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Digital Innovation, Data Revolution and Central Bank Digital Currency

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Digital Innovation, Data Revolution and Central Bank Digital Currency*

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Abstract

Under the developments of digital innovation, global expansion of cashless payments and the emergence of crypto-assets, some argue that central banks should issue digital currencies that can be used by ordinary people instead of paper-based banknotes. The debates on central bank digital currencies are now gathering great attention from worldwide. Although many of major central banks, including the Bank of Japan, do not have an immediate plan to issue digital currencies that can replace banknotes, some central banks are seriously considering whether they should issue digital currencies in the near future or have already issued them as pilot studies. The debates on central bank digital currencies cover broad issues, such as their possible impacts on payment efficiency, banks' fund intermediation, liquidity crises and the transmission mechanism of monetary policy. All of these issues have important implications for the functions of money as well as its future. Digital innovation expands the possibility of money and enables new types of money with a variety of functions to emerge. These functions may include not only traditional payments but also processing various information and data attached to payments as well as executing transactions. In order to consider the pros and cons of central bank digital currencies as well as the future of money, it is needed to assess their possible impacts not only on payment efficiency but also on financial structure and the overall economy. It is also important to examine their impacts on effective utilization of data and the dynamics of "networks externality", which is one of major characteristics of payment infrastructure.

Keywords: central bank digital currency, innovation, payment, negative interest rate

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* The views expressed in this paper are those of the authors and do not necessarily reflect the official views of the University of Tokyo or the Bank of Japan.

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1. Introduction - What are central bank digital currencies?-

The term "Central Bank Digital Currency (CBDC)" usually means "digitalized instruments for payments and settlements issued by central banks as their liabilities (central bank money)"[1].

There exist two types of central bank money (base money) issued by the central bank as their liabilities, which are (a) banknotes and (b) central bank deposits including reserve deposits. Banknotes, which are paper-based, can be used 365 days a year and 24 hours a day by anyone for daily transactions. On the other hand, central bank deposits, which were formerly managed through paper-based central bank ledgers, have already been digitized in most countries. Central bank deposits are mainly used for large-value-settlement by banks, and their availability is under constraints of the operating hours of central bank settlement systems and the eligibility of direct participants to central bank accounts.

In parallel with these two categories of central bank money, CBDCs can be categorized into two types, as below. (Bank for International Settlements【2018】introduced similar classification[2].)

(a) CBDCs used by general public for daily transactions instead of banknotes

(b) CBDCs for large-value settlements, which are based on central bank deposits and adopt new technologies such as distributed ledger technology (DLT)

At this juncture, central banks generally allow only a limited number of entities such as banks to directly access to central bank accounts. In this regard, if CBDCs in the former ((a)) category are issued through central bank accounts, the issuance of CBDCs will be similar to widening the access to central bank accounts also to ordinary people and operating central bank settlement systems on 24/7 basis. The issuance of CBDCs in the former (a) category may accompany wide-ranging issues

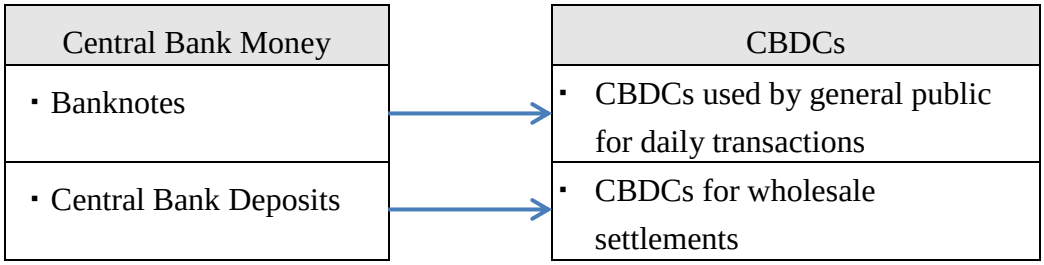
[1] Central bank deposits such as deposits in reserve accounts have already been digitized in most countries. Nonetheless, they are not categorized as CBDC.

