermediaries. Settlement is the bottom part of the payment process. Based on the settlement result, the institutions where the accounts of both parties to the transaction are located complete the final transfer of monetary claims. The participants are the institutions where the accounts of both parties to the transaction are located and the payment system. The participating entities in the payment transaction clearing process include payment institutions, clearing intermediaries and payment systems.

<table>
<thead>
<tr>
<th>Process</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Transaction</td>
<td>Generation, sending and determination of payment instructions</td>
</tr>
<tr>
<td>Clearing</td>
<td>Exchange of payment instructions between institutions where accounts are located; calculation of debts to be settled</td>
</tr>
<tr>
<td>Settlement</td>
<td>Final transfer of monetary claims between account institutions based on liquidation results</td>
</tr>
</tbody>
</table>

There is a fundamental difference between "money" and "wallet". Intuitively, the funds paid through fiat money go directly to the merchant's account without any additional fees, while when using tools such as payment software to withdraw cash, you need to pay a fee for using the wallet.

Third-party payment tools such as Alipay have contributed greatly to fostering cashless transaction habits, and the ecosystem around payment tools has become more mature, which has laid a foundation for the development of digital Chinese Yuan or Renminbi (RMB). However, mainstream payment tools are also being used for illegal acts such as excessive collection and trafficking of customer information and false transactions.

Although the use of digital currency does not conflict with third-party payment tools, objectively, digital currency is a "better cash", its convenience is no less than third-party payment tools, and users may prefer to choose digital currency out of consideration for fees and privacy and security. Promoting the interaction between digital RMB and existing electronic payment tools can achieve the unity of security and convenience.

The further aggregation of digital currency and third-party payment tools should consider convenience in the use scenario, make good use of existing tools and their ecology, and realize the interconnection of money and wallet. At the same time, the controlled anonymity property of digital currency should be strengthened to effectively protect personal privacy data and meet the public's information security needs. There is a certain contradiction between convenience and security, and the combination of pilot experience and the use of technology can achieve a relative balance between the two.

1.4 Categorization of Digital Payment Systems

The digital payment system can be divided into two categories – business-level digital payment system and country-level digital payment system.

1.4.1 Business-level Digital Payment Systems

Business-level digital payment systems can be divided into two categories:

1) Point-of-sale payments, including the use of credit and debit cards, radio-frequency identification (RFID) enabled devices and biometrics-enabled technologies;

2) Contactless payments, such as mobile applications, online browsers, electronic wallets and machine-readable technologies, to send or receive a specific value.\(^\text{10}\)

The growing popularity of mobile devices is changing the way people spend and pay. With five billion mobile phones in the world, the development of global mobile payment innovation has reached new heights. This is reflected in the rapid expansion of payment institutions, the steady growth of transaction volume and the number of users, and the emergence of new service solutions that fill gaps in the traditional financial system. In terms of transaction scale, according to the latest data from market research firm, Merchant Machine, the global mobile payment transaction volume increased from USD2.2 trillion in 2016 to USD4.3 trillion in 2018, with a compound annual growth rate of 39.4 per cent. It is expected that the global mobile payment scale will continue to maintain high growth momentum in the future, with the transaction value reaching USD6.1 trillion in 2019 and nearly USD14 trillion in 2022.\(^\text{11}\)

In terms of activity, 34.5 per cent of the world's registered mobile payment accounts are currently active. Among them, Latin America and the Caribbean maintain the highest user activity, at 48.5 per cent. Asia (East Asia and the Pacific and South Asia) has the fastest growing user activity, with several countries increasing by more than 10 percentage points.\(^\text{12}\)

By country, China has the highest mobile payment penetration rate in the world, with about 47 per cent of mobile phone owners using mobile wallets to pay. This is followed by Norway, a Nordic country with a population of only 5.2 million, but with a higher respect for innovation and a 42 per cent mobile wallet usage rate, significantly higher than the rest of Europe. Ranked third is the United Kingdom (UK), where the convenience of mobile payments is also of great interest, with a 24 per cent mobile wallet usage rate. Six countries in the Asia-Pacific region are among the top 10. In addition to China, Japan and Australia rank fourth and fifth with a mobile wallet usage rate of 20 per cent and 19 per cent, respectively, while the United States of America (USA), Singapore and Canada rank seventh to ninth with mobile wallet usage rates of around 17 per cent.\(^\text{13}\)

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\(^{13}\) https://direct.mit.edu/asep/article/19/3/1/93345/Mobile-Payment-in-China-Practice-and-Its-Effects
From the perspective of payment institutions, Merchant Machine survey data shows that Alipay has 650 million users, ranking first among global mobile payment institutions, followed by Wechat pay, with more than 550 million users. Apple pay ranked third with 507 million users, followed by Google pay with 421 million users and Paypal with 377 million users. Samsung Pay has attracted 140 million users and is ranked fifth, although in recent years the user base has shrunk.14

In terms of users’ age, young people aged 18-34 are unquestionably the largest users of mobile payments, with 48 per cent of them having a mobile wallet installed and 32 per cent not having a mobile wallet but are interested in the feature. Middle-aged people aged 35-44 also welcome mobile payment applications, with 44 per cent of users using mobile wallets and another 32 per cent interested in using mobile wallets. Among seniors aged 65+, 22 per cent use mobile wallet services and 50 per cent do not have a mobile wallet and are not interested in it.15

1.4.2 Country-level Digital Payment Systems

The research and promotion of legal digital currencies, which is also known as CBDC, is still in progress and there is no commonly accepted definition globally. In 2018, the Bank for International Settlements (BIS) used the "flower of money" model to propose the core attributes of legal digital currency, as follows:16

- Issuer – Legal digital currencies are issued by central banks
- Monetary form – Legal digital currencies exist in digital form
- Access method – Legal digital currencies can be accessed based on accounts or tokens
- Versatility – Legal digital currencies can be used at wholesale or retail

Since its introduction, the flower of money model has been widely accepted by academics and political circles.

1. Central Bank Issuance

Legal digital currency is a new type of payment means issued by the central bank, and as an alternative to cash in circulation, it has the basic functions of money and legal tender.

Legal digital currency can replace paper money and cash and belongs to the base currency in broad money. Under the environment of controlled anonymity of the central bank, legal digital currency can enter the commercial banking system and replace cash in circulation through activities such as access and settlement.17

Guaranteed by the sovereign credit of the state, the legal digital currency adopts the same unit of the denomination as traditional fiat money and can be used as a payment instrument for general use by the public.

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14 https://merchantmachine.co.uk/rise-of-mobile-wallets-2022/
public, has the three basic functions of traditional fiat money as follows:18 –

- A measure of value.
- A medium of exchange.
- A store of value.

Legal digital currency is fiat and mandatory.19 The legal digital currency is the only digital currency that is recognized by the central bank and can be used for payment and settlement operations in the market. Under the condition that the technical equipment permits, no institution or individual can refuse to accept the legal digital currency when users use it to pay for transactions and settle debts.

The attribute of central bank issuance enables the legal digital currency to overcome the limitations of private digital currencies and has the feasibility of large-scale popularization. The central bank provides credit backing for legal digital currency, can mobilize the national force to promote its development and promotion, and has information on currency circulation. This way, legal digital currency can overcome the disadvantages of private digital currency such as unstable value, unpopular application and difficult supervision. In addition, the circulation of information on legal digital currency can facilitate central bank’s analysis of the macroeconomic situation and the effect of monetary policy regulation, which is a function that private digital currency does not have.

2. Digital Form

A legal digital currency is a legal tender in digital form. Digitization is the most important attribute that distinguishes legal digital currency from traditional fiat money. The digital form of legal digital currency can be either a number in an account or a string of cryptographic numbers verified by a specific cryptography and consensus algorithm under a username. Yao Qian20 proposed a scalable model of legal digital currency, which expresses legal digital currency as a combination of user identification (ID), currency information, issuer information and cryptographic signature with scalable attributes. The mathematical model of legal digital currency can also have programmability with designs such as circulation requirements and time constraints embedded in it.

The way the digital form of legal digital currency is realized is closely related to its circulation framework. The circulation framework of legal digital currency can be divided into a single-tier circulation framework, a two-tier circulation framework and a hybrid circulation framework, in which the legal digital currency is generated, stored and transmitted in different paths.21 The single-tier circulation framework refers to the issuance of legal digital currency by the central bank directly to the public. The two-tier circulation framework refers to the issuance of legal digital currency by the central bank directly to the public through commercial banks. The hybrid circulation framework refers to the central

bank issuing legal digital currency directly, while commercial banks provide payment services.

The digital form of legal digital currency brings new opportunities and challenges to central banks. On the one hand, the digital form gives the legal digital currency attributes that are different from traditional physical fiat currencies, such as traceability and programmability. As a result, digital fiat currencies can help combat monetary crime and improve the efficiency of monetary policy, as well as flexibly adapt their properties to future payment needs. On the other hand, the digital form poses new challenges for central banks in terms of monetary security and financial stability. Central banks need to ensure the security, non-repeatability and non-counterfeit ability of fiat digital currencies, balance the traceability and anonymity of fiat digital currencies, improve the capacity and stability of the operating system, and cope with the impact of fiat digital currencies on the financial system.

3. Access Method

The access method refers to the mode in which the payment is realized by the legal digital currency. Currently, there are two main types of access methods for legal digital currency – account-based and token-based.22 Account-based access means that the ownership of the holder of the legal digital currency account is tied to the access status, and during the transaction, the holder can complete the transfer only after the account identity is verified. Access to legal digital currency is completely dependent on the unique ID of the account holder.23 Token-based access means that the central bank only redeems the claim when the holder of the legal digital currency knows the key (digital pass). Only the holder with the correct digital pass is allowed to access the legal digital currency system and effect transactions. In the general token-based case, the holder's privacy can be effectively protected.

Access to legal digital currency needs to be done in a payment clearing system. Payment clearing systems for legal digital currencies include both centralized and distributed types, based on centralized and distributed ledgers, respectively.24 Centralized ledgers are traditional centralized databases that store data on multiple physical nodes that are controlled by an authoritative entity (core node). The core node is responsible for controlling the transaction reality of the legal digital currency, monitoring the transaction process and recording the transaction data in real-time.25 DLT is a database that replicates, shares and synchronizes large-scale data among decentralized network members (or nodes).26 Different nodes jointly manage the ledger of legal digital currency in a decentralized manner and update the data using a "consensus mechanism" algorithm coordinated

among multiple nodes. Distributed ledgers can free data storage from dependence on a single institution or device.

4. Universality

Universality refers to the scope of application of legal digital currency. Based on the size of the application scope, there are two main types of legal digital currencies – retail-side legal digital currency or retail central bank digital currency and wholesale-side legal digital currency or wholesale central bank digital currency. Retail-side legal tender is not limited to financial institutions such as banks, and includes ordinary residents and businesses, and its application is open to the entire retail market. Retail-side legal digital currencies can improve payment efficiency, ensure payment security and enhance financial inclusion. The wholesale legal tender is intended for financial institutions, and its application scope is aimed at the interbank market, i.e., the wholesale funds market. Wholesale-side legal digital currency expands the application of legal digital currency in the wholesale segment. In addition to the traditional wholesale segment such as issuance and repatriation, the wholesale-side legal tender can be used in scenarios such as securities transactions and cross-border transfers. In the large-value clearing system of the wholesale funds market, the use of wholesale-side legal tender can enhance transaction security and improve transaction efficiency.

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2. Three Development Phases of Digital Payment

To better understand digital payment systems, it is significant to consider their different development phases, which can be categorized into three phases. Currently, we are in the first phase in which digital payment systems are simply transformations of traditional payment systems. Soon (phase two), independent digital payment systems that do not rely on existing payment systems will likely emerge. These independent digital payment systems can be viewed as pilot experiments to innovate and disrupt traditional payment systems. In the far future (phase three), the independent digital payment systems will become the core infrastructure in the digital world as these digital-born payment systems become more effective than traditional payment systems, as shown by Figure 1-1.

We will discuss all three phases respectively.

Figure 2-1: The three phases of digital payment

2.1 Phase 1: Transformation of Traditional Payment Systems

Today’s payment systems are based on the procedures, standards and institutions set during the age of industrialization, when digitalization was still a fantasy. As part of these traditional payment systems, money needs to be printed or forged by authoritative factories, trading needs to take place at third-party institutions and financial services are invented based on such real-world limitations.

Today, domestic and international payment and settlement procedures continue to take longer than expected and have become barriers to achieving higher efficiency and lowering the cost of financial systems. With the rapid advancement of digital technologies, we need to seriously consider how to build a better payment system taking full advantage of digital technologies.

The current solution is to remodel the traditional payment system, using mature digital technologies to
modify small parts of the traditional payment system. The entire payment system itself seems too large and complex to rebuild from the ground up, even though we know that a digital-born payment system will be better. This is called the transformation of traditional payment systems. The architecture, as well as the core components, have not been changed because it will take a huge amount of time and labor to rebuild the entire payment system.

The traditional payment system will continue to be used because it is secure, stable and accepted by all, but no single entity will be able to bear the potential risks that new technology creates. However, financial institutions, especially banks, have seen the advantages of digital technologies, and those with high risk tolerance will become the first to embrace new technologies. This first phase will continue for some time until people find that those easily modifiable parts of the system have all been modified already.

2.2 Phase 2: Independent Payment Systems

The current development of the digital economy is still in the stage of deep integration of the traditional economy and digital technology. Today's digital economy is more of a "digital transformation" of the traditional economic system in the real world, i.e., it is still a fusion of the traditional economy and digital technology, which is still dependent on the market, business and financial system of the traditional economy in the real world. In the short term, the digital financial system will continue to be attached to the traditional economic system of the real world, relying on the real-world economic system to be able to operate.

