e-HKD:
A Policy and Design Perspective

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Section 1

Executive summary

1. Executive summary

Over the past few years, central banks across the world have been exploring Central Bank Digital Currency (CBDC). The Hong Kong Monetary Authority (HKMA) first began its CBDC journey in 2017, and has been actively collaborating with other central banks and the Bank for International Settlements (BIS) Innovation Hub Hong Kong Centre on wholesale CBDC (i.e. Multiple CBDC Bridge). In June 2021, the HKMA commenced Project e-HKD to study the feasibility of retail CBDC (rCBDC) in Hong Kong, covering both technical and policy considerations. Following the release of the HKMA technical whitepaper on technical design options for rCBDC, this paper provides a wide-ranging study of other issues, including use cases, potential benefits and challenges, as well as design and legal considerations for the introduction of e-HKD.

As a new electronic form of central bank money, e-HKD could bring both benefits and challenges to Hong Kong's currency and financial stability, as well as its role as an international financial centre. With appropriate functionalities and attributes, e-HKD could help position our city for the challenges of alternative units of account (i.e. stablecoins) dominating in Hong Kong, even though such possibility remains remote. The potential programmability aspect of e-HKD could also enable innovative applications (e.g. smart contracts), provided that the associated challenges (e.g. programme glitches) are properly addressed.

While e-HKD could provide an alternative payment method, a widespread prevalence of e-HKD at the expense of physical cash may actually render the payment system more vulnerable to cyberattacks and power/network outages, as well as create a perception of intensifying competition in the retail payment landscape, even though it is not the objective of introducing e-HKD. While there is a concern that potential holders' switching from deposit to e-HKD could lead to bank disintermediation especially during a financial crisis period, adversely affecting banks' funding and their capacity to supply credit, the run risk for banks in Hong Kong would be very low in any case, given depositors' confidence in the Deposit Protection Scheme and the HKMA's prudential regulations and oversight. Appropriate design choices (i.e. unremunerated vs. remunerated) and adequate safeguards (e.g. maximum account balance) could help address the risk, though further in-depth considerations would be required as an overly restrictive scheme could discourage potential users of e-HKD.
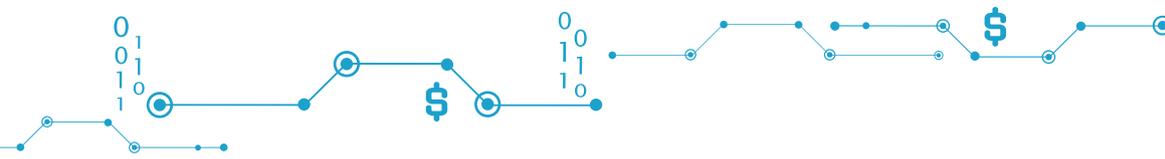
More generally, the design of e-HKD requires very careful consideration. In particular, its circulation must be fully backed by USD assets held in the Exchange Fund in accordance with the Currency Board principles under the Linked Exchange Rate System (LERS). There is a need to ensure that e-HKD upholds user privacy while also ensuring the integrity of the e-HKD system, given that full anonymity, while technically feasible, is not a plausible option due to anti-money laundering/counter-financing of terrorism (AML/CFT) requirements. To the extent that e-HKD acts as the digital version of Hong Kong dollar cash, its legal mandate and legal tender status would logically be expected to align with that of existing Hong Kong dollar notes and coins.

In light of the wide range of policy issues involved in introducing e-HKD, the HKMA would like to seek your feedback on these issues. It should be noted that the HKMA has not yet made a decision on whether and when to introduce e-HKD, and will remain open-minded in considering the issues carefully.