[2] Bank for International Settlements (2018) categorized CBDCs into "General Purpose CBDC" and "Wholesale CBDC".

to be carefully examined. These issues may involve, for example, the risk of crowding-out of bank deposits and squeezing banks' financial intermediation, as well as the risk of accelerating the shift of funds from bank deposits to CBDC through "flight to quality" in stressed circumstances.

On the other hand, CBDCs in the latter ((b)) category can be regarded as an evolved form of central bank deposits, which have already been digitized, through the adoption of new technologies to enhance their utility. In this regard, CBDCs in the latter ((b)) category may not involve many brand-new issues, although CBDCs in the former ((a)) category may accompany various new and fundamental issues to be carefully examined. Therefore, this paper will focus mainly on CBDC in the former ((a)) category and their relevant issues, unless otherwise noted[3].

【Chart 1】Relationship between Central Bank Money and Two Types of CBDCs



2. Thoughts behind Proposals to Issue CBDCs

Recently, CBDCs and their relevant issues have been gathering great attention in various international forums, due to the following factors and interests.

2.1. Enhancing Efficiency and Reducing Costs of Payments through Applying New Digital Technologies

Growing interests in CBDCs have been supported by recent developments of digital technologies and expansion of cashless payments in many countries. In view of these

[3] In addition, there are many legal issues regarding CBDCs. For example, in many jurisdictions banknotes are treated as "legal tender", and it will be needed to consider whether CBDCs should also be defined as legal tender and consequently be given special status as payment instruments.

developments, more scholars and practitioners have come to ask whether central banks can and should also make use of new digital technologies in order to enhance the efficiency and the utility of their own payment and settlement infrastructure.

Since the birth of iPhone in 2007, the number of smartphones has skyrocketed worldwide within just a decade. Accordingly, mobile payments have been growing rapidly in many countries. In addition, there have been traditional cashless payment instruments such as credit cards, debit cards and e-money, which have also generally been spreading. Besides, new types of decentralized technologies such as blockchain and distributed ledger technology (DLT) were born a decade ago.

Nevertheless, banknotes are still based on paper-based technologies. Therefore, if ordinary people want to use central bank money for their transactions in order to avoid credit risks, they have to use paper-based banknotes as the only available option. Consequently, they have to bear the costs for storing and conveying banknotes as well as various costs for keeping them safe. In view of these costs, some people, especially academia, argue that central banks should also make use of digital technologies to enhance the utility of central bank money. They argue that the issuance of CBDCs will enable general public to use risk-free and digitized payment instruments for daily transactions, believing that wider use of risk-free, digitized CBDC for broad transactions will enhance efficiency and safety of payments and reduce overall costs of economic transactions[4].

2.2. Decrease of Cash in Some Countries and Financial Inclusion

In Scandinavian countries such as Sweden, the volume of cash has recently been substantially declining, partly due to the developments of private-based mobile payment instruments. Governor Ingves of Sveriges Riksbank explained in his speech

[4] There are also proposals that private entities issue digitized payment instruments backed up by safe assets. For example, some commercial banks have expressed the idea of issuing “utility settlement coins”, based on blockchain and DLT.

that the number of shops accepting cash was decreasing in Sweden, and that it would continue to decline also in the near future.

Payment instruments generally have strong "network externality", in which the expansion of user network increases the utility of these instruments for each user[5]. (For example, if some payment instruments are accepted by more shops, the utility of these instruments for the user will increase.) Governor Ingves in his speech referred to the possibility that cash was losing its network externality, and pointed out the risk that some people would face difficulty in obtaining cash in the near future. Governor Ingves also explained that Sveriges Riksbank is doing comprehensive studies on whether it should issue digital-based currencies (e-krona) or not, in order to fulfill its responsibility as the nation's central bank to provide risk-free payment instruments to general public.

Managing Director Lagarde of the International Monetary Fund pointed out the promotion of financial inclusion as one of the possible benefit of issuing CBDCs, in a sense that CBDCs will provide the opportunities to many people to use risk-free payment instruments[6]. In addition, several policymakers in public authorities, including Governor Ingves and Managing Director Lagarde, also referred to the risk that payment markets could be dominated by a limited number of big private firms in accordance with the decline in cash as well as the expansion of private-based digital payment instruments. They generally support deeper studies of CBDCs also in terms of containing the problems and risks stemming from monopolization or oligopolization of payment markets by private entities.