In the second phase, independent digital payment systems will emerge, which are digital native and self-circulating economic systems in the virtual world. It should be recognized that the virtual economic system can create a huge "digital native economic system" market in the digital world based on making the real economy better and stronger. The digital economic system is oriented to digital content and can complete the whole process of digital asset identification, valuation, circulation and another self-circulating economic system, which is not rigidly dependent on the real-world economic system. The economic system is not rigidly dependent on the real-world economy. From the perspective of development, the digital economic system started from the real economy, but its broad development prospects foretell the huge future potential of the digital native economy market, so it is necessary to build a self-looping digital value and financial system. This self-looping economic system requires a new operating mechanism and technical means, which in turn require technological innovation and financial infrastructure changes.

2.3 Phase 3: Core Infrastructure of the Future Digital World

Due to the outstanding characteristics of blockchain technology for credible value transmission and stable closed-loop operation, the financial industry has reached a consensus on reconstructing the operation mechanism and infrastructure based on blockchain technology. The industry has also prototyped technologies such as Web 3.0, decentralized finance and decentralized autonomous organization, and explored digital native services including digital artworks and games. The market value of the global digital native economic system of the meta-universe has reached the scale of USD1.9 trillion, which is close to the scale of Italy's annual gross domestic product (GDP).

In the future digital world, we will need a brand new digital economic infrastructure, which can solve all
the problems from the industrial age, and ensure scalability, security, efficiency, robustness and trust by all stakeholders. In this third phase, led by the concrete needs originating from the digital world, the core infrastructure of the digital native economy will surpass all and dominate the future.

In summary, digital payment is not only a commercial experiment as currently viewed by many people, but it will become the dominating infrastructure in the future digital economy. It may create a potentially huge new digital market that may be beyond everyone’s imagination for now. Therefore, no one should be left behind from the start because this would indicate the failure to grasp the opportunity to embrace and compete in the coming trillion-dollar market. Those who still doubt digital payment should have a long-term view and take necessary actions now.
3. Overview and Analysis of the Regulatory Status Worldwide

As a new industry generated by technological innovation, the digital currency may become a new generation of financial infrastructure, and its emergence is a challenge to the traditional financial system and financial security. For all countries, digital currencies are new, therefore, effective ways to regulate them, balance digital security and privacy protection, and balance financial innovation and risk prevention are issues that governments need to consider and address when formulating regulatory policies.

3.1 Regulatory Practices of Major Countries

Digital currency regulation has become a global problem. According to TokenNet, among 257 countries or regions in the world, 132 countries have no restrictions on digital currency issuance, transaction and circulation, while the rest of the countries have incorporated digital currency into their regulatory systems and formulated corresponding regulatory policies. Countries have different attitudes towards digital currency regulation according to their national conditions and financial market development, but there are some similarities in the regulatory content and regulatory framework, mainly related to positioning, issuance, trading and taxation of digital currencies (see Table 3-1). Among them, the regulatory policies of China, Japan, Singapore, UK, USA (United State of America) and other countries are somewhat representative.

3.1.1 USA

The USA has a cooperative federal and state regulatory model for the regulation of digital currencies, adopting a strategy that encourages development and regulation at the same time. At the federal level, regulators regulate digital currencies and their derivatives from a financial innovation perspective. For example, the Financial Crimes Enforcement Network defines bitcoin as a "transformable virtual currency" and requires that bitcoin "pass-through operations" be subject to supervision. The Securities and Exchange Commission (SEC) calls private digital currency a security product and bitcoin "mining" contracts are "investment contracts".

At the state level, each state has its own rules for regulating digital currencies, with independent and diverse policies that have not yet been harmonized. For example, New York State has taken the lead in introducing a licensing system to regulate digital currency practitioners, Wyoming exempts cryptocurrencies from property taxes, and Arizona and Georgia allow residents to pay taxes and fees using cryptocurrencies.
Table 3-1: Comparison of digital currency regulatory policies in selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Definition</th>
<th>Issuance</th>
<th>Trade</th>
<th>Taxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Non-legal digital currency</td>
<td>Allowed</td>
<td>Anti-money laundering, anti-terrorist financing</td>
<td>Yes</td>
</tr>
<tr>
<td>UK</td>
<td>Non-legal digital currency</td>
<td>Allowed</td>
<td>Anti-money laundering, anti-terrorist financing</td>
<td>Yes</td>
</tr>
<tr>
<td>Germany</td>
<td>Legitimate means of payment</td>
<td>Allowed</td>
<td>Inclusion in the national regulatory system</td>
<td>Yes</td>
</tr>
<tr>
<td>China</td>
<td>Virtual goods</td>
<td>Not allowed</td>
<td>Initial Coin Offering(ICO), anti-money laundering</td>
<td>No</td>
</tr>
<tr>
<td>Russia</td>
<td>Virtual goods</td>
<td>Progressive permission</td>
<td>Illegal financing, anti-money laundering</td>
<td>No</td>
</tr>
<tr>
<td>Singapore</td>
<td>Non-legal digital currency</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>Japan</td>
<td>Legitimate means of payment</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>Korea</td>
<td>Non-legal digital currency</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>Australia</td>
<td>Legitimate, deemed property</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Legitimate means of payment</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>Canada</td>
<td>Legitimate means of payment</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
<tr>
<td>India</td>
<td>Non-legal digital currency</td>
<td>Not allowed</td>
<td>Anti-money laundering</td>
<td>No</td>
</tr>
<tr>
<td>El Salvador</td>
<td>Fiat money</td>
<td>Allowed</td>
<td>Anti-money laundering</td>
<td>Yes</td>
</tr>
</tbody>
</table>

As the breadth and depth of the digital currency market develop, the USA has built a flexible regulatory system, with the SEC playing a central role in the digital currency regulatory process. The SEC requires ICO (Initial Coin Offering) companies to register with a stock exchange, and publishes a "digital asset" investor contract framework that characterizes digital currencies as securities. In February 2019, the US House and Senate introduced the Blockchain Promotion Bill, which clarifies the industrial policy of blockchain and proposes to strengthen the regulation of digital currencies. At the end of 2019, a total of 21 bills related to blockchain and crypto-digital currencies were introduced in the US Congress, of which the Crypto Coin 2020 Act, introduced in the Senate, divides cryptocoins into
three major categories – cryptocommodities, cryptocurrencies and cryptosecurities – to be regulated by Futures Trading Commission, Financial Crimes Enforcement Network and SEC, respectively.

Since 2020, against the backdrop of the impact of COVID-19 and increasing competition between central banks and private digital currencies in many countries, the USA has tightened its regulation of digital currencies, with the Federal Reserve, the Office of the Comptroller of the Currency and the Federal Deposit Insurance Corporation considering the creation of an "interagency sprint group" to create a unified regulatory framework for digital currencies.

3.1.2 United Kingdom

The UK is open to digital currencies and has implemented a regulatory sandbox. The UK Treasury, the Bank of England, and the Financial Conduct Authority (FCA) have set up a digital currency working group to manage the risks of digital currencies. In 2015, the UK Treasury released the "Digital Currency Government Call for Information Feedback" report, stating that the UK government has adopted an anti-money laundering law to regulate digital currencies while working with the Digital Currency Standards Association. In the same year, the FCA proposed a regulatory framework for digital currencies and a regulatory sandbox model, in which digital currency trading platforms could apply to enter the regulatory sandbox, and digital currency exchanges could legally exist in the UK after the application was approved.

The UK is not as sensitive as other countries in regulating ICO activities and has not issued a specific regulatory scheme, only issuing ICO risk alerts to remind investors of the risks of ICO activities, and ICOs are not regulated by the FCA. In 2018, the Bank of England adopted comparable management standards for digital currency exchanges as stock exchanges and cracked down on financial crimes of digital currencies. As the Governor of the Bank of England, Andrew Bailey, noted in his Davos Forum speech, the key to the regulation of digital currencies is to combat financial crime. The HM Revenue and Customs considers digital currencies as an asset, and digital currency transactions are subject to capital gains tax, and digital mining is also taxable under UK regulations. In 2019, the FCA issued the "Guidance on Cryptocurrency Assets" document, which sets out the regulatory framework for the digital currency market and states that transactional tokens are not regulated for the time being. Due to the excessive volatility of cryptocurrencies such as bitcoin, in 2021, the FCA prohibits the sale of derivatives of cryptocurrency assets to retail-type consumers to protect consumer interests.

3.1.3 China

In 2013, when the price of bitcoin soared, the People's Bank of China and five other ministries jointly issued the “Notice on Preventing the Risks of Bitcoin”, positioning bitcoin as a virtual commodity without legal compensation, not a real currency, and should not be circulated in the market as a currency. In 2017, the price of bitcoin surged again and ICO activities became popular worldwide. In response, the central bank jointly issued the “Announcement on Preventing Risks of Token Issuance and Financing”, which pointed out that token issuance is an illegal financing act and banned ICO, and STO(Security Token Offer), IFO(Initial Fork Offerings), IEO(Initial Exchange Offerings), IMO(Initial Miner Offerings), etc. extended from ICO were identified as illegal financial activities. Subsequently, all domestic digital currency trading platforms were shut down.

In 2018, the China Banking Regulatory Commission issued the “Risk Alert on Preventing Illegal Fundraising in the Name of Virtual Currency and Blockchain”, to alert the public to the speculation of virtual currency and explicitly prohibit financial institutions from carrying out digital currency-related
business.

Since June 2021, the Chinese government has started to shut down the mining of bitcoin and other virtual currencies. It has required banks and payment institutions to comprehensively check and identify the fund accounts of virtual currency exchanges and over-the-counter dealers, and cut off the payment chain of transaction funds promptly, so the legal space for digital currencies in China is very limited. The Securities and Futures Commission of Hong Kong, China has issued documents such as "Statement on Initial Token Offerings" and "Statement on the Regulatory Framework for Investment Management Companies and Trading Platform Operators of Virtual Asset Portfolios" to clarify the content and scope of regulation.

3.1.4 Japan

Japan actively supports the development of digital currencies. Japan has the second-largest digital asset trading market in the world and was the first country in the world to legalize digital currency trading and introduce a trading license. The Japanese Cabinet signed an amendment to the Funds Settlement Act in 2016 to incorporate digital currencies into the legal system, stipulating that digital currencies such as bitcoin can be used for payments. Japan's Financial Services Agency has been improving the regulatory mechanism and legal system for digital currencies, and in 2019, issued the "New Coin Offering Rules and Guidance" to strengthen the regulation of digital currencies and make the digital currency business transparent and compliant.

Given the cross-border transaction and payment characteristics of digital currencies, Japanese regulators are taking a leading role in the international regulation and collaborative governance of digital currencies by strengthening cooperation with overseas regulators and implementing collaborative regulation through experience sharing and holding roundtable forums on cryptoassets. In addition, Japan's National Tax Agency is discussing the taxation of digital currencies and intends to enact the "Proceeds of Virtual Currencies and Other Income" to implement tax regulation of digital currencies.

3.1.5 Singapore

Singapore is more inclusive of digital currencies. The Monetary Authority of Singapore (MAS) implements sandbox regulation, aiming to create a favourable institutional environment for fintech companies. In 2017, the MAS issued the "Guide to Digital Currency Pass-Throughs", which classifies digital currencies into securities, applications and payments. The MAS does not exclude ICO projects in the process of promoting sandbox regulation. The MAS has been regulating digital currency exchanges and over-the-counter platforms in terms of both risk control and compliance, focusing mainly on money laundering and terrorist financing risks, network and technology risks, and platform compliance.

The Singapore authorities are also focused on tax regulation of digital currencies. The Inland Revenue Authority of Singapore issued the "Taxation Guidelines for Digital Currency Income Tax", which stipulates that businesses that use digital currencies such as bitcoin to buy or sell goods or services must pay a 7 per cent value-added tax on goods, and digital currency exchanges are subject to a 17 per cent income tax on profits earned.
3.2 Non-bank Regulation Analysis

Regulatory requirements for payment services provided by non-banks may be applied in either a differentiated or uniform manner. Some requirements, while imposed across payment services, may be applied differently. This is the case for licensing/registration requirements, minimum capital, safeguarding funds and other security requirements, and interoperability. Other requirements are in general uniformly applied across payment services, such as those relating to anti-money laundering/combating the financing of terrorism (AML/CFT), risk management and cybersecurity, data protection, and consumer protection. The discussions that follow, which are based on a desktop review of published documents, are organized along these two types of regulatory requirements.

3.2.1 Regulatory Requirements with Differentiated Application

1. Licensing/Registration

Some jurisdictions have general licensing frameworks for all, or at least multiple, payment services. However, non-banks that offer prepaid payment instruments and e-money issuance require different licenses. Jurisdictions may also have different licenses depending on the size or type of service provided. They can be categorized by functionalities, transaction amounts and geographic areas, as follows:

1) For functionalities, Singapore has three licenses for non-bank payment service providers –

standard payment institutions (SPIs), major payment institutions (MPIs) and money changing. SPIs are subject to specific thresholds based on the number/type of services offered. MPIs are not subject to any volume restrictions but are subject to more stringent regulation and supervision. Money-changing licensees, meanwhile, can provide only the service of buying and/or selling foreign currency in Singapore.