Section **2**

Introduction
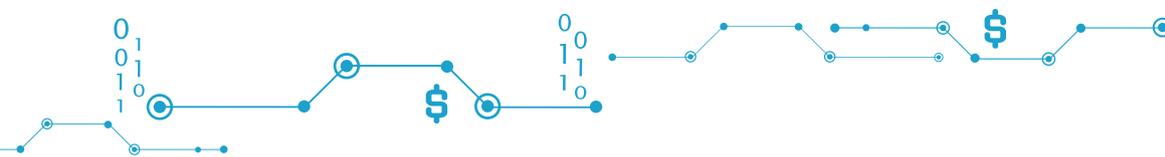
2. Introduction

In 2017, the HKMA began researching CBDC (see Box 1 for details) under Project LionRock. Since then, it has been actively collaborating with the Bank of Thailand, the Digital Currency Institute of the People's Bank of China (PBoC), the Central Bank of the United Arab Emirates and the BIS Innovation Hub Hong Kong Centre to study the potential of wholesale CBDC for cross-border payments under Project Multiple CBDC Bridge (mBridge). The HKMA commenced Project e-HKD in June 2021 to study the feasibility of an rCBDC in Hong Kong, i.e. e-HKD (Figure 1). Subject to its functionalities and design features, e-HKD can pose both opportunities and challenges to the HKMA's main functions of maintaining currency stability, financial stability, and Hong Kong as an international financial centre (including the development of financial infrastructure). This paper discusses the abovementioned issues, noting that the HKMA has not yet made a decision on whether and when to introduce e-HKD.
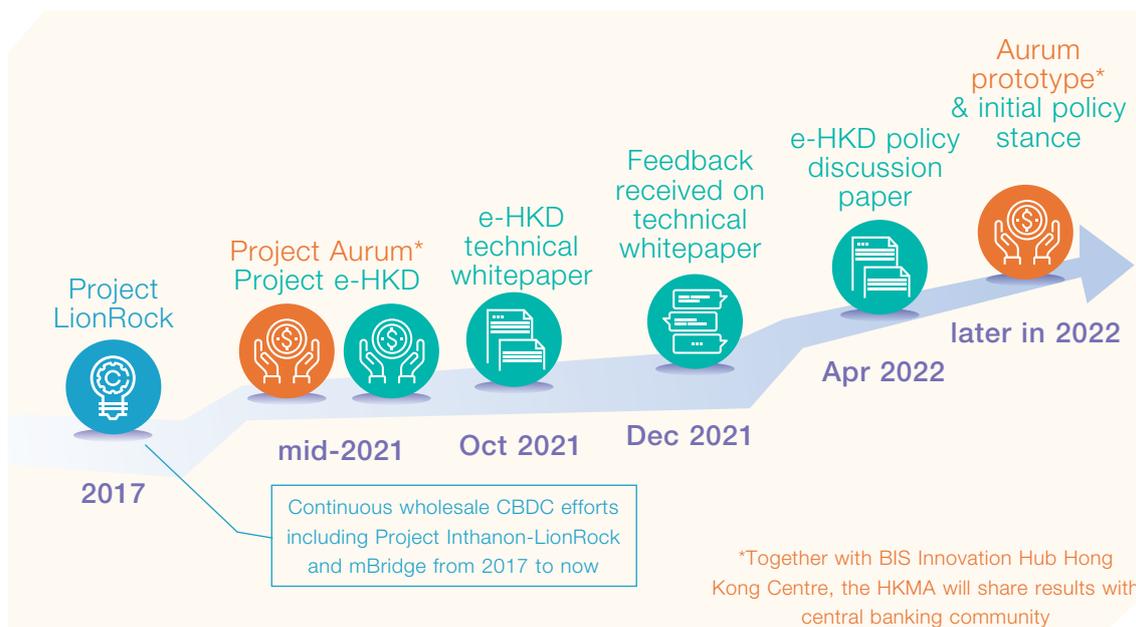

Figure 1: The CBDC journey of the HKMA

Box 1

What is CBDC and how is it different from other forms of money?