In addition, some scholars argue that central banks will be able to continue raising the seigniorage by issuing CBDCs, even though physical banknotes are replaced by digital payment instruments.

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[5] For example, if more shops accept credit card payments, the utility for each consumer to carry credit cards will increase. On the other hand, if more consumers carry credit cards, the utility for each shop to accept credit card payments will increase. Nowadays various payment instruments are competing with each other to expand their networks. They are trying to expand their networks because they understand the importance of "network externality" in payment businesses.

[6] Lagarde (2018)

2.3. Blockchain, Distributed Ledger Technology and Crypto-assets

A decade ago, blockchain and distributed ledger technology (DLT) were introduced by the article written by Satoshi Nakamoto[7]. Based on these technologies, Bitcoin, the first crypto-asset, was issued in 2009. The emergence of these de-centralized technologies and crypto-assets has also encouraged wider entities to be interested in the concept of CBDCs.

Since the issuance of Bitcoin, various types of crypto-assets have been issued. Although these crypto-assets were originally born as digitized payment instruments, many of them have actually been used as speculative investment tools. Accordingly, cautious views against crypto-assets have been also growing from a viewpoint of consumer protection. In view of such developments of crypto-assets, some people also support the idea of issuing CBDCs, believing that the CBDC will discourage speculation on crypto-assets. They argued that consumers would be less interested in crypto-assets as digitized payment instruments, if they can always use CBDCs instead[8].

"Anonymity" is also an important issue on this front. Banknotes carry only the information of "value", and even central banks, the issuers of banknotes, cannot know who possesses them. In this regard, banknotes have anonymity as payment instruments. On the other hand, the issuers of private-based digital payment instruments are often able to obtain various information and data attached to payments and transactions. Accordingly, as private-based digital payment instruments extend the possibility of utilizing information and data linked to payments, they also raise privacy issues. In this regard, some people expect that CBDC, through applying blockchain, DLT and encryption technologies, could realize anonymity similar to banknotes on a digital basis, in order to protect privacy of the users.

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[7] Nakamoto (2009)

[8] Crypto-Assets do not use sovereign currency units such as JPY and USD. In this regard, CBDCs are not categorized as crypto-assets.

2.4. Crime Prevention and Anti-Money Laundering

There are also arguments for supporting the issuance of CBDCs from a different perspective. The opinions in the previous section support "anonymous" CBDCs. On the other hand, some people support CBDCs because CBDCs could rather reduce the level of anonymity. They argue that banknotes, due to their anonymity, tend to be used for criminal activities, tax evasion and money laundering. They think that it is better to encourage general public to use CBDCs, instead of banknotes, for high-value transactions in order to prevent criminal activities, tax evasion and money laundering, on the condition that the level of anonymity of CBDCs is lower than that of banknotes. For example, the People's Bank of China announced on January 20, 2016 that it had a plan to issue CBDCs in future, and pointed out the prevention of tax evasion as one of the possible benefits of issuing CBDCs[9].

The arguments described in the previous section try to create digital payment instruments with anonymity, like paper-based banknotes, through applying de-centralized technologies to CBDCs. On the contrary, the arguments illustrated in this section aim at creating digital payment instruments without full-scale anonymity.

2.5. Enhancing the Effectiveness of Monetary Policy

There are also opinions mainly from academia that the issuance of CBDCs will enhance the effectiveness of monetary policy if central banks could realize both positive and negative interest rates on CBDCs[10]. Thus, the impacts of CBDCs on monetary policy depend largely on whether CBDCs should bear interests or not.

Some support the concept of interest-bearing CBDCs, arguing that the interest rate on CBDCs can work as the effective lower bound of wide-ranging interest rates and thereby facilitate central banks to control market interest rates. For example, if a central bank raises the interest rate on its CBDCs, commercial banks would be forced to raise their deposits rates so as to prevent outflows of their deposits to CBDCs.