2) For transaction amounts, the Japanese regulatory framework categorizes funds transfer service providers (FTSPs) into three segments, depending on the maximum transaction value they can execute. Authorization is required for FTSPs that are not subject to any maximum transaction value limit, while registration is required for FTSPs subject to a limit of JPY1 million and JPY50,000 per transaction.

3) For geographic areas covered by the service, the USA and China are two representative examples. Geographic heterogeneity for licensing requirements is best illustrated in the USA, where all money transmitter licensing is done entirely at the state level. While both the federal government and consortiums of state regulators have made efforts to harmonize money transmitter licensing requirements, there is no unifying framework as yet. Chinese licensing requirements vary slightly depending on the geographic coverage of the business (e.g., whether nationwide or limited to a single province).

Two types of licensing models are used in

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jurisdictions that allow non-banks to issue e-money – the narrow bank model and the non-bank model, as follows:

1) Under the narrow bank model, non-banks can apply for a limited banking license that allows them to offer a limited set of banking services. Payment bank licenses are available under the Indian and Mexican legal frameworks, as well as in Switzerland in a slightly different format (fintech license). Even though payment banks are not able to provide the full range of banking services (e.g., lending is prohibited), the fact that they are banks means that they can issue deposits covered by deposit insurance and offer interest-bearing products, something typically unavailable for their non-bank counterparts. Payment banks, however, are regulated under the banking law and therefore subject to stricter rules than traditional e-money issuers since they have to comply with most of the prudential requirements applicable to traditional banks (e.g., capital, liquidity and leverage ratio). In practice, payment bank licenses remain underused in the countries where they are available, which may be related to the regulatory burden that comes with having a banking status.

2) The non-bank model allows specific types of non-bank institutions to issue e-money (e.g., e-money institutions, prepaid instrument issuers or stored value issuers). Jurisdictions whose framework allows such institutions include Brazil, China, the European Union (EU), Russia, Singapore, UK and USA. This is also a common approach in jurisdictions that want to foster financial inclusion. According to the Bill and Melinda Gates Foundation’s “2019 Digital Financial Services Regulation and Supervision Reference Guide”, this is the case in Colombia, Ghana, Kenya, Malaysia, Myanmar, Peru, Rwanda, Sri Lanka and Tanzania. In these jurisdictions, mobile network operators leverage their existing telecommunication channels, extensive customer bases, and strength in marketing and branding digital products in venturing into e-money issuance. Mobile network operators are typically required to establish a special purpose vehicle for providing this service.

2. Minimum Capital and Safeguarding of Funds

Most jurisdictions have initial and ongoing capital requirements for non-banks that provide payment services. Initial capital requirements are typically flat but may vary depending on the payment volume allowed under the license. This is the case for SPIs in Singapore, which have a capital requirement of only SGD100,000, as compared with the SGD250,000 required for MPIs.31 Some jurisdictions adjust the initial capital requirements based on changes in payment volume and the adjusted value constitutes the ongoing capital requirement. These adjustments are generally calculated by taking a percentage (around 1-2 per cent) of payment volume over a specified horizon and adding it to the initial capital requirement. These percentages may be part of a sliding scale with different surcharges based on the marginal increase in payment volume – as is the case in the EU, Turkey and UK – or just a flat percentage of rolling transaction volume, such as in Brazil.

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Some jurisdictions have capital requirements that are contingent on the location of the non-bank payment service provider (NBPSP) or the type of payment service provided. For US money transmitters, initial and ongoing capital requirements vary heavily across states and must be complied with if a money transmitter wishes to add out-of-state locations. In China, capital requirements are significantly lower – CNY30 million versus CNY100 million – if the payments provider operates exclusively within one province. The EU requires EUR20,000 for remittance services and EUR50,000 for payment initiation services, compared with EUR125,000 for all other payment services (except account information services).

For non-banks that issue e-money, ongoing capital requirements are typically set as a percentage of the e-money float. These are usually around 2-5 per cent of the e-money float. Colombia, the EU, Peru and Saudi Arabia all have requirements of 2 per cent, whereas Australia’s requirement is 5 per cent. In the EU and UK, capital requirements may increase if the e-money issuer provides other services, such as granting credit.

3. Interoperability

Interoperability is the least common regulatory requirement, and its application varies across payment services. For example, it is required in a noticeably smaller number of jurisdictions for account information services and money transfer services, and it is not required at all for virtual asset services. Brazil and Singapore are examples of jurisdictions that require interoperability or have the power to do so for at least some payment services. Brazil requires it for e-money issuance, acquiring of payment transactions and payment initiation services. In Singapore, the Payment Services Act reserves the right for the MAS to mandate that payment services adopt “any common standard” to ensure interoperability.

However, there are soft requirements or ongoing plans to achieve interoperability in other jurisdictions. Indonesia, where QR codes have been heavily adopted as a method of payment, has created national frameworks for QR code interoperability. Similarly, China is promoting the establishment of industry-level QR code payment interoperability. The EU recently adopted a new retail payments strategy, explicitly desiring that future retail payments systems will be pan-European and interoperable. The UK published its “New Payments Architecture” blueprint in 2017. One of the key design principles mentioned in the blueprint was end-to-end interoperability. In Japan, a consortium of private institutions led by the five major Japanese banks set up a commission to explore ways to make small-amount digital payments infrastructure more interoperable.

3.2.2 Regulatory Requirements with Uniform Application

1. AML/CFT

AML/CFT requirements are the most common type of requirement across payment services and jurisdictions. AML/CFT requirements are standardized and are meant to mitigate specific

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money laundering and terrorist financing typologies found in payment services. These requirements include, among others, implementation of broad know-your-customer (KYC) and customer due diligence (CDD) standards, as well as documentation and reporting of suspicious transactions. Some jurisdictions such as India, the Philippines and Russia apply a tiered approach to KYC and CDD, in which low transaction or balance limits result in reduced KYC/CDD requirements.

In a few cases, jurisdictions may be exempt from AML/CFT requirements for payment services that are considered to have low money laundering and terrorist financing risk. For example, Singapore adopted a risk-based approach and exempted certain low money laundering and terrorist financing risk products from AML/CFT requirements, while applying more stringent AML/CFT requirements for higher risk areas. Furthermore, jurisdictions have requirements in place that aim to increase transparency in money transfers. Following the Financial Action Task Force Recommendation no. 16, countries require information on payers and payees of transactions to prevent, detect and investigate money laundering and terrorist financing incidents. The amount and type of information required depends on whether the transactions are national or international. In the EU, for example, this requirement is implemented in Regulation 2015/847.

Compliance with AML/CFT requirements is quite important for NBPSPs to avoid derisking. NBPSPs are often seen as having higher money laundering and terrorist financing risks because they are not subject to the same level of supervision as banks. This can lead banks, which are needed by non-bank payment service providers to facilitate transactions, to refuse to partner with them. The European Banking Authority issued a statement in 2021 clarifying that compliance with AML/CFT requirements does not require financial institutions to refuse or terminate business relationships with entire categories of customers that they consider a higher money laundering and terrorist financing risk.33

2. Risk Management and Cybersecurity

For risk management, including internal controls, the requirements are largely uniform across payment services provided by non-banks. These usually relate to ensuring operational resilience at the legal entity level (the entity providing the payment service) and regulatory compliance is often assessed during on-site inspections. This is also true for NBPSPs that are part of big tech groups, even if operational incidents that can arise from their non-financial services may generate systemic disruptions. These requirements cover outsourcing or third-party dependencies, which put the ultimate responsibility of monitoring and assessing the risks of such third parties on NBPSPs. They must ensure that the third parties they deal with have risk management policies, procedures and controls that are at least as stringent as those required for regulated firms.

Information security and cybersecurity requirements for NBPSPs are quite common across jurisdictions. NBPSPs are required to develop cybersecurity policies commensurate with their business characteristics, size, risk profile, nature of transactions, the sensitivity of underlying data and other factors. The criteria for such assessments may be included in broad operational resilience frameworks, such as in Brazil, or through specific

cyberhygiene requirements, such as in Singapore. Compliance with these requirements is assessed through a combination of regular reporting and on-site inspections. In addition to the aforementioned cybergenic requirements, Singapore requires a “penetration test” for any applicant intending to provide online payment services. In the USA, all money transmitters are subject to federal cybermedicine requirements, though individual states are allowed to implement more rigorous rules.

3. Data Protection

Data protection laws usually cover a broad range of institutions, including NBPSPs. These laws generally define “consent” standards to process data or transfer data, outline the rights of data subjects and explicitly define personal data (and in some cases “sensitive” data). The EU, for example, has the General Data Protection Regulation (GDPR), which broadly applies to all organizations that do business in the EU including those based in other countries. Turkey’s Data Protection Law mandates consent to process data, the right to delete all data and other consumer data privacy rights. The law also requires data controllers to register with the Personal Data Protection Board and provide it with their data processing inventory, personal data retention policy and personal data destruction policy. In February 2020, China updated its standards on the protection of personal financial information (PFI). The updated standards include a right to view and delete PFI and apply not just to licensed financial institutions, but to any institution processing PFI.

Data protection laws may also cover cross-border transfers of data. South Africa’s Protection of Personal Information Act (POPIA), which was passed in 2013 but entered into force in July 2020, has extensive cross-border data transfer requirements. Japan’s Act on the Protection of Personal Information (APPI) was amended in June 2020 to enhance the provision of information to individuals whose data are subject to cross-border transfers. Other jurisdictions may require approval for the cross-border transfer of very sensitive data (GDPR and Turkey). Moreover, both POPIA and APPI include reporting requirements for data breaches.

4. Consumer Protection

Some jurisdictions have dedicated consumer protection requirements for NBPSPs. In addition to general consumer protection laws, those jurisdictions have consumer protection rules that are specific to the financial sector (e.g., South Africa) or specific even to payment services following an activity-based approach (e.g., China, EU, Indonesia, Japan, Singapore and UK). Consumer protection requirements in the payment space mainly focus on transparency and disclosure of certain information, such as fees, as well as handling of complaints and prevention of fraud.

Disclosure of transaction fees is an important theme in consumer protection requirements for money transfers. Jurisdictions generally require service providers to disclose in advance the total amount of fees charged for a transaction (general fee and exchange rate margin). The EU’s Cross-Border Payments Regulation 2, for example, sets rules on the cost of cross-border payments and the transparency of currency conversion charges within the EU. It applies to national and cross-border payments that are denominated either in euros or a national currency of a member State other than the euro and that involve a currency conversion service.

The issue of transaction costs is especially important in the case of remittances, where fees can account for up to half of the amount sent by migrant workers to their country of origin. The issue’s importance is highlighted in the United Nations’ 2030 Agenda for
Sustainable Development, where reducing the transaction costs for migrant remittances to less than 3 per cent and eliminating remittance corridors with costs higher than 5 per cent are included as specific targets.34

3.3 Impact of Legal Digital Currency on the Regulation of Monetary Policy

Legal digital currency is not only related to the efficiency and security of the payment system, but also affects the effectiveness of monetary policy transmission. With the development of ICTs (information and communications technology) and financial digitization, traditional currencies can no longer meet the needs of the modern economy.

Compared with traditional currencies, legal digital currencies can bypass bank accounts and have smart contract features such as cryptographic identification and information storage, which can help strengthen the central bank’s dynamic regulation of currency, optimize monetary policy transmission, and better support economic and social development. However, the issuance of legal digital currency may change the financial system, which in turn affects monetary policy regulation. This section analyses the impact of legal digital currency on monetary policy regulation.

3.3.1 Impact on the Regulation Toolbox of Monetary Policy

The settings of the circulation framework, access and interest-bearing characteristics of legal digital currency will have an important impact on the existing monetary policy regulation. The impact of legal digital currency on the existing monetary policy regulation is mainly reflected in three aspects – monetary policy tool system, target system and transmission channel.

Monetary policy instruments are variables that can be directly controlled by the central bank. It has been shown that the impact of the legal digital currency on the effectiveness of current monetary policy instruments depends mainly on the characteristics set by the legal digital currency, which are reflected in the following three aspects:

1) The impact of token-based non-interest-bearing legal digital currencies on monetary policy instruments is neutral.35 This type of legal digital currency does not fall under the category of monetary policy instruments and does not have a significant impact on the macroeconomy. The token-based non-interest-bearing legal digital currency is similar to the digital form of paper money, which only replaces paper money in the issuance process and has no substitution effect on other assets of residents, such as bank demand savings and financial assets. Currently, central banks are inclined to issue token-based non-interest-bearing legal digital currencies that are closer to paper money without fully assessing the risks of legal digital currencies to reduce their possible and unpredicted risks.