Central bank money is money issued or backed by the central bank. Traditionally, there are two forms of central bank money, namely notes and central bank reserves. Notes are physical money that can be used by the public, while central bank reserves are electronic money only accessible to eligible financial institutions with clearing accounts at central banks. CBDC is a new form of central bank money that is both electronic and accessible by the public (i.e. electronic version of coins and notes), as well as having potential new features and functions (e.g. smart contracts and cryptography) depending on design and technical feasibility. While commercial money (e.g. bank deposits) is also electronic money and can perform many functions that can potentially be offered by CBDC, the fundamental difference setting them apart is that CBDC is a liability of the central bank and is therefore completely free of credit risk, whereas commercial money is a liability of the depository institution and has credit risk in case of closure of the depository institution (though very low in Hong Kong).
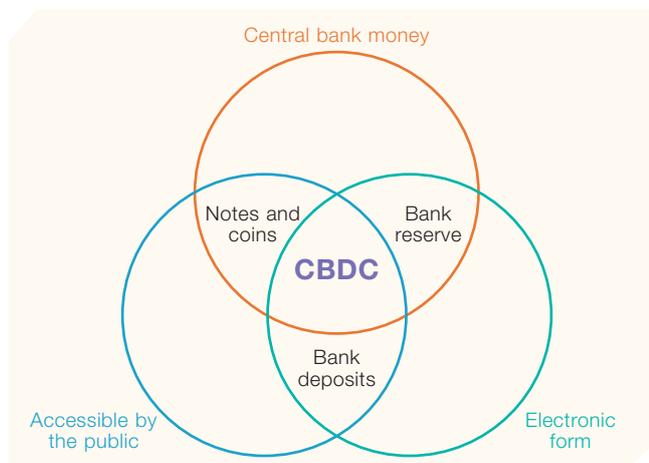
Figure B1: Forms of money (see "Retail central bank digital currency: design considerations, rationales and implications", Reserve Bank of Australia Bulletin September 2020)

CBDC is also fundamentally different from other crypto-assets, as CBDC is issued and backed by the central bank, whereas crypto-assets are privately issued and not backed by the central bank. Thus, the market prices of other crypto-assets are often volatile, making them unsuitable as stores of value, units of account or means of payment. While a class of crypto-assets called "stablecoins" attempt to lower their price volatility by pegging themselves to some other assets, these "stablecoins" remain subject to risks associated with the backing assets as well as counterparty risk.[1]

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[1] For more details, see Section 3.2.

Section **3**

What are the potential benefits brought by rCBDC?
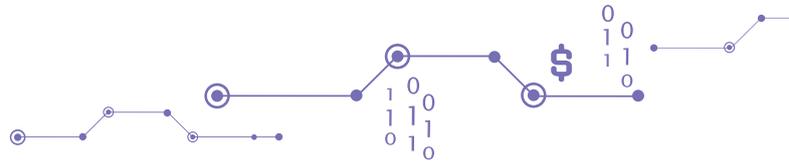
3. What are the potential benefits brought by rCBDC?

Central banks globally have explored rCBDC for some of the following potential benefits: (1) improving the availability and usability of central bank money; (2) positioning for the challenges of new forms of money; (3) supporting innovation and meeting future payment needs in a digital economy; (4) improving resilience and efficiency of the payment system; and (5) reinforcing the transmission of monetary policy.[2] This section discusses whether these potential benefits are applicable to the case of Hong Kong, given the difference in the monetary policy regimes, payment landscapes, and other policy considerations.

3.1 Improving the availability and usability of central bank money

The provision of trusted money is a core responsibility of central banks. The supply of the safest form of money to banks, businesses and the public underpins daily life and daily commerce. A common and stable unit of account allows payments to be settled efficiently and safely, ensuring effective implementation of monetary and exchange rate policies.

As an electronic form of central bank money, rCBDC would increase the availability and usability of central bank money, allowing it to be used in a much wider range of situations than physical cash. In general, households and private companies that do not have a clearing account with the central bank are only able to use central bank money in the form of notes. The introduction of rCBDC would enable them to hold central bank money in electronic form, and use it to make payments. In economies with reducing physical cash in circulation, amid increasing popularity of digital payments which may not necessarily serve underbanked communities (e.g. those in geographically remote areas) for commercial reasons, rCBDC is considered as a way to increase the availability of central bank money and promote financial inclusion.