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[9] http://www.pbc.gov.cn/goutongjiaoliu/113456/1134693008070/index.html

[10] See, for example, Bordo & Levin (2017).

In addition, there are arguments mainly from academia that the issuance of CBDC will enable central banks to realize negative interest rates through decreasing nominal value of CBDCs. According to these arguments, if a central bank becomes able to overcome "zero lower bound (ZLB)" of nominal interest rates through making the interest rate of its CBDC negative, it would not need to consider effective "margin" to avoid ZLB in setting its inflation target. Consequently, the central bank will become able to fix its inflation target at theoretically optimal level, which is likely to be zero-inflation in an ideal price index, and thereby will contribute to enhancing economic welfare over the longer time horizon.

2.6. Enhancing Financial Stability through Quasi-Narrow Banking

There are also arguments that the issuance of CBDCs could contribute to financial stability. In the modern banking system, commercial banks issue demand deposits and make loans and investments through "maturity transformation". In this system, if "bank-run" occurs and many depositors rush to a troubled bank's counter to withdraw their deposits simultaneously, the bank may not be able to satisfy their depositors' demands due to the lack of liquidity. Such mechanism has been the main reason why central banks' "lender of last resort (LLR)" function and deposit insurance are needed to maintain financial stability. In order to eliminate those risks stemming from banks' maturity transformation, some academia proposed to introduce "narrow banks", which issue demand deposits with being fully backed up by safe assets without making loans or investments through maturity transformation.

If a central bank issues CBDCs and replaces bank deposits with them, banks would not have any room to perform the function of maturity transformation. There are opinions in the academia that the issuance of CBDC could eliminate destabilizing factors stemming from banks' maturity transformation through such mechanisms. In this regard, these opinions are very close to the idea of "narrow banking"[11].

[11] In Switzerland, on June 10, 2018 the national referendum on the Sovereign Money Initiatives, which aimed at prohibiting banks' creating money, was held. This Initiative was rejected.

【Box】Several Pilot Cases and Studies of Central Bank Digital Currencies

Some central banks have already embarked on extensive studies about the possibility of issuing CBDCs in the future. They generally see potential benefits of CBDCs as enhancing utility and efficiency of payments. They also see the benefits of promoting financial inclusion and perform central banks' responsibility to provide risk-free payment instruments in CBDCs. According to their official statements, they do not explicitly aim at replacing bank deposits or obtaining seigniorage through issuing CBDCs. In this regards, it seems that there are differences between central banks and academia in terms of expected benefits of CBDCs.

Sveriges Riksbank (Sweden, e-krona)

Sveriges Riksbank has already published two reports on its "e-krona" project. As backgrounds of the project, Riksbank raises several factors such as recent decrease of cash. (Now cash-to-GDP ratio in Sweden is slightly over one percent.) Riksbank explains that it will continue extensive studies about e-krona from various perspectives, such as performing the responsibility as the central bank to provide risk-free payment instruments and containing possible risks stemming from the domination of e-krona payment markets by a limited number of foreign companies.

Banco Central del Uruguay (Uruguay, e-Peso)

Banco Central del Uruguay has implemented its pilot project of "e-Peso", in which it issued its CBDCs ("e-Peso") of 20 million peso to 10 thousand users from October 2017 to April 2018. The users charged e-Peso by using smartphone APPs developed by private firms, and used e-Peso for payments in shops participating in the project. Banco Central del Uruguay explained that, in view of the decreasing trend of cash, the project aimed at developing the infrastructure for digital payments and promoting financial inclusion.

People's Bank of China (China)

People's Bank of China announced on January 20, 2016 that it had a plan to issue its CBDCs in future. As possible benefits of issuing CBDCs, it stated that CBDCs could contribute to enhancing efficiency, utility of payments and settlements. It also pointed out the prevention of tax evasion as one of the possible benefits of issuing CBDCs.

2. Issues regarding CBDCs

3.1. Possible Designs of CBDCs

It is possible to design various styles of CBDCs, which can be classified into several categories from the following perspectives:

3.1.1. Who Can Possess and Use CBDCs?

In terms of eligible holders of CBDCs, there can be two types of CBDCs. The first type of CBDCs can be held and used by general public like banknotes. The second type of CBDCs can be held and used by a limited number of entities such as commercial banks, and CBDCs in this type are close to central bank deposits.