2) Account-based non-interest-bearing legal digital currency under the single-tier circulation

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framework may bring negative impacts on other monetary policy tools.\textsuperscript{36} Firstly, the central bank’s direct issuance of legal digital currency for the whole society will overturn the existing currency issuance and circulation system, which will have a greater impact on the current monetary policy regulation system. Secondly, a legal digital currency based on accounts open to the public will compete with traditional commercial bank accounts, squeeze out deposits and shrink the credit regulation channel of monetary policy.\textsuperscript{37}

3) Finally, legal digital currency accounts that are non-interest-bearing will raise the effective lower bound on interest rates, which will not only reduce the room for monetary policy operations, but will also diminish the effect of the central bank's guidance.\textsuperscript{38} As a result, countries that are piloting legal digital currencies generally agree that the convenience offered by the current single-tier circulation framework may struggle to offset the risks it poses.\textsuperscript{39}

Account-based interest-bearing legal tender in a single-tier circulation framework may bring negative impacts to existing monetary policy instruments. Unlike non-interest-bearing paper money, interest-bearing digital currencies have investment properties and can be used as liquid assets similar to deposits and treasury bonds. Central banks can assign positive, zero or even negative interest rates to legal digital currencies depending on economic fluctuations.\textsuperscript{40}

It has been argued that interest-bearing legal digital currencies can break the limits of the effective interest rate floor and become an effective medium of exchange.\textsuperscript{41} Since interest-bearing legal tender can meet the need for an effective medium of exchange, improve the efficiency of the payment system and eliminate the problem of "zero interest rate floor" caused by paper money, developed countries in the West have high expectations for it. However, some scholars argue that as long as paper money exists, interest-bearing legal digital currencies cannot eliminate the effective interest rate floor constraint and may even increase the risk premium and limit the


scope of monetary policy operations. Moreover, some scholars have emphasized that interest-bearing legal digital currencies will weaken the role of traditional monetary policy tools. On the one hand, the public will be more inclined to hold the legal digital currency for transactions, and the decrease in deposits will lead to a decline in commercial banks' reserves, making the reserve ratio less effective. On the other hand, the fast transfer and 24/7 applicability of legal digital currency may weaken the effect of rediscounting policy tools.

### 3.3.2 Impact on the Target System of Monetary Policy

The impact of legal digital currency on the current monetary policy target system is mainly reflected in the following two aspects.

1) Firstly, the issuance of legal digital currency may have an impact on the ultimate goal of monetary policy. The ultimate goal of China's monetary policy has begun to change from "stabilizing growth and preserving the value of the currency" to "stabilizing growth, transforming the model, adjusting the structure and controlling risks". However, the systemic risks that may be caused by legal digital currency are still uncertain. On the one hand, the issuance of legal digital currency will affect the money supply transmission mechanism, make the operation of monetary policy more difficult, and make it difficult to determine the regulation of aggregate supply and demand. On the other hand, the issuance of legal digital currency may lead to the expansion of central banks' balance sheets, exposing them to systemic credit risk. In particular, if a legal digital currency leads to a decline in liquidity for commercial banks, the central bank will need to provide additional liquidity to commercial banks and decide how to allocate funds across commercial banks. All these scenarios will increase the difficulty for the central bank to achieve its ultimate goal.

2) Secondly, the issuance of a legal digital currency may have an impact on the intermediation objective of monetary policy. At present, all studies have concluded that legal digital currency can enhance the efficiency of transmission from operational to price-based intermediation targets. However, scholars are more controversial about how the legal digital currency affects the quantitative intermediation

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target. On the one hand, scholars argue that the issuance of legal digital currency will weaken the measurability, controllability and relevance of the quantity-based intermediation target. The issuance of legal digital currency will squeeze out short-term deposits and increase time deposits, resulting in greater volatility of money multipliers. On the other hand, some scholars argue that legal digital currency can help the central bank dynamically regulate the money supply and improve the relevance of quantitative intermediation targets to the real economy. In addition, some scholars believe that legal digital currency will enhance the efficiency of interest rate intermediation targets. The traceability, time dependence, sector dependence and economic state dependence of legal digital currency can enhance the measurability, controllability and relevance of the interest rate intermediation target.

3.3.3 Impact on the Transmission Channel of Monetary Policy

The impact of legal digital currency on the transmission channel of monetary policy is mainly reflected in the credit channel, which is manifested in the following two aspects.

1) Firstly, the legal digital currency may weaken the bank lending channel. The bank lending channel refers to the fact that monetary policy increases the funds available to commercial banks for borrowing by increasing their excess reserves and deposits, and the increase in loans leads to an increase in business investment and household consumption, and ultimately an increase in aggregate output. The impact of the legal digital currency on the bank lending channel depends on the financing structure of banks. If commercial banks are more dependent on financing from the central bank, then the central bank has more influence on the funds available to commercial banks and the bank lending channel is more efficient. However, if commercial banks have a wider range of financing channels, the central bank's ability to discipline their liquidity will be weaker. In addition, commercial banks' access to external funding from different sources may increase financial risks and weaken the efficiency of monetary policy transmission.

On the one hand, the legal digital currency will replace bank deposits in current accounts and increase the pressure on banks to absorb deposits. On the other hand, the legal digital currency will make commercial banks more dependent on wholesale

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end financing, making the overall financing cost and financing instability of commercial banks rise\textsuperscript{54}.  

2) Secondly, a legal digital currency may weaken the corporate balance sheet channel. The corporate balance sheet channel refers to the fact that monetary policy increases corporate net worth by pulling up corporate stock prices, which in turn mitigates corporate adverse selection and moral hazard problems, and the amount of loans available to firms rises, allowing investment and total output to increase.\textsuperscript{55} The issuance of legal digital currency may change the balance sheets of economic agents, increase the volatility of traditional base money and weaken the effectiveness of credit channels.\textsuperscript{56} In particular, legal digital currency in a single-tier circulation framework may directly change the way firms lend to each other and weaken their demand for bank loans. Parlour and others\textsuperscript{57} constructed a two-stage partial equilibrium model that examines the impact of legal digital currency at the wholesale and retail ends on bank lending decisions. The legal digital currency on the wholesale end reduces the cost of interbank settlement. While this increases social welfare in general, it increases inequality in lending across regions. In contrast, the legal digital currency on the retail end will expand the overall size of lending. Not only will it not replace traditional monetary policy tools, but it can also improve regulatory efficiency.


\textsuperscript{55} Carl E. Walsh, Monetary Theory and Policy (MIT Press, 2017).


4. Technical Architecture of CBDC

Based on the observation of industry practices, most CBDC systems utilize a centralized architecture, with a few experimentations on decentralized solutions. This section provides a detailed analysis of the advantages and disadvantages of the centralized and decentralized architectures.

4.1 Four Fundamental Infrastructures are Required

Any functional digital payment system requires four foundational infrastructures to be implemented.

- First, the electricity supply needs to be reliable. Digital payments depend on power, which is often inaccessible in many developing countries, both in urban and rural settings.
- Second, having a robust ICT infrastructure is paramount. Similar to electricity, mobile networks do not offer coverage in sparsely populated and rural areas, where they are most needed to enable mobile money solutions, with appropriate voice, text messaging and other communication services.
- Third, the basic payment structure such as automated clearing houses and payment switches, along with system interoperability, needs to be in place.
- Fourth, the personal ID infrastructure, such as reliable ID systems (mainly digital ID), can help digital financial service providers carry out their due diligence and enable access to patrons of digital finance.

4.2 Classification of Legal Digital Currency Payment Systems

The stable and safe operation of the payment system is an important guarantee for the efficient transmission of monetary policy and the rapid development of the financial market. Building a payment system that is compatible with legal digital currency is an important prerequisite for the successful issuance of legal digital currency. According to the latest progress of global legal digital currency research and development, the payment system of legal digital currency is mainly divided into centralized payment systems and decentralized payment systems. The differences between the two are mainly in the following two aspects – whether they are hierarchical, and whether each node can clear and settle directly, shown as Figure 4-1.
4.3 Centralized Digital Payment System

4.3.1 Architecture of Centralized Payment System

Since it is difficult for a single system to support the huge volume of financial business, traditional centralized payment systems are often divided into multiple subsystems that handle different financial businesses. According to the payment systems in China, Japan, Republic of Korea, Singapore, UK and USA, centralized payment systems are often composed of multiple subsystems, including large-value payment systems, small-value (retail) payment systems, securities settlement systems and foreign exchange settlement systems. The four main payment subsystems, including (1) large-value payment system, (2) Retail Payment System, (3) Securities Settlement System, and (4) Foreign Exchange Settlement System, are described below.

1. Large-value Payment System

The large-value payment system mainly handles business-related large and priority payments, and the specific business can be roughly divided into three areas as below:

- The large-value payment system connects banking and financial institutions nationwide and provides a channel for interbank payment and clearing for each banking and financial institution.
- The large-value payment system directly provides fund settlement services for the bond trading market, interbank lending market and other financial markets.
- The large-value payment system can provide fund settlement services for other payment systems such as the retail payment system and the intercity bill exchange system.
Figure 4-2: Three areas of large-value payment systems

1. Connects banking and financial institutions nationwide and provides a channel for interbank payment and clearing for each banking and financial institution.
2. Directly provides fund settlement services for the bond trading market, interbank lending market and other financial markets.
3. Provide fund settlement services for other payment systems such as the retail payment system and the intercity bill exchange system.

The transfer process of a large-value payment system generally consists of the following five steps:

1) Participants submit payment instructions.
2) The system stores the payment instructions and then determines the order of sending based on a series of factors, which include instruction delay cost, liquidity cost, risk management, queue management and queue release algorithm.
3) Once a payment instruction is submitted, the payment system checks whether the instruction meets the basic conditions for settlement, i.e., whether there are sufficient funds (or overdraft limit) in the payer’s settlement account. If not, the payment instruction is returned to the originating bank or temporarily stored in the central processor.
4) If the settlement condition is satisfied, an optional algorithm is provided for the release of queued instructions.
5) The system analyses whether the payment is irrevocable and final, and provides a way to transfer the settlement assets between the sender and the receiver.

In terms of the choice of model for large-value payment systems, the full RTGS has gradually replaced the DNS as the main choice for large-value payment systems in most countries since the 1990s. The RTGS is capable of continuous funds transfer instruction processing and final settlement. Full amount means that each transaction is settled independently, rather than the total amount of debits and credits being rolled over; and real-time means that settlement continues without interruption and can be settled at any moment in business. To achieve a real-time and full settlement, banks need to hold more liquid assets to ensure that payment orders are processed in real-time without delay, which requires more liquidity from banks. The current RTGS plays an extremely important role in the national payment system. In 2020, China’s large-value real-time payment system processes 5.13 trillion payment transactions amounting to CNY5.648 trillion, accounting for 68.91 per cent of the payment system and 55.59 times of the total GDP in 2020. Although the settlement risk of RTGS has been reduced compared to DNS, it still faces certain risks in the operation process. Specifically, the settlement risk of RTGS includes: 58

• Credit risk, i.e., losses caused by default of one party in the transaction at maturity.
• Liquidity risk, although no default occurs, one party in the transaction delays settlement at maturity, resulting in the liquidity of the recipient being affected.
• Systemic risk, where one or more participants fail to fulfill their settlement obligations, generating a domino effect leading to a series of payment defaults among participants in the payment network.

2. Retail Payment System

The retail payment system mainly handles payment services with relatively small amounts. In addition to traditional debit-credit business, retail payment systems can be applied to daily payment businesses closely related to daily life, such as payroll payment, utility bill collection, pension payment, interbank deposit and exchange, providing payment clearing services with high business volume and low cost to meet the diverse needs of society.

Unlike large-value payment systems, national micro-payment systems still mostly use DNS that sends payment instructions in bulk and rolls them in real-time, but the netting is only done at the end of a given business cycle (usually one business day) to complete the final transfer of claims (debts) between participants. Compared to RTGS, DNS is more liquid but has a greater settlement risk. A netting system settles at the end of a business day, meaning that one party to the transaction needs to provide day-to-day credit to the other party, and the settlement interval is lengthened leading to higher settlement risk.

In summary, the large-value payment area adopts a real-time, full settlement model, sacrificing some liquidity efficiency to reduce settlement risk. In contrast, the micro-payment area adopts a timed, net settlement model, which enhances the liquidity of the system at the cost of increased credit risk.

Compared with the large-value payment system, the micro-payment system processes more payment transactions, but the individual amount is lower. In 2020, China’s micro-payment system processed 34.58 trillion payment transactions of a total amount of CNY146.88 trillion.\(^5^9\)

3. Securities Settlement System

The securities settlement system mainly handles securities transaction settlement and clearing operations. After the securities transactions are completed, the securities settlement system approves and calculates the price of the securities receivable and payable by both parties to the transaction, transfers the securities from the seller to the buyer, and transfers the funds from the buyer to the seller.

Securities settlement is divided into two methods – full settlement and net settlement – which have the characteristics of both RTGS and DNS models. Full settlement is the most basic transaction method in which a single transaction is used to clear securities transactions that have been concluded between two parties. Securities and funds are delivered one by one after clearing and the system stops settlement if one of the parties has insufficient bonds or funds. Full settlement is applicable when the single transaction amount is large and the number of participants is small, such as in the interbank market. In 1989, to reduce the risk of securities trading, experts in the field of securities clearing in various countries

\(^5^9\) Statista.
38
proposed the principle of Delivery Versus Payment (DVP), i.e., the principle of simultaneous delivery of securities and clearing of funds. Since then, Germany, Hong Kong, Japan and other countries and regions have connected their securities clearing systems with large-value real-time payment systems to realize securities payments.

Netting is based on a single market participant and does not clear a single transaction, but rolls the balance of securities and funds bought and sold by the participant, and settles with the participant based on the rolled net result. Netting is more suitable for markets with small single transaction amounts, many participants, and frequent and active transactions, and requires close cooperation between the settlement system and the funds clearing system. Netting can be further subdivided into bilateral netting and multilateral netting, depending on whether an intermediary clearing agency is introduced. Bilateral netting refers to the rollover of the balance of all transactions concluded between two parties, and both parties settle according to the net amount obtained from the rollover. Multilateral netting, on the other hand, involves the settlement of all securities and funds receivable and payable for all transactions by a settlement participant, with each settlement participant settling with the securities registrar and clearing agency based on the net amount of the difference.

In comparison, multilateral netting is more efficient but also riskier. To control risk, multilateral netting often introduces an authoritative intermediary “central counterparty” to provide the final settlement of securities and delivery of funds for each participant. Most securities markets currently use the multilateral netting model because of its greater operational efficiency.