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[2] See "Central bank digital currency – opportunities, challenges and design". Bank of England Discussion Paper March 2020.
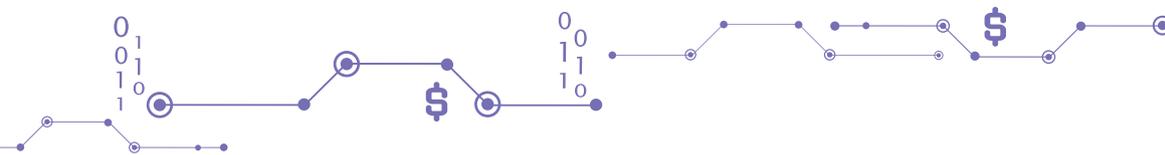
In the case of Hong Kong, while commercial money (e.g. bank deposits, stored value facility (SVF) float) performs many functions that can potentially be offered by e-HKD and indeed is the most prevalent payment option nowadays, a fundamental difference between e-HKD and commercial money is that the former would be a liability of the Government and would be free from the risks of failure of any commercial entity.[3] While physical cash or e-HKD are free of credit risk, commercial bank deposits are also perceived to be of little risk and enjoy strong public confidence because of the soundness of the Hong Kong banking system, as well as the safety and the efficiency of the retail payment services provided by banks.[4] On the other hand, given that physical cash in circulation remains sizeable in Hong Kong, and given that the unbanked population is small in Hong Kong, issues of declining cash use and financial inclusion do not serve as compelling rationales to introduce e-HKD.[5]

3.2 Positioning for the challenges of new forms of money

New forms of crypto-assets that describe themselves as the "future" of payment or money (e.g. certain types of "stablecoins") have emerged in recent years. Currently, the majority of their use cases appear to reside in them acting as a "bridge" for trading between fiat currencies and other crypto-assets.[6] Also, they are not yet widely considered by the general public as a means of payment, possibly due to various reasons including counterparty risk (which includes but is not limited to credit, liquidity and operational risks) and the lack of user protection (Figure 2), which ultimately lead to

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[3] With robust banking supervision, and deposit insurance protecting households in the event of a failure, Hong Kong's last bank failure was more than 30 years ago. In 1991, the collapse of Bank of Credit and Commerce International led to the closure of its Hong Kong subsidiary, Bank of Credit and Commerce Hong Kong Ltd.

[4] People's willingness to hold bank deposits also reflects the confidence that bank deposits can be readily converted into cash, which is a risk-free central bank money. Without such an anchor of central bank money, there is no guarantee that the value of bank deposits would be stable as it depends on the soundness of the banks. See "Central bank digital currencies: defining the problems, designing the solutions" Fabio Panetta (2022).

[5] The HKMA attaches great importance to financial inclusion and has been expending significant effort on promoting access to basic banking services by different segments of society to meet the basic needs of people's daily lives and the needs of legitimate businesses for funds transfers.