3.1.2. Will CBDCs be Issued Directly or Indirectly to General Public?

If CBDCs are issued to general public, there can be two options in terms of the ways to provide them. One option is that the central bank issues its CBDCs directly to ordinary people without using intermediate agencies. The other option is that central bank issues its CBDCs primarily to intermediate agencies such as commercial banks, which provide digitized risk-free payment instruments to individuals.

3.1.3. Will CBDCs be Account-based or Token-based? Will CBDCs be Anonymous? Will De-centralized Technologies be Applied?

If the central bank issues CBDCs to general public, they can be "account-based", in which the central bank allows ordinary people to directly access to its accounts, or "token-based", in which each user can charge a certain amount of CBDCs to IC cards or smartphone APPs and transfer them to other users directly[12]. This issue is closely linked to other relevant issues, such as anonymity of CBDCs and the technologies applied to CBDCs.

[12] Sveriges Riksbank, the European Central Bank, Norges Bank and the Central Bank of Iceland have made similar classification of CBDCs into "account-based" CBDCs and "value-based" CBDCs. See, for example, Sveriges Riksbank (2018).

In order to issue CBDCs to general public, one option is that the central bank broadens the range of direct participants to its accounts. At this juncture the direct access to central bank accounts is allowed only to a limited number of entities such as banks in most countries. By allowing not only banks but also individuals to directly access to central bank accounts, the central bank could provide "account-based" CBDCs to general public.

In providing account-based CBDC, the central bank will not need to adopt de-centralized technologies such as blockchain or DLT, since the central bank can continue functioning as a trusted central ledger-keeper of CBDCs[13]. In terms of anonymity, since the relevant information and data of account-based CBDCs can be obtained by the issuing central bank, account based-CBDCs may not have the same level of anonymity as that of banknotes.

On the other hand, for token-based CBDCs, which can be transferred directly among users without being recorded in central bank accounts, there might be some room to consider the adoption of de-centralized technologies such as blockchain or DLT[14]. The anonymity of token-based CBDCs may vary depending on their design. Nonetheless, at least theoretically, it would be possible to provide a certain level of anonymity to token-based CBDCs through, such as, applying digital-based encryption technologies[15].

[13] From a viewpoint of the costs for creating trust, Bitcoin has to create trust, which is indispensable for any payment instruments, from scratch. Therefore, bitcoin has to spend a substantial amount of electricity for "mining". On the other hand, as long as a central bank maintains stability of the value of its currency, it is regarded as being already trusted by public, and it will not have incentives to spend additional costs for verifying transactions, since it will be cheaper to use existing public trust.

[14] It is also possible to consider another type of CBDCs, which use IC cards or smartphone APPs and seem like token-based but all the transactions are recorded in a centralized ledger, like private-based e-money "Suica" in Japan.

[15] Sveriges Riksbank announced to consider whether anonymity should be given to low-value transactions through value-based e-krona. See Sveriges Riksbank (2018).

3.1.4 Will the Amount of CBDCs be Regulated by the Central Bank?

If anyone can obtain CBDCs in exchange for cash or bank deposits without any limit, the exchange rate between them can be stably one by one, but there could be the risk of wide-scale "flight to quality" from bank deposits to CBDCs in stressed environments. On the other hand, if the central bank imposes the limit on the amount of CBDCs, the exchange rates among CBDCs, cash and deposits would be destabilized since CBDCs may accompany scarcity premium.