4. Foreign Exchange Settlement System

The foreign exchange settlement system mainly deals with cross-border foreign exchange fund settlement business. The foreign exchange market structure can be divided into two levels – the retail market and the wholesale market (also known as the interdealer market or interbank market). Foreign exchange dealers, foreign exchange brokers and customers are the three common types of subjects in the foreign exchange market.

The most widely used foreign exchange settlement system in the world is continuous linked settlement (CLS), which is a multi-currency foreign exchange clearing bank. In 1994, HSBC, JP Morgan, Barclays and 20 other major global foreign exchange banking groups jointly established CLS. In September 2002, CLS started its formal operation, headquartered in New York, and supervised by the Federal Reserve, with London and the USA as the main operating locations. The process of cross-border payments is as follows: a clearing account is opened at the central bank of the country corresponding to the main currency of the CLS, it is connected to the real-time payment systems of different countries, and the clearing of different currencies and short position capitalization is realized through the local RTGS.

The CLS relies on the Society for SWIFT for communication links with its members. As an interbank non-profit international cooperation organization, SWIFT is a communication network, a telecommunication channel in the international collection and payment system, which mainly assumes the function of information transfer in cross-border transactions and does not involve fund transfer. The standard format of messages introduced by SWIFT provides a standard language for international interbank data exchange, allowing different financial institutions in the world to use a
uniform way to account for payments and receipts or exchange other information.

In recent years, the SWIFT system monopolizing or cutting off the cross-border payment channels of target countries has become the main means for some countries to implement financial sanctions, thus posing a threat to the global financial security.

4.3.2 Advantages and Disadvantages of Centralized Payment System

The centralized payment system has a long history and is well established in all aspects. However, with the development of financial technology and the diversification of public payment needs, the disadvantages of centralized payment systems have become increasingly apparent. The following is a detailed analysis of the advantages and disadvantages of centralized payment systems.

1. Advantages of Centralized Payment System

The centralized payment system facilitates centralized management and operation. The existence of a centralized institution is one of the core features of a centralized payment system. Authoritative institutions coordinate and manage the system, and the system operates on a more solid basis. The central bank of each country is often in a central position in the payment system, playing multiple roles. Central banks contribute to the advantages of centralized payment systems in three main ways as below:

1) Central banks provide credit protection. People need to trust that money will be generally accepted and that payment will be executed, and this trust is achieved primarily through the central bank and the centralized ledger it manages.

2) Central banks provide financial regulation. The central bank sets system access standards and provides inspection and supervision of financial institutions involved in payment settlement.

3) Central banks provide macro regulation and innovation leadership. Central banks launch monetary policies based on economic development to influence macroeconomic trends. At the same time, the central bank shoulders the responsibility of financial innovation and continuously explores new technologies and directions to improve the efficiency of system operation.

The structure of the centralized payment system is complete, and the settlement system is consummate. The centralized payment system is divided into several subsystems, which correspond to different areas of financial business processing, and can cover the needs of multiple transaction types. From daily retail small payments to interbank large fund transfers to cross-border foreign exchange settlements, all these scenarios can find corresponding departments and corresponding systems to complete transaction processing. Some of the subsystems establish linkage channels between them to achieve complementary advantages. For example, in developed economies such as Germany, Hong Kong, Japan, UK and USA, securities settlement systems are connected to large-value real-time payment systems to achieve DVP settlement.

In addition, the diversified and specialized development of payment service organizations further extends the service functions of payment systems. Payment service organizations include governments, industry associations, emerging fintech companies, etc. The wide application of ICTs has provided opportunities for non-banking organizations to enter the payment service field. The
original third-party payment institutions have transformed and added financial management and marketing services to their original payment business, making their services more diversified and comprehensive. The rise of diversified payment service organizations helps build a healthy and win-win payment ecological collaboration system.

Furthermore, the presence of sound payment and settlement laws and regulations guarantee the healthy operation of the payment and settlement system. During the development of the centralized payment system, the management laws and regulations as a supporting system have generally improved. At present, the centralized payment system has established a high level of modern operation management regulations in the access of participants, payment instructions, rollover arrangements and settlement finality. A corresponding legal system for electronic bills, credit card payments, Internet banking payments, and other emerging electronic payment business-related laws and regulations is being built. Sound legal support can effectively prevent potential risks during the operation of payment systems.

2. Disadvantages of Centralized Payment System

The centralized payment system requires centralized settlement and clearing, resulting in shortcomings in its application scenarios, and its disadvantages are mainly manifested in the following three aspects:

Funds cannot be directly transferred between systems and the turnover of funds is slow. The traditional centralized payment system adopts a centralized scheme. Within a single subsystem, it is difficult to realize direct transfer between points, and it needs to rely on intermediaries for credit endorsement, which limits the efficiency of fund turnover. Specifically (Figure 4-3), Customer A of Bank X wants to initiate a payment to Customer B of Bank Z. If Bank X does not have a clearing account with the central bank, Bank X needs to rely on Bank Y, which has a clearing account with the central bank, as a correspondent bank to process the transaction. Bank Y and Bank Z will then process the transaction through the clearing account at the central bank before Customer B can receive the transfer from Customer A. In the case of cross-border payments, the fund’s transfer process is more cumbersome, involving multiple participants from the depositary bank, the central bank of each country and the bank abroad (the delegated correspondent bank or a branch of the bank established abroad). Each cross-border transaction needs to be recorded and reconciled in the institution’s books, with numerous transaction steps and low transaction efficiency.\(^\text{60}\)

\(^{60}\) Zhe Ren and Weijie Hu, "Blockchain technology and the change of payment system", *China Finance*, no. 14 (2016).
Figure 4-3: The reliance on intermediaries in centralized payment systems

Customer A will have to go through a number of banks to get to customer B if Bank X does not have a clearing account with Bank Z.

- Cross-border interconnection of national payment systems suffers high-risk contagion potential. The current cross-border payment systems all have the joint participation of central banks and commercial banks in multiple countries. To achieve a cross-border settlement, banking institutions in different countries are often directly or indirectly connected. As a result, the inability of one participant in the system to settle its debts or the disruption of the system itself may lead to the risk that other participants in the system will not be able to settle their debts promptly. The more interconnected a payment system is, the deeper the risk contagion. System failure may bring about widespread liquidity problems and credit problems that threaten the stability of the entire system and the financial system.

- Centralized payment systems may weaken the financial inclusion of legal digital currencies. Financial inclusion is one of the important issues of concern for central banks. Payment systems are an important part of financial market infrastructures and an important part of developing financial inclusion. The access of users to legal digital currency under centralized payment systems will become difficult, which raises the concern of central banks about financial inclusion. On the one hand, the coverage of centralized payment systems does not meet the needs of financial inclusion in each country. Especially in countries and regions with relatively backward economic development, modern payment systems cannot reach poor people. On the other hand, the introduction of legal digital currency in the centralized payment system requires a lot of human and material resources to set up and maintain new access rights to legal digital currency. In addition, centralized payment systems are not conducive to increased global financial inclusion. When legal digital currencies are used to improve cross-border payments, the centralized account option is not a good solution to the divergences and limitations among current global settlement systems. Within certain security boundaries, the global cross-border payments market prefers instruments with high payment efficiency. However, central banks' systems of accounts are focused on the security of their currencies and are designed on the principle of risk minimization, which is more inefficient. More importantly, differences in national systems of
accounts add to the difficulty of global financial inclusion.

To sum up, the centralized payment system has many years of technical accumulation and practical experience and has gradually built up a comprehensive framework system under the coordinated operation of the central institution and constructed the necessary supporting facilities for the system operation. The existing centralized payment system can not only cover the needs of different types of fund transfers, but also complete the whole process of daily transactions in a relatively efficient and stable manner. However, the centralized payment system has certain shortcomings. Since centralized payment systems are often composed of different branch systems and cross-border interconnection of payment systems in various countries, the efficiency of fund turnover is affected on the one hand, and the risk contagion potential is high on the other. At the same time, the current centralized payment system has restrictions in terms of transaction methods and transaction areas, and cannot achieve compatibility, which to a certain extent weakens financial inclusion.

4.4 Decentralized Digital Payment System

The decentralized payment system built on distributed ledger has great potential to solve existing problems in transaction efficiency, risk control and financial inclusion, and has received attention from governments. Countries and regions such as China, Japan, Singapore and Europe have taken the lead in technology validation and application practice.

Core Technologies of Decentralized Payment System

A distributed ledger is a database of assets that can be jointly governed and shared in a network consisting of multiple sites or multiple institutions. In a distributed ledger, each node records the complete transaction record and can participate in verifying the legitimacy and validity of the transaction, avoiding the risk of destruction of the transaction record due to the destruction of a single bookkeeper or node and guaranteeing the security of the data. The core problem that needs to be solved by DLT is how payment transactions and agreements should be conducted in a transaction environment that lacks the third party as a credit guarantee.

As Figure 4-4 shows, the core technologies of distributed ledgers mainly include cryptographic algorithms, peer-to-peer (P2P) network, consensus mechanisms, smart contracts and distributed storage. Together, these technologies determine the characteristics of distributed ledgers such as decentralization, information that cannot be forged or tampered with and information traceability.

1. Cryptographic Algorithms

A cryptographic algorithm is a mathematical function that implements encryption and decryption operations. Cryptographic algorithms are the basic core technology to guarantee the confidentiality, authenticity, security, and non-repudiation of transactions. In the process of transferring payment, the sender converts the message to be sent as “plaintext” into a meaningless random message, i.e., “ciphertext”, a process called encryption. The process of reconverting the ciphertext to plain text is called decryption. Both encryption and decryption are achieved through a “key” (Figure 4-5).
Common cryptographic algorithms include symmetric cryptographic algorithms, asymmetric cryptographic algorithms and hash algorithms.

- **Symmetric cryptographic algorithm** is an algorithm in which the keys used for encryption and decryption are the same, or can be derived from each other. Typical symmetric cryptographic algorithms include Data Encryption Standard (DES), Advanced Encryption Standard (AES) and International Data Encryption Standard (IDES). In 1977, the USA announced DES as the encryption standard, after which symmetric cryptographic algorithms developed rapidly and were widely used. According to the different data processing methods, symmetric cryptographic algorithms can be divided into group cryptographic algorithms and stream cryptographic algorithms. Packet cipher algorithms divide plaintext data into equal-length “blocks” and encrypt them in groups. The stream cipher algorithm uses a key to form a keystream, and then encrypts the plaintext using the “one-at-a-time” principle, using the bit as the unit of encryption. The former has good diffusivity and encryption does not change over time, but the error propagation rate is relatively high and is mainly used in commercial applications. The latter is less diffusive and the encryption varies with time, but the error propagation rate is low and is mainly used in military applications.

- **Asymmetric cryptographic algorithm** is an
algorithm in which the keys used for encryption and decryption are different. In this algorithm, the decryption key cannot be introduced from the encryption key, so the encryption key can be made public. Typical asymmetric algorithms include RSA, ElGamal, etc. Compared with symmetric cryptographic algorithms, asymmetric cryptographic algorithms are more complex and secure in computation, but slower in encryption and decryption.

- Hash algorithm refers to the creation of an input information string without a fixed length into a fixed length output information string known as the “hash value”. The hash algorithm is conflict-resistant (different input strings cannot generate the same output string) and irreversible (the input string cannot be deduced backward from the output string). The hash algorithm is widely used in the fields of digital signature and message verification.

It is worth noting that in 2010, China independently developed four cryptographic algorithms SM1, SM2, SM3 and SM4, which can realize the functions of symmetric, asymmetric and promiscuous algorithms, replacing the international common algorithms.

2. P2P Networks

A P2P network is a network structure that eliminates centralization and treats all network participants as peers, distributing tasks and workloads among them.

In traditional communication, a client/server network architecture is often used, in which the server is responsible for data storage, retrieval and communication services, and is at the centre of the communication process. The client/server architecture is centralized, not only to maintain the consistency of services, but also to facilitate service maintenance and upgrades. One of the disadvantages of the client/server architecture is if the server fails, the system operation is likely to be paralyzed. Therefore, to ensure the stability and reliability of the system, a client/server architecture requires the high performance of the server and network loop.

In the P2P architecture, the information is exchanged on the P2P network as both client and server, without relying on a central node. Therefore, even if a few of the nodes fail, the operation of the overall network is not affected and is not prone to paralysis. Compared with the client/server architecture, the P2P architecture has higher openness and flexibility, breaks through the performance bottleneck of the centralized architecture and improves the overall efficiency of the system operation. P2P communication is the basis for the realization of the distributed network.

In a P2P network, the server faces a series of practical problems after exit, such as what kind of link to connect between nodes, how nodes join and exit the network, how to retrieve resources and locate nodes efficiently, etc. The current mature P2P networks can be divided into four categories (Figure 4-6).

In a centralized P2P network, a central node is set up in the P2P network to establish connections with other nodes. Other nodes on the network store all the resource information they have on the central node, and when a node needs to query, it only needs to submit keywords to the central node, which searches all the resources and locates the node that can provide content services. The nodes establish connections and complete information transmission between nodes themselves. Unlike the client/server architecture, the main role of the central node here is to provide information retrieval services and is not responsible for transmission, thus the load on the server is greatly reduced. However, the presence of the central component makes the system a bottleneck in terms of
1) The distributed structureless P2P network breaks the limitation of the central component. This network eliminates the server and the resource information is distributed to all nodes. When a query is needed, a node broadcasts a request to a neighboring node, which retrieves its resources and forwards them in flooding and random walks if there is no corresponding content. The number of forwarding is limited, and nodes obtain information based on the query results. Although the central component is eliminated, the network is completely random, and the information query is slow, consuming and incomplete in results, which is not suitable for large-scale commercial applications.