[6] As reported by the November 2021 issue of the European Central Bank's Financial Stability Report, around 75% of all trading on crypto trading platforms involved a stablecoin in September 2021.
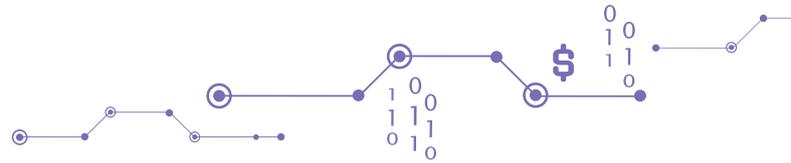
redemption risk. Financial regulators in different parts of the world, including the HKMA, are looking into the appropriate regulatory treatment for such types of crypto-assets.
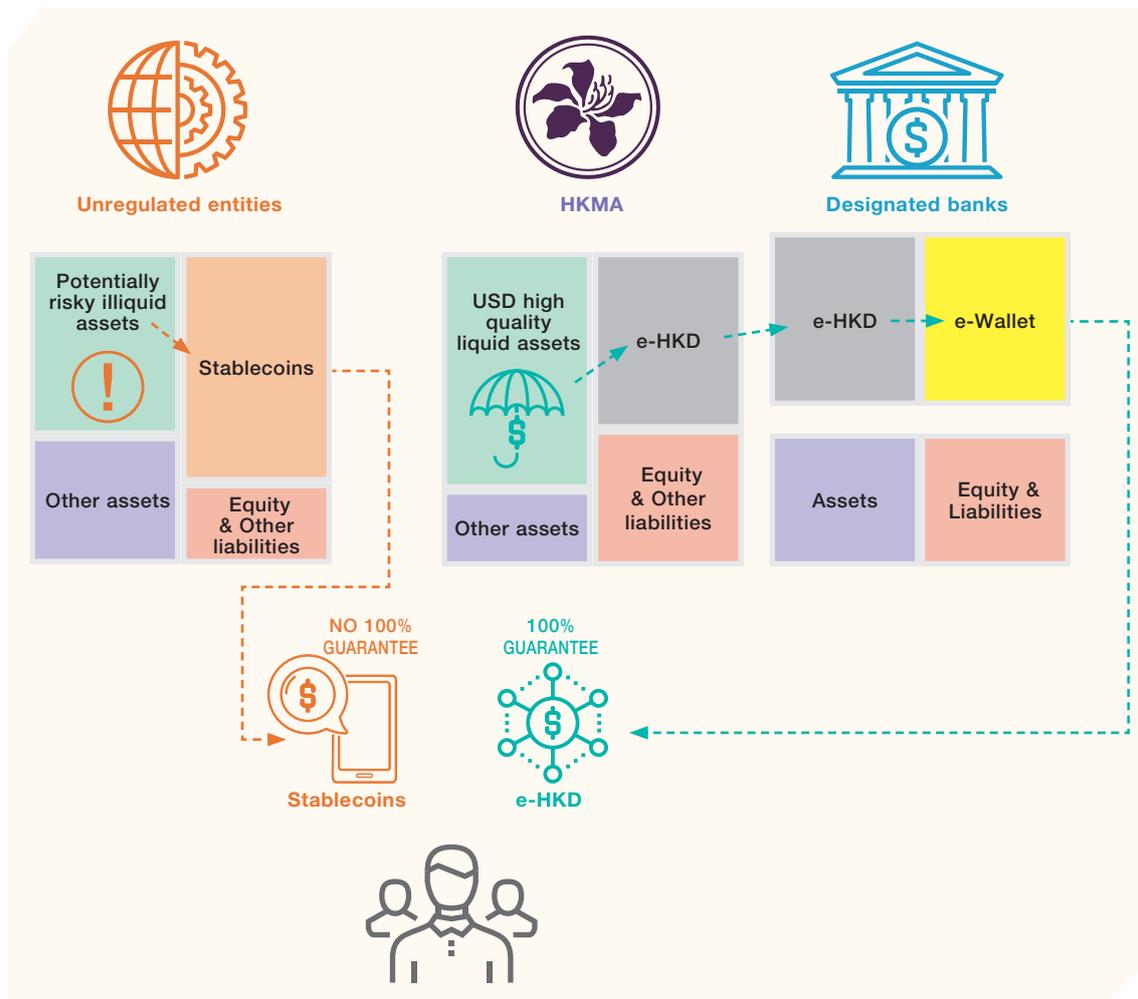
Figure 2: Comparing stablecoins and e-HKD

With continued developments in stablecoins, it cannot be ruled out that a popular stablecoin may eventually emerge. In a scenario where the use of these stablecoins becomes widespread, particularly if these stablecoins can offer better payment/ remittance or to the extent that domestic goods or services are priced in such stablecoins, the role of the domestic currency as the single unit of account could be undermined. If a stablecoin becomes widely used by the general public with relative ease, there is also an added risk of undermining payment integrity due to potential operational or financial failures of these stablecoins, or accelerating the flight to these
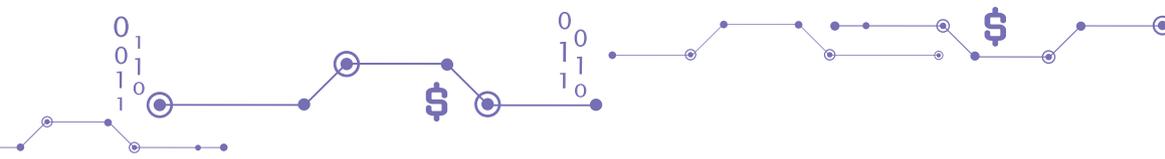
stablecoins during any financial crisis period, thereby undermining the control of central banks over local monetary conditions.