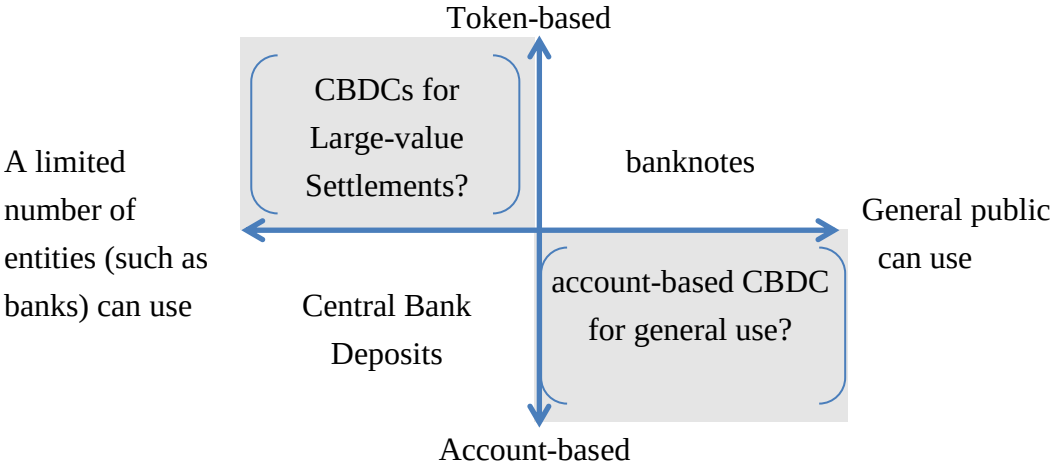
3.1.5 Will CBDCs Bear Interests?

Whether CBDCs bear interests or not may depend largely on what kinds of roles and functions the issuing central bank wants CBDCs to perform. If CBDCs are regarded as digitized payment instruments to be used instead of banknotes, CBDCs could be designed as non-interest-bearing as banknotes. On the other hand, there can be an argument that CBDCs should bear interests, since central bank deposits bear interest in many countries and CBDCs are similar to existing central bank deposits, in a sense that both of them are digitized central bank liabilities. Moreover, it is also possible to consider CBDCs whose interest rate stays zero when the interest rate on central bank deposits is positive but may turn into negative if the interest rate on central bank deposits becomes negative, in order to reduce the impacts of CBDCs on banks' financial intermediation[16].

At this juncture, there are only two types of central bank money, which are banknotes and central bank deposits. Banknotes are non-digital, anonymous, token-based and for general public, and central bank deposits are account-based, without anonymity and for limited entities such as commercial banks. Due to digital innovation, it is becoming possible to imagine various types of central bank money between them.

[16] See, for example, Mersch (2017).

【Chart 2】Digital Innovation May Extends the Frontiers of Central Bank Money



: The areas digital technologies are exploring

3.2. CBDCs, Financial Structure and Monetary Policy

The designing of CBDCs will influence various aspects of financial structure and the economy, such as banks' fund intermediation and the transmission mechanism of monetary policy. The magnitude of impacts of CBDCs on them may depend on country-specific factors, various frictions and complicated intercourses of them and it is extremely difficult to make quantitative assessment on it at this juncture. Accordingly, the following assessment remains tentative and qualitative.

3.2.1. Possible Impacts of CBDCs on Banks' Credit Intermediation

If CBDCs replace not only banknotes but also bank deposits, they could reduce the volume of banks' credit intermediation, and their impacts could become bigger if CBDCs bear positive interests. Nonetheless, even though the interest rate on CBDCs is zero, CBDCs could still squeeze bank deposits under low interest rate environments since the interest rate margin between CBDCs and bank deposits could not be large.

In the current baking system, commercial banks issue deposits while making loans and investments through maturity transformation. These functions of banks

contribute to the efficiency of transactions through the provision of commercial bank money (bank deposits) as payment instruments, as well as the efficient allocation of financial resources to promising projects through private-based initiatives.

Central banks are neither destined to make loans directly to individuals and non-bank private firms, nor superior to commercial banks and other private entities in terms of the capacity to make judgment on risks and returns of various projects. Therefore, if CBDCs replace not only banknotes but also bank deposits substantially, they could distort efficient resource allocation in the economy.

The magnitude of the decrease of banks' fund intermediation by the introduction of CBDCs will depend on various factors. In particular, it will depend largely on whether CBDCs bear interest or not. Also, the differences between market interest rates and the interest rate on CBDCs could be influential factors. Moreover, it would also be needed to examine whether and to what extent commercial banks could cover the decrease of their deposits through market-based funding, and how banks' funding costs would change consequently.