2) The distributed structured P2P networks overcome the blindness of search in P2P networks. This network allows nodes to be organized according to some structure, such as a distributed hash table (DHT). In DHT, each node is given a logical address and information resources are dispersed into each node according to the logical address. The nodes provide storage and query services for the information resources they are responsible for. The precise connection between resources and nodes on this network is only suitable for finding precise resources and is equally unsuitable for large-scale commercial applications.

3) The distributed structured P2P networks overcome the blindness of search in P2P networks. This network allows nodes to be organized according to some structure, such as a distributed hash table (DHT). In DHT, each node is given a logical address and information resources are dispersed into each node according to the logical address. The nodes provide storage and query services for the information resources they are responsible for. The precise connection between resources and nodes on this network is only suitable for finding precise resources and is equally unsuitable for large-scale commercial applications.

4) The hybrid P2P network is widely used today which combines the features of centralized and distributed P2P networks by dividing the nodes into two categories: normal nodes and super
nodes. Ordinary nodes are connected to super nodes through a star structure, while super nodes are connected to each other in a structureless and random way. The super nodes are responsible for the query requests of the managed ordinary nodes. The query speed is accelerated in this model, and although the presence of super nodes still poses a threat to system security, the threat is greatly reduced compared to the C/S architecture.

3. Consensus Mechanism (Consensus Algorithm)

The consensus mechanism, also known as the consensus algorithm, is the process by which nodes in a P2P network that lack trust among each other follow a predetermined mechanism to reach an agreement on the data state of the network. On distributed networks, facilitating decentralized nodes to reach consensus is a challenge. The mutual distrust among nodes brought by decentralization may lead to problems such as data disagreement and malicious nodes. Through consensus mechanisms, nodes in a P2P network rely on a set of widely-accepted mathematical algorithms to establish trust. Technical endorsement replaces centralized institutions and mutual trust among nodes to create new credit and achieve "self-trust" in the network. In the DLT architecture, different formulas and algorithms can be used according to different application scenarios. Current common consensus mechanisms include proof of work, proof of stake, and delegated proof of stake.

In the proof-of-work mechanism, any node in the distributed network can participate in bookkeeping. According to Satoshi Nakamoto who began coding the first implementation of bitcoin in C++ in 2007 and wrote the bitcoin white paper in 2008, the bookkeeping right of each transaction belongs to the node that completes the "workload" first. The workload here refers specifically to mining, i.e., the use of computing power to solve a complex mathematical puzzle. After the node with the bookkeeping rights updates the ledger, the other nodes on the network update it simultaneously. To encourage nodes to participate in maintaining the consistency of the ledger, the bitcoin protocol has a corresponding incentive mechanism, in which the node that obtains bookkeeping rights is rewarded with a certain number of bitcoins, thus motivating nodes to compete for arithmetic power and work together to maintain the stability of the network. The advantage of this mechanism is that it guarantees the security and decentralization of the system, and the number of node identities does not affect the consensus result, so it is free to enter and exit. The disadvantage is that proof of work artificially raises the computational cost of confirming transactions, which causes a waste of arithmetic power and energy on the one hand, and prolongs the settlement cycle, with a maximum of seven transactions per second in the case of bitcoin, making it difficult to implement for commercial applications.

The proof-of-stake mechanism uses proof-of-stake instead of proof-of-counterpower in proof of work. In this case, the node with the highest stake gets the bookkeeping rights instead of the node with the highest count. The amount of equity is quantified by the "age of the currency", which is equal to the number of currencies multiplied by the time the currency has been held. The more currency a node holds, the longer it has held the currency, and the older it is, the more equity it has, and the harder it is for participants to mine in proportion to the age of the currency. The advantage of this mechanism is that it avoids the problem of wasted resources in proof of work. The disadvantage is that it tends to create a Matthew effect, where people with more wealth have more equity and are more likely to gain bookkeeping rights and bookkeeping incentives, leading to a
situation where wealth becomes more and more concentrated. When the final wealth is highly concentrated, the security of the system is difficult to be guaranteed.

The delegated-proof-of-stake mechanism converts all holders' interests into equal "votes" and allows holders to vote for a certain number of nodes as "trustees" to carry out verification and bookkeeping. Each node on the network votes for a trustee to sign the block for each transaction, and delegated proof of stake ensures that the trustees can do their job accurately through technical protection. The advantage of this mechanism is that it significantly improves the efficiency of consensus reaching, the speed can reach the second level and the democracy of delegated proof of stake is higher than proof of stake. The disadvantage is that there are too few nodes involved in transaction confirmation, and the decentralization is more reflected in the voting process.

4. Smart Contracts

A smart contract is a set of computer programs that can automatically verify and execute the terms of a contract when set conditions are met. In the 1990s, Szabo [61] first introduced the concept of a smart contract and summarized it as a set of promises defined in mathematical form, with a computer automatically executing the terms of the contract protocol. The process of running a smart contract is as follows: first, the program code is programmed according to the terms of the contract, and then the computer obtains data from the outside world to assist in judgment. When the system finds that the set conditions have been met, it starts to execute the contract terms automatically to realize the transfer of assets. Smart contracts translate contract terms into program code, which becomes the vehicle for legal contracts. Unlike legal contracts, smart contracts are self-executing and self-enforcing and have high practical application value. However, due to the lack of a practical platform, smart contracts did not receive much attention at the beginning.

The rise of blockchain has provided an opportunity for the development of smart contracts. While there is no central authority for unified management in distributed networks, smart contracts can reduce human intervention in the transaction process and use events as the driver to hold and transfer digital assets on the ledger based on program code, thus replacing the central authority to achieve some of the functions of traditional systems. Smart contracts are widely used in mainstream blockchain systems that provide open-source platforms for smart contracts and support corresponding contract programming languages. Among them, Bitcoin, Ethereum and Hyperledger are currently the most mature smart contract platforms.

Smart contracts can improve transaction efficiency. The transaction process does not require an intermediary, which enhances the efficiency of contract verification and execution. Smart contracts can also ensure contract execution. Once deployed to the blockchain, it cannot be changed and will be executed to the end as long as the conditions are met, and human intervention is ineffective.

However, the current development of smart contracts is still in its infancy, and its application has certain

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limitations. Firstly, there are security vulnerabilities in the program code as smart contract execution relies on the computer program written. On the one hand, the original meaning of the traditional contract may be distorted when converted to machine language, and on the other hand, the already formed contract code may have the risk of coding errors. Secondly, blockchain platform limits the execution performance. The current blockchain platform has limited data processing capacity and scalability, and it is difficult to avoid the same limitations for smart contracts running on the platform.

4.4.1 Advantages and Disadvantages of Decentralized Payment System

1. Advantages of Decentralized Payment System

Currently, central banks are very interested in the potential of distributed ledgers to improve existing payment systems and transaction processes and have begun to explore the feasibility of using decentralized payment systems to issue legal digital currencies. The advantages of decentralized payment systems are mainly reflected in the following three aspects:

1) Under a decentralized payment system, the number of money circulation links is significantly reduced and the efficiency of financial operation is improved. Through decentralized payment systems, money transfers can avoid complicated systems, both domestic and cross-border transfers can create a direct transaction channel between payee and payer, which has a cost advantage and efficiency advantage while reducing systemic risk. Blockchain technology can significantly improve the operational efficiency of existing payment systems and bring transformative effects to the financial system. Among them, the costly and inefficient cross-border payment is one of the excellent scenarios for the application of blockchain technology in the payment system. While the traditional cross-border system faces multiple obstacles such as cross-currency, cross-border and economic contracts, blockchain can realize "transaction-as-settlement", which automatically completes the settlement process during the transaction and significantly improves the efficiency of cross-border transfers.62

2) A decentralized payment system creates a decentralized credit mechanism and provides an opportunity for financial transaction model innovation. DLT can generate credit value spontaneously in the system through consensus mechanism and cryptographic algorithm, without relying on the endorsement of central institutions, realizing "decentralization". This mechanism has an impact on old business models such as third-party payments and fund escrow, but provides opportunities for emerging financial transactions. For example, in the Internet field, blockchain technology is widely used in Internet insurance, equity crowdfunding, online lending and other models. Applying blockchain technology on equity crowdfunding platforms can enable P2P transactions between investors and enterprises and solve the problems of compliance and security of fund management.63 In summary, the introduction of blockchain technology in the financial payment


system can help promote new business models.

3) A decentralized payment system can enhance payment system liquidity and reduce transaction funding costs. Under a distributed account, all P2P transactions can be performed instantly. Legal digital currencies under the P2P (individual-merchant) payment settlement model are much less dependent on bank accounts and are available 24 hours a day, 365 days a year, significantly increasing the liquidity of market participants. Distributed accounts can have positive or negative interest rates, and this interest-bearing feature makes token-based models of legal digital currencies superior to cash currencies. As a result, state-backed digital currencies can be widely accepted among end users and achieve sufficient liquidity to replace thousands of digital currencies. The use of fiat digital currencies instead of cash by individuals and companies can reduce the cost of maintaining a supply of physical currency and preventing counterfeiting.

2. Disadvantages of Decentralized Payment System

The development of decentralized payment systems based on DLT is still at a nascent stage and is not mature enough for the deployment of large-scale payment systems. The main disadvantages of decentralized payment systems include the following:

1) The decentralized payment system still faces certain technical risks and the security of the system account has hidden dangers. Firstly, the underlying technology of the system itself still has certain defects and loopholes. For example, blockchain technology has the risk of the soft and hard fork and key loss, and hacking attacks may lead to system paralysis, data theft, tampering or asset theft in the system. Cryptographic algorithm technology is at risk of being cracked. Cryptographic algorithms are essentially mathematical problems, and mathematical analysis attacks are the main threat to various cryptographic algorithms based on mathematical puzzles. Quantum computing can produce many results for mathematical problems in a relatively short period, and with the gradual development of quantum computing over the next 10-15 years, it is likely to bypass the security mechanisms that underpin distributed ledgers. Secondly, the failure of a single link in the system may bring down the whole system. All links of the decentralized payment system are implemented through the Internet, which requires very high computer and network technologies. Negligence or failure in any one of the algorithm design, system operation or equipment maintenance can damage the legal digital currency system and cause huge losses.

2) Decentralized payment systems are automated and programmed and are less flexible as they cannot be changed after operation. DLT is very complex and contains a series of mutually compatible protocols, and most of the transaction steps are automated by the program. Coding is written upfront, and once the system is up and running it is difficult to fix potential


vulnerabilities or adjust the original blockchain protocol, even if the developer proposes changes. Such features play a role in reducing human intervention and improving the efficiency of transactions, but they lead to the overall blockchain system being less flexible than other systems. Many scholars have shown that the performance that distributed systems can produce is currently lower than the existing computing systems (centralized) in most developed countries and that traditional central bank-based payment systems are usually more efficient than distributed ledger-based payment systems.

3) Distributed payment technology may have an impact on financial stability. Distributed payment technology is characterized by multilateral mutual trust and decentralization, and transaction activities are easily separated from the central clearing mechanism, resulting in increased risk exposure between the parties to the transaction and increased difficulty in risk monitoring and control. At the same time, the competitiveness of established financial institutions may be affected as users' reliance on traditional financial intermediaries such as banks decreases. The involvement of some technology companies in the financial business in an unregulated manner may easily bring unfair competition in the market. At the system level, it may increase the correlation between institutions and the complexity of the financial system, reinforce herding effects and market resonance, and enhance risk volatility and procyclicality. While the efficiency of capital flows increases, the transmission of risks gradually accelerates, and the behavior of market participants becomes more homogeneous, thus affecting financial stability. This places higher demands on the judicial review and operational regulation of central banks, and central bank tokens must be properly designed to reduce the risk of becoming a source of financial instability.

4) The supporting policies and regulations of decentralized payment systems have not been perfected, and the legal binding force is weak. After the establishment of legal digital currency relying on similar blockchain technology, there will be more payments, exchanges and contracts directly running on the chain. The current regulations are not yet clear on how technically-regulated contracts such as smart contracts should be regulated, and the ability to respond to the iterations of currency technology is becoming insufficient. Strong legal support measures can effectively prevent potential risks in the operation of payment systems and restrain a series of behaviours that may be detrimental to the operation of payment systems.
5. Case Studies in China

Digital payment has become an infrastructure in China as a commercial service. Companies and the government are working together to ensure that social responsibilities are met so that ubiquitous, accessible, indiscriminative and trustworthy digital payment services are provided to all citizens equally and efficiently. In this section, the development of the digital payment system and CBDC in China is discussed.  

5.1 Third-party Digital Payment Development in China

Since 2015, digital life scenarios such as e-commerce, mobile payment, online taxi, online education and remote medical care have been expanding and have become an important part of people's life. Nowadays, whether it is in the small towns in the border area to the north, or in megacities such as Guangzhou and Shenzhen, digital payments such as QR code payment and face payment have gradually replaced traditional payment methods for a wide variety of services including coal, water, electricity, heating, travel, investment, finance, shopping and entertainment. The efficient and convenient payment experience has enhanced people's happiness and sense of achievement in digital life. Digital payment and digital currency have flourished and become the symbolic achievements of China's digital finance.