While a widespread use of stablecoins in Hong Kong remains a remote possibility, it would be prudent for Hong Kong to better position itself for future challenges. In this regard, the introduction of e-HKD could help the HKMA support the continued use of Hong Kong dollar as the single unit of account in Hong Kong and reduce the risk of alternative units of account dominating. To fulfil this role, e-HKD must be able to cater for the needs of the public. In particular, it should be economical, secure against fraud, free of any market risk or issuer default risk, user-friendly and efficient (Figure 3).

Meanwhile, in light of the potential financial stability risks they pose, the HKMA is working on the regulatory approach to stablecoins, taking into account international recommendations, the market and regulatory landscape both locally and in other major jurisdictions, and the characteristics of payment-related stablecoins.[7] Therefore, the financial stability risks associated with stablecoins could be mitigated as long as they are appropriately regulated, and it is not essential to introduce e-HKD for such purpose.

Figure 3: Key attributes of e-HKD

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[7] In January 2022, the HKMA issued a discussion paper on crypto-assets and stablecoins, inviting views from the industry and the public on the relevant regulatory approach.
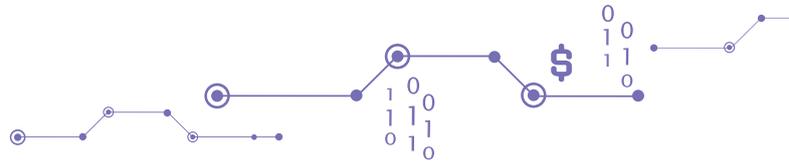
3.3 Supporting innovation and meeting future payment needs in a digital economy

As the economy is increasingly digitised, there is a possibility that an rCBDC could offer and enable greater innovation in payments and payment-related digital services. Noting global researches on rCBDC have always explored using new technologies (e.g. distributed ledger technology (DLT)) and tokenisation, it would be worth deliberating whether and to what extent these technologies may improve the existing systems and benefit the wider public as economic activities are moving further online. For instance, in a decentralised form of finance where DLT and tokenisation are predominantly adopted, rCBDC may have the potential of being used as a credible means to settle tokenised asset transactions.

Whether and to what extent an rCBDC would support programmability is a design choice of the issuing authorities, having regard to the associated pros and cons. A programmable rCBDC (i.e. an rCBDC in which a programme can be stored) could enable innovative applications in the digital economy.[8] For example, it could support smart contracts (i.e. protocols that self-execute when certain conditions are met) to facilitate automated payment (e.g. on insurance policies such that travellers can receive compensation automatically in the event of flight delay with the fulfilment of the specified pre-condition(s) as confirmed by a designated oracle, see Figure 4).[9] rCBDC could also facilitate the provision of fiscal subsidies to the public, though similar registration and verification processes, and hence the lead time and efforts, will still be required. In addition, depending on the popularity of rCBDC, other means of disbursement and registration may still be required to cater for certain segments of the community.

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[8] Although programmability has yet to be included as a feature in the whitepaper "e-HKD: A Technical Perspective", the proposed architecture does provide support for service extensibility to allow banks and payment service providers (PSPs) to implement or add transaction programmability as an overlay service. If programmable payments are implemented, what is stored in an e-HKD transaction are the conditions for enacting the payments (in the option field) that are pre-programmed by the payer and to be executed by the payer's bank.

[9] The application of smart contracts would be useful for capital market transactions. For example, it can be applied to facilitate delivery-versus-payment (i.e. simultaneous exchange of the ownership of an asset and its consideration), as a way to mitigate principal and settlement risk involved in transactions, which could be beneficial at both wholesale (i.e. financial institutions) and retail investor levels.
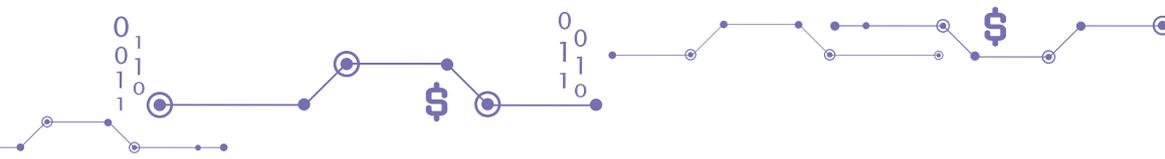
While