If CBDCs replace not only banknotes but also bank deposits, the balance sheet of the issuing central bank will expand. Therefore, it will be necessary to examine what types of assets the central bank will and should hold, and how the structure of the central bank balance sheet will change accordingly.

Also, we should bear in mind the possibility that commercial banks issue digitized payment instruments as their own liabilities in order to compete with CBDCs. There could be two options for banks to reduce risks for their own payment instruments.

One option for banks could be to issue their own digital payment instruments to their depositors with using deposits as collateral. In this case, deposit insurance could also be used to ensure the safety of these instruments. This option might lead to the question of whether we need CBDCs or not, since low-risk digital payment instruments could be available even under the current institutional frameworks.

Another option for banks could be to issue their own digital payment instruments with being fully backed up by safe assets, without relying on deposit insurance.

Regarding this option, we might need to consider whether and to what extent imposing limit on banks' credit creation for the purpose of securing the safety of payment instruments will distort efficient allocation of financial resources. This issue is closely linked to the classical issues of "narrow banking".

3.2.2 Possible Impacts of CBDCs on Liquidity Crises

If the central bank issues its CBDCs to general public, people would expect that they are accessible through the Internet and smartphones, since the purpose of issuing CBDCs is to enhance payment efficiency through applying digital technologies. Nonetheless, CBDCs could also accelerate "bank run" and spillovers of liquidity problems in stressed circumstances, since depositors could withdraw their deposits and purchase CBDCs on the Internet or through smartphones without rushing to bank branches or ATMs. In other words, CBDCs might also facilitate "digital bank run".

It is worth noting that "digital bank run" may occur even now without having any CBDCs, since depositors can use internet banking for transferring their deposits to other banks. Moreover, even though depositors withdraw their deposits and buy CBDCs, the central bank is able to fill the liquidity gap through providing as much liquidity as those flown into CBDCs, at least on aggregate basis. Nonetheless, it might not be easy for the central bank to find out troubled banks suffering from the shortage of liquidity and supply liquidity to them appropriately and immediately, especially in stressed situations where spillovers of liquidity problems and asymmetry of information tend to accelerate market turmoil.

3.2.3. Possible Impacts of CBDCs on Monetary Policy

If the central bank issues interest-bearing CBDCs, the interest rate on CBDC could become the effective lower bound ("floor") of wide-ranging market interest rates. As more entities can access to CBDCs, the interest rate of CBDCs could work as lower bound more extensively.

On the other hand, if the central bank tries to reduce the impacts of interest-bearing CBDCs on bank deposits, the interest rate on CBDC would be kept sufficiently low. In addition, since risk-free CBDCs inherently have competitive advantages over bank deposits, the central bank would be required to make delicate judgments on appropriate level of the interest rate on CBDCs, with taking changing public confidence on the overall banking sector into consideration. Therefore, it may not be easy for the central bank to use the interest rate on CBDC purely for monetary policy purposes.

There are also arguments that CBDCs could facilitate the central bank to overcome zero lower bound (ZLB) of nominal interest rates if the interest rate on CBDCs can be negative. Nonetheless, as long as banknotes remain people can use them in order to avoid negative interest rates. Accordingly, the issuance of CBDCs alone will not eliminate ZLB. Moreover, if the central bank reduces the nominal value of its CBDC held by general public, it could face strong opposition from ordinary people and the credibility of the central bank, which reduces the nominal value of its liabilities by its own judgment, could be impaired.

On the other hand, if the interest rate on CBDCs is always zero, CBDCs could work as strong ZLB. Compared to paper-based banknotes, it would be less costly to hold, store and manage CBDCs. Accordingly, it would become easier for economic entities to avoid negative interest rates by shifting their financial assets to CBDCs.

At this juncture, central banks all over the world do not aim at intentionally replacing bank deposits with their CBDCs. No central bank tries to eliminate paper-based banknotes. In view of these strategies actually taken by central banks, it would be appropriate to maintain cautious views on the magnitude of CBDCs' enhancing the effectiveness of monetary policy.