Third-party payment is the engine of China's digital payment development. It solves the problem of trust between buyers and sellers who do not meet on e-commerce platforms and is an intermediate platform for the payment of funds between buyers and sellers in the absence of credit guarantee or legal support. The essence of the operation of third-party payment is to set up an intermediate transition account between the receiver and the payer so that the transfer of funds can be controlled and stopped, and only when both parties agree can they decide the destination of the funds. Alipay is a third-party mobile and online payment platform established in Hangzhou, China in February 2004 by Alibaba Group.

The payment platform has developed digital payments by expanding into offline markets. In 2011, Alipay held most of the market share of online e-commerce transactions, while the domestic offline payment market was mainly occupied by commercial bank cards. To develop an offline payment business and gain a larger market share, Alipay tried various payment mediums and officially launched its mobile QR code payment business on 1 July 2011 as a push into the domestic offline payment market.

In March 2012, Alipay cooperated with banks to invest in 30,000 Alipay point-of-sale machines for the e-commerce cash-on-delivery market, providing full coverage of cash-on-delivery service point-of-sale applications in first and second-tier cities in China. In August 2013, Alipay announced that it would stop its offline point-of-sale business. In the same month, Tencent officially released WeChat version 5.0, which included the WeChat QR code payment mode.

Alipay and other organizations have continued to

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66 All data in this section are from Statista.
improve and optimize the QR code payment mode as well as its security to develop more payment businesses, and as a result, QR code payment has become a common payment mode in the domestic offline market. There are two main product models of QR code payment—the user-merchant interaction mode and the user-user interaction mode. Among them, the user-merchant interaction mode can be subdivided into the user-sweep mode and the user-swipe mode.

Face swipe is a new payment method being explored by the payment industry. With the so-called face payment, the user does not need to carry a bank card and mobile phone and can complete payment directly through the "brush face" function. In 2018, Alipay and WeChat Pay launched Dragonfly and Frog, respectively. There are other face payments in China such as UnionPay cloud flash payment, Suning payment and Baidu flash payment.

Face payment can be an important way for seniors to cross the financial digital divide. In 2019, China's face payment users reached 118 million, with the main application scenarios (Figure 5-1) being supermarket convenience stores (40.2 per cent), shopping malls (36.8 per cent), vending machines (27.6 per cent), in-store entertainment consumption (25.4 per cent), and in-store food and beverage consumption (21.2 per cent).

Digital payment has improved the quality of life of residents. Data shows that in 2019, 69.6 per cent of users used mobile payment daily, of which the proportion of use for clothing, food and other daily essentials ranked first (at 98.1 per cent) followed by the use for paying utility bills and public travel (both at 78 per cent). The proportion of use for ticketing categories such as buying performance tickets and movie tickets was 53.4 per cent, and the proportion of use for business travel categories such as buying air tickets and staying in hotels was 52.2 per cent.

Mobile payment has penetrated every aspect of residents' daily life, and "a mobile phone goes everywhere" is becoming a true reflection of people's daily life. The number of digital payment users in
China continues to grow, and as of June 2020, the number of mobile network payment users reached over 800 million, accounting for 86.5 per cent of mobile Internet users. China is ranked first in the world for three consecutive years for its volume of mobile payment transactions, which is expected to reach CNY2,926,747.4 billion by 2022.

5.2 Chinese CBDC Development

According to the "White Paper on the Progress of Research and Development of China's Digital RMB" issued by the People's Bank of China, the research and development of China's digital RMB can be traced back to 2014. The People's Bank of China, the central bank of China, held a seminar on digital currency in January 2016, announcing the commencement of research on digital currency and striving for the early launch of a digital currency issued by the central bank. China's digital RMB has been piloted in multiple locations by 2021 (Figure 5-2).

The development of the digital RMB is driven by a combination of technological factors, social demand factors and international competition factors. In terms of technological factors, digital technology is driving the rapid development of electronic money and mobile payment, and promoting the change of monetary form. As for social demand, with the development of the digital economy, the public demand for digital payment tools is further heightened. The traditional mobile payment tools have room for improvement in terms of financial inclusion, payment efficiency and privacy protection. In terms of international competition, private digital currencies, once applied on a large scale, will bring challenges to China's monetary sovereignty and policy independence.

Based on the above background, the research and development objectives of the digital RMB include responding to the payment needs in the digital economy era as well as maintaining the national sovereign currency status. The digital RMB at this
stage is positioned as an alternative to reserve money (M0), handling the small payment needs of retail customers, using a two-tier circulation framework, featuring loosely coupled accounts and enabling controlled anonymity. The digital RMB remains technology neutral and does not have a predetermined technology path, adheres to a public product positioning and does not accrue interest, enables dual offline payments, and has a variety of product forms, including software apps and hardware wallets (e.g., cards, wearable devices, mobile phones with SE (Security Elements), etc.).

For better application of Chinese CDBC, China lead many international cooperation with other countries. In the year 2017, the Hong Kong Monetary Authority of China initiated The LionRock project, which is a legal digital currency research focusing on the impact of DLT on the existing financial system and addressing the challenges faced by cross-border payments.

In the year 2018, The Hong Kong Monetary Authority of China and the Bank of Thailand launched the joint legal digital currency research project Ithanon-LionRock to jointly study the application of legal digital currency for cross-border payments. In December 2019, both parties completed a proof of concept based on DLT.

The Inthanon project is an independent legal digital currency study conducted by the Bank of Thailand, which is divided into two phases. The first phase studied areas such as cash tokenization, bond tokenization, congestion solutions and automated liquidity provisioning mechanisms, the second phase studied bond lifecycle management, interbank repo and transaction of coupons against payments, and data reconciliation and compliance.

The Inthanon-LionRock research project, are focusing on cross-border coupon processing and simultaneous payment settlement, including efficiency of cross-border settlement, efficiency of liquidity management, local regulatory compliance and enabling broader application scenarios. The project will continue to study in depth the technical, operational, regulatory and legal issues related to fiat digital currencies in the future.

5.3 Development Status of China’s Digital Payment

Figure 5-3 shows the number of mobile payment users in China from 2013 to 2020, the number of mobile payment users in China exceeded 852 million in 2020, while the penetration rate ranked at the top among major countries in the world. The latest data shows that around 852.5 million people used mobile payment transactions as of December 2020, up from around 765 million users in March 2020 in China. The adoption rate of mobile payment among mobile Internet users in China was over 86 per cent, representing a user base of more than 800 million (Figure 5-4). Other data also shows that the mobile payment penetration rate reached almost 90 per cent in urban areas.

The market share of mobile payment in China is also dominating. As shown in Figure 5-5, the mobile payment market share reached 83 per cent in 2018, demonstrating explosive growth from 3.5 per cent in 2011.
Figure 5-3: Mobile payment users in China, 2013-2020

![Graph showing the growth in mobile payment users in China from 2013 to 2020.]

Figure 5-4: Mobile payment usage rate in China, 2016-2020

![Graph showing the growth in mobile payment usage rate in China from 2016 to 2020.]


Figure 5-5: Mobile payment market share in China, 2011-2018

![Graph showing the growth in mobile payment market share in China from 2011 to 2018.]

In 2020, the number of mobile payment transactions in China amounted to 123.22 billion, up from 101.43 billion in the previous year, which only 0.12 billion in 2010 (Figure 5-6). China’s mobile payment industry is growing. There were more than 123 billion mobile payment transactions in the country, valuing a total of CNY432 trillion, representing a 21 per cent growth from the previous year (Figure 5-7).

Alipay and WeChat Pay are the top players in the payment market and mobile payment market in China, around 94.4 per cent of the population in China’s main cities chose Alipay or WeChat Pay as their main means of payment. Alongside the mushrooming of tax-free stores, Chinese luxury travelers have taken mobile payments with them around the world. From Galleries Lafayette in Paris to local diners in Bali, you can find the blue sign accepting Alipay everywhere. Alipay has been providing services in more than 200 countries all over the world. Shopping with mobile payment apps has become a new norm for Chinese tourists across the globe. Approximately 60 per cent of Chinese tourists use Alipay and 35.2 per cent use WeChat Pay while travelling abroad.
5.4 Analysis of China’s Digital Payment Triumph

Digital payment has become an infrastructure in China. Companies and the government are working together to ensure that social responsibilities are met so that ubiquitous, accessible, indiscriminative and trustworthy digital payment services can be provided to all citizens equally and efficiently. Three key factors are required for making China the leading country for digital payment development.

First are the driving forces of online shopping platforms that has played a key role in boosting digital payment penetration in China. In 2020, e-commerce transactions in China reached approximately CNY11.76 trillion, representing a 10.6 per cent year-on-year growth (Figure 5-8). The e-commerce market in China has maintained steady growth in recent years. The global online buyer penetration rate was estimated at 64.6 per cent. In comparison, the Chinese online buyer penetration amounted to 79.1 per cent(Figure 5-9). The number of online shoppers in China reached more than 782 million in 2020.

Business-to-consumer (B2C) e-commerce is an important component of China’s e-commerce market. In 2013, it accounted for about 1 per cent of China’s GDP. Even though the growth momentum of annual B2C e-commerce sales has been slowing down, it still was forecast to have approximately 10 per cent annual growth in 2021. Small, a subsidiary of Alibaba, JD and Suning was among the leading B2C e-commerce retailers in China as of the first quarter of 2020. Since its initial public offering on the New York Stock Exchange in September 2014, Alibaba became one of the largest Internet companies worldwide. As of the third quarter of 2018, it ranked second only to Google based on brand value. Alibaba Group is not solely focused on B2C business, it also dominates in consumer-to-consumer and business-to-business segments.
The second factor contributing to China's digital payment success is the mobile manufacturers. In Figure 5-10, we can see that China has almost twice the number of mobile users as the next country in rank, indicating the high market volume for digital payment. The competitive mobile phone markets in China have enabled everyone, no matter old or young, poor or rich, banked or non-banked, access to mobile devices and digital payment services.

Flourishing mobile markets make China one of the mobile-first countries. In June 2021, over one billion people in China accessed the Internet via a mobile device, up from around 986 million at the end of 2020 (Figure 5-11). According to Statista, with 4.68 billion people accessing the Internet via a mobile device worldwide, Chinese mobile Internet users take 21 percent of the overall share.
The third factor contributing to China’s digital payment success is the ICT infrastructure. 4G/5G base stations and related networks such as metropolitan area networks, backbone networks and transmission networks, have become the solid foundation for digital services, which include not only digital payment services, but other applications and services that can take full advantage of the networks, boosting the development of digital payment penetration.

China first started its 4G commercial roll-out and 5G commercial roll-out in 2014 and 2019, respectively. By the end of 2021, the number of 4G and 5G base stations in China amounted to 5.9 million and 1.43 million, respectively (Figure 5-12, Figure 5-13). The construction of high-speed ICT infrastructures is crucial support to the rapid increase of mobile users.

In 2021, China has a total of 1.643 billion mobile subscribers with 1,069 million 4G subscribers and 355 million 5G subscribers, with 4G/5G subscribers making up over 85 per cent of all Chinese mobile users, according to statistics from the Ministry of Industry and Information Technology of the People’s Republic of China.

Leading infrastructures have laid a solid foundation
for mobile payments as well as mobile applications. China will continue its rapidly expanding its 5G infrastructure. According to forecasts, the number of base stations is projected to reach over six million by 2024.

Compared to the 5G base stations development in leading countries such as the USA, whose 5G base stations only reached 50,000 in the year 2020, China has deployed 14 times more 5G base stations than the USA, and the large volume of investment in ICT infrastructures has laid the solid foundation for digital payment and digital economic development.

Based on GSMA’s statistics and forecast of 5G adoption in 2025 (Figure 5-14), we can see that despite China’s large and complex terrain conditions, the adoption rate is expected to be the third highest in the world.

Based on Statista (Figure 5-17), China’s 5G connection is jumping from 13% to 51% in just three years, which laid a solid user base for more versatile, solid and secure mobile payment application markets.
5.5 Potential Impact on CBDC that Needs Attention

The potential impact on CBDC should be paid attention in the following three aspects:

1) The High-speed Development of ICT.
2) The Philosophical Impact should be Considered.
3) The Social Impact should be Considered.

It will be taken into discussion respectively.

5.5.1 The High-speed Development of ICT

The development of science and technology has brought about a high level of human civilization, and with the emergence of digital currency, it has led to further development in scientific research in China. Under the high-tech industry, digital currency was born and has a high level of sophistication with fingerprint recognition biometric technology. ICT is constantly applied in various fields to support the innovative development of the currency issuance
model. Digital currency integrates the application of encryption technology, e-commerce technology, and various physical, biological, financial and other industry technologies.

### 5.5.2 The Philosophical Impact should be Considered

Analyzed from a philosophical perspective, the birth of digital currency directly affects the development of our financial situation, leading to change in the financial industry. As an intangible currency, digital currency contributes to the growth of our economy, and the philosophical connotation of digital currency plays a facilitating role in the Marxist system, which can better promote the development of Marxist communism and achieve the ideal economic form. The circulation of digital currency also has some negative philosophical implications, such as the fact that people are in the form of online numbers in their daily shopping and when they get a paycheck. This form of transaction of a string of numbers tends to shake people's basic philosophy, and in this mode of monetary circulation, people can get into a philosophical dilemma that affects the long-term development of digital currency.