4. CBDCs and Utilization of Information and Data

In considering the issues of CBDCs and the future of money, it is important to pay close attention also to the ideal style of utilizing information and data for the

economy. Since the biggest factor behind increased interests in CBDCs is the innovation in information technologies that are extending the frontiers of money and payment instruments, it is strongly needed to pay close attention to the issues of information and data. In addition, it is also needed to consider "network externality", which is particular in payment infrastructure.

In recent years the volume of data produced in the economy have been drastically increasing, and data are now regarded as "the oil in the twenty-first century", which can produce various added-value. Payments are accompanied by a variety of economic transactions, and firms are eager to collect and utilize data of various transactions as the core of their businesses.

Under these developments, it is becoming critical for a variety of businesses to collect data through payment instruments. Firms now expect digital payment instruments to convey not only value data but also wide-ranging customer and transaction data. Through payment instruments many firms are trying to grasp the data on who buys what, when and where. For example, credit cards with the function of royalty programs have been issued in order to satisfying such business needs for acquiring customer data.

Under these developments, money and data are becoming closer to each other. For example, the discount offered to customers using royalty programs is actually regarded as the prices paid by firms to purchase customer data. Moreover, many firms are now collecting customer data through providing quasi-money rewards, such as "miles" in royalty programs, to be used for the purchase of a variety of goods and services, to customers who offers their own data. From customers' viewpoints, they are exchanging their own data with purchasing power.

Under these circumstances, it is becoming more and more important to consider the ideal style of utilizing information and data attached to economic transactions, in thinking about and designing the ideal style of money and payment instruments in future, including CBDCs.

At this juncture, central banks issue banknotes to general public, while allowing the direct access to their large-value settlement systems only to a limited number of entities. From the viewpoint of utilizing information and data, central banks are obtaining information and data necessary for maintaining safety and stability of overall payment and settlement systems through operating their own systems, without occupying the information and data attached to people's daily payments. Instead, central banks allow private entities to utilize them, and encouraging private firms to promote innovation in payment services.

Nowadays, in retail payment services many private firms are competing with each other to offer a variety of payment tools and infrastructure such as credit cards, e-money and mobile payments. The competition in payment businesses is now being intensified because more and more businesses are becoming eager not only to enhance utility of their payment services but also to collect and utilize big data. In the past the accumulation and utilization of data attached to payments had been dealt with mainly by banks. In recent years, nevertheless, many non-banks such as e-commerce companies, FinTech startups and BigTech firms have been entering into payment businesses and trying to accumulate and utilize big data.

Under these environments, digital payment instruments will be asked to perform wider functions to convey various data. Accordingly, the issues of data security and privacy are expected to become more important. In addition, payment instruments will be expected to work also as tools to implement contracts and transactions through, such as, making use of "smart contract" functions. In view of those potentials of payment instruments in future, it is required for relevant entities to consider how and to what extent CBDCs and future money are able to contribute to safe and efficient use of information and data.

In addition, payment instruments generally have strong network externality. Indeed, now in Japan many digital payment instruments are competing with each other to enlarge their user networks. In this regard, since risk-free CBDCs inherently have competitive advantages over private-based payment instruments, we need to be

aware of the risk that CBDCs, if designed inappropriately, could crowd-out private-based payment instruments, and thereby discourage innovation and efficient utilization of data.

Now in many countries, digitization of payments is gathering great attention worldwide in parallel with growing interests in the utilization of data. In view of these developments, it is becoming all the more important to strike an appropriate balance between securing safety of payment infrastructure and promoting innovation and effective use of big data, in order to make full use of digital technologies for increasing economic welfare. These perspectives are critical in considering the issues of CBDCs, the future of money and the ideal style of payment and settlement infrastructure in the era of digitization.

In this regard, it would be needed to seek for optimal balance of the safety of payment instruments and effective use of data through, such as, utilizing and combining various technologies and service providers. For example, private banks and firms might able to issue innovative and convenient digital instruments with reinforcing their soundness CBDCs, central bank money or other schemes, while allowing themselves to collect and utilize relevant data. As shown in this example, it would be needed to seek for optimal design of payment infrastructure in future with combining technologies and business practices, so as to maximize the benefits of digital technologies to the economy.

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