### 5.5.3 The Social Impact should be Considered

The issuance and application of digital currency can control illegal and criminal behaviour to a certain extent. Digital currency is produced through new technological means and is relatively high in security. The application and implementation of digital currency can combat the phenomenon of economic crime. Digital currency has its own unique characteristics and attributes, which helps management at a later stage, and the public security department can easily review the information or freeze the cash. The high-tech nature of digital currency makes it safer to circulate and use the currency, and less likely to produce damage to the currency. It also ensures the privacy of consumers and meets the needs of contemporary consumer groups for currency applications. Due to the convenient mode of application of digital currency, it has been gradually applied to various social industries, such as education and healthcare, and different social industries have been affected by the economic impact brought by digital currency. As a new form of currency, digital currency can effectively achieve credit accumulation and promote the further development of monetary credit system construction. The social credit value of digital currency is currently rising, becoming the main monetary transaction method chosen by individuals or enterprises.

### 5.6 Future Applications and Way Forward

China's digital currency has a relatively promising development prospect but needs to continuously overcome the difficulties it faces in the development process. The advantageous nature of digital currency gives a positive impetus to social and economic growth, thus promoting the effective development of digital currency in the future. The current issuance and application of China's central bank digital currency has broken through the traditional form of currency circulation and has gradually replaced private digital currency. The emergence of central bank digital currency has enhanced the rate of currency circulation and become the main force of the currency market, which can control the use of credit through smart contracts and thus strengthen the stability of the financial system. The application structure of private digital currencies, on the other hand, affects the effectiveness of monetary policy and is not conducive to the long-term development of digital currencies.

The digital currency of Chinese central bank is
gradually becoming the main monetary development trend today, which can better realize the precise placement of loans. In addition, financial supervision should be increased to promote the safety and scientific nature of digital currency issuance and application, and reduce the risk factors arising from the financial system. In the process of digital currency development, it is necessary to adhere to the effectiveness of scientific financial supervision, and the circulation of digital currency should be effectively supervised in accordance with the standards of capital flow supervision in traditional financial institutions, to promote the regularity and stability of China's financial development. Digital currency should continue to improve the balance and stability of the currency ecosystem, expand the derivative financial business, and be able to form a digital currency application system to attract more customers and enhance the market share of digital currency. The circulation of digital currency needs an ecological environment rather than mandatory policy implementation.

The country should actively explore the issue of digital currency and look for a better-quality development strategy based on lowering the issuance cost to attract users and expand the coverage area of digital currency. Regarding the underlying technology of digital currency, China should pay attention to advancements in technology, continuously strengthen transnational cooperation, ensure the quality of technology application and provide technical support for the development of digital currency.

China's digital currency research institutions should analyze the issuance and application of the central bank's digital currency, and be able to continuously develop application technologies that are conducive to the development of digital currency. This includes the use of new technologies, optimizing the path of technology application and supporting the development of different technical architectures.
6. Recommendations for Developing Digital Payment Systems

New technologies bring new opportunities, but also bring new challenges. For digital payment systems, which is widely used in financial sector, has the least endurance to technical risks, while the cutting-edge technologies they use has the most potential to unpredicted supervision issues. So risk management for digital payments systems should be given the highest priorities. Besides that, fostering an enabling technical and market environment is vital to the healthy development of digital payment systems.

6.1 Risk Management

6.1.1 Risk Management Recommendations for the Account-based Model

A complete legal digital currency access model requires the central bank to make careful trade-offs between the efficiency and security dimensions. To this end, the following issues should be paid attention to in the construction of an account-based risk management system:

1. The improvement of relevant laws and regulations should be actively promoted. A comprehensive review of the monetary legal framework and appropriate adjustments to improve it would be needed. By improving the relevant laws and regulations, illegal and criminal acts from legal digital currency accounts could be better prevented and reduced. Regulations across the world prevent financial institutions from opening personal deposit accounts for those who do not present their identity documents or do not use the names on their identity documents. This is an important measure to prevent customers from using financial institutions to commit illegal and criminal acts. From the perspective of currency circulation, the legal digital currency system shares common technical characteristics with the deposit currency circulation system. Legal digital currency could keep a record of all transactions in circulation in the system, effectively preventing and reducing crimes and avoiding the occurrence of many transactions with legal tender. Therefore, the legal digital currency system is a monetary system in which accounts must be set up. When third-party institutions such as commercial banks manage the legal digital currency system on behalf of

customers, it is necessary to improve the existing laws and regulations based on the protection of the status of the central bank and allow third-party institutions such as commercial banks to check and audit the identity of customers.

2. The trustworthiness of commercial banks and other third-party institutions should be ensured. Trustworthy third-party institutions could be embedded in the account-based model of the legal digital currency operation mechanism. This is because, in a token-based model, banks may allow financial institutions to take on the responsibility of identifying customers, registering legal digital currency accounts on their behalf and providing the necessary customer service. At the same time, banks may choose to establish a large number of branches or points of contact with the public to confirm the true identity of users before they open accounts in their names. For digital currency accounts that allow direct access to individuals, banks should provide state-of-the-art real-time settlement systems so that the payment system would be more secure, resilient and efficient. This requires a high level of trustworthiness from commercial banks or third-party institutions. In a legal tender operating system, proven and integrated technology would allow all payments to be settled instantly in legal tender, with no counterparty risk and no credit risk. According to the “deposit money account” system theory, an account-based legal digital currency could provide an attractive alternative to deposit insurance. In this way, account-based legal digital currencies would make the financial system safer through the universal use of truly risk-free and highly liquid assets.

3. Increased responsiveness should be achieved through technological enhancements. With the development of high-speed networks and the popularity of smart mobile terminals, the scale, frequency and number of transactions between different entities have exploded. Considering the public’s increasing demand for transactions and the inherently significant technical and digital characteristics of legal digital currency, technical capability enhancement would become an important part of risk management. Therefore, emphasis needs to be placed on introducing intelligent and non-intelligent digital technologies into the risk management system to empower the improvement of risk management capabilities and revolutionize the regulatory system. All in all, the legal digital currency as a new thing must be improved at the technical level to guarantee its safe circulation in the economy and bring a positive impact to the economic system.

4. One’s position in the legal digital currency system should be carefully considered. In theory, the management of the legal digital currency circulation system should be vested in the central bank. However, the subjects of the circulation system include not only every individual with the ability to act, but also various types of units – not only national subjects, but also foreign subjects who have the demand for using the currency. Therefore, it is difficult for the central bank to specifically operate and

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manage the legal digital currency circulation system. Although central banks could greatly enhance their role in the economy by interacting directly with the public through an account-based model, this implies a radical change in financial intermediation that may come with serious risks. Kahn and others suggest that central banks could allow individuals to access transaction verification systems and settlement transaction systems. Meaning and others argue that the most feasible way is for central banks to provide a legal digital currency that provides the underlying payment platform but does not deal directly with the public. The financial institution would be responsible for managing the legal digital currency account but would not take over legal digital currency issuance and transactions, thus ensuring that the legal digital currency remains a liability of the central bank to the end user.

6.1.2 Risk Management Recommendations for the Token-based Model

A secure token-based model needs to focus on solving the problem of token counterfeit fraud and reducing the risks associated with anonymity. To this end, the following issues should be addressed in the construction of a risk management system for token-based models:

1. Central banks should implement controlled anonymity while maintaining token-specific properties. In the actual operation process of legal digital currency, there is a dilemma in the choice of anonymity. If the third party of the transaction is not anonymous, it would intensify the risk of personal privacy exposure. However, if the third party is allowed to be completely anonymous, it may facilitate criminal acts such as tax evasion, terrorist financing and money laundering. For this situation, it is suggested that controlled anonymity based on the token model could be tried. The central bank should guide the network security management department to improve the anti-attack performance of the legal digital currency system and urge the data security management department to safeguard user accounts, private keys and other sensitive information from theft or malicious leakage, to achieve a reasonable balance between individual privacy information protection and currency circulation order maintenance. This move could not only reduce the system burden of commercial institutions, but also facilitate the central bank’s ability to grasp the necessary economic transaction data to better achieve prudential management and regulatory objectives such as anti-money laundering, anti-fraud and anti-counterfeiting.

2. The verification process of legal digital currency should be optimized, and the cost of counterfeiting should be increased. In the token model based on DLT, user access to transactions still needs to be verified through the central node of the system or the so-called notary node. A ledger is also in a sense a form of account.


Within a decentralized system, the cost of faking the source of a token is the cost of changing the ledger. The counterfeiter would have to pay more to change the ledger to ensure the fake tokens have the appropriate value. This mining would make it very expensive to tamper with the transaction records, thus discouraging potential counterfeitters from committing forgery. Within the constraints of a reasonable framework and mechanism design, decentralized technologies could effectively help decision makers integrate distributed ledgers and achieve better centralized control. Before the emergence of cryptocurrencies, legal digital currencies were mainly kept on their digital ledgers by authorizing a few legally qualified financial institutions to record ownership of the currency, thus eliminating the risk of double spending. With this in mind, central banks could provide risk guarantees for users by linking tokens to their identities through intermediaries. If users lose their private keys, they are allowed to use alternative means to prove their identity.

3. A pluralistic and dynamic risk regulation system should be defined and industry standards should be set. Legal digital currency risk management could not be separated from the joint efforts of the central bank, regulatory authorities, financial institutions and trading entities, and a hierarchical multiple risk management systems could fully leverage the inherent comparative advantages of different regulators. Therefore, it is important to build a multifaceted and coordinated regulatory approach, refine and clarify the responsibilities and authority of each regulatory authority, and create a safe, trustworthy, fair and just operating environment for the circulation of legal digital currency.

The regulatory authority could make use of financial technology to adjust the regulatory methods such as business model risk pricing in real-time according to the update of the legal digital currency blockchain technology to match the current legal digital currency operation mechanism. Third-party financial institutions should strictly regulate the workflow and ensure that the information disclosure system is robust enough to provide the regulatory authorities with all effective data related to the circulation of legal digital currency transactions so that the relevant parties could understand the specific situation promptly. Trading parties should enhance the concept of honest trading and enrich their trading skills to ensure that no irregularities occur and be able to deal with damage to their rights and interests. All participants of the legal digital currency system should strengthen the control of their own information risk, credit risk and operational risk to prevent the risk of business failure or financial crisis on normal payment activities and ensure the stable circulation of the central bank's digital currency.

4. International legal digital currency risk management cooperation should be

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strengthened. Reducing the complexity of cross-border transactions is one of the direct goals of the legal tender system. Financial institutions should closely communicate with developed countries, and conduct exchanges and cooperation to jointly address global issues such as cross-border money laundering, financial fraud and illegal fund transfers in the field of Internet finance under the premise of further expanding the financial sector to other countries. If transactions involving money laundering or terrorism are discovered during the regulatory process, countries could promptly pass relevant investigation information through the sharing mechanism and realize on-chain forensics and tracing based on blockchain technology to locate individual users, ultimately ensuring effective monitoring of cross-border financial activities by national central banks.

6.2 Promoting Digital Payment Systems

For developing countries with poor access to financial services, rural area’s preference for using cash, low urbanization rate and education level, the policies from central bank and coordination to realize financial inclusion is the key to promote digital payment systems. Recommended actions include the following:

1. **Promote top-level innovation in establishing non-cash payment promotion policies to provide a basis for financial payment technology and business innovation.**

   More specifically –

   - Establish clear and unambiguous guidelines at the national level, for paperless, off-site and cashless public services.
   - Protect the legitimate rights and interests of individuals.
   - Promote the formulation of e-government development.
   - Promote legislation in the field of payment, to improve the laws and regulations that should accompany the implementation of a cashless society.
   - Clarify the right to protect various types of risks for non-cash payments.

2. **Promote the establishment of a national biometric ID system to create favorable conditions for the development of financial inclusion.**

   The biometric ID system could record the basic information of every citizen and support the implementation of the financial inclusion plan, which could greatly change the social government and financial service environment. More specifically it is suggested to link ID card information, telecommunication information and bank account information that are in the hands of public security departments, telecommunication operators and financial departments., etc. The bank accounts, ID cards and mobile phone accounts could be bound together. By allowing every citizen to be identified and recorded by formal finance, it will promote financial inclusion in remote and rural areas.

3. **Regularly publish payment development plans to improve foresight and interaction with the public on the development of the payment**

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75 Yuan Zeng, "The Legal Status, Role and Regulation of Legal Digital Currency", Eastern Jurisprudence, no. 3 (2021).
industry.

It is recommended that the central banks of developing countries regularly issue payment development plans to assess the development of the national payment industry over a certain period of time, and plan for the development of payment in the next certain period of time. This could increase the openness and transparency of the central bank's payment management, and improve the interaction with payment market participants and the public.

4. Strengthen the dominant position of the central bank in the development of mobile payment and pay attention to and prevent the impact of monopoly on the security of the payment market.

Therefore, the following specific actions are recommended –

- Strengthen supervision to prevent monopolistic institutions from abusing their market position and inhibiting the innovative development of small and medium-sized enterprises through exclusive affiliated services and bundled sales.
- Increase the coordination and promotion of mobile payment business.
- Take the lead in organizing banks and payment institutions to develop and promote digital payment products, to promote the balanced development of the mobile payment industry.

5. Strengthen international exchanges and cooperation and carry out sandbox regulation pilot in the field of payment innovation.

More specifically –

- Strengthen international exchanges on non-cash payment technology and business, especially increasing exchanges and cooperation with emerging economies.
- For countries with uneven levels of regional financial development, it is recommended to explore the establishment of pilot zones for the implementation of regulatory sandboxes before carrying out unified sandbox regulation at the national level. For example, in regions with leading development of financial technology, early and pilot implementation could coordinate the application, approval, testing, management and promotion of financial payment technology innovation, and explore the establishment of a complete sandbox regulatory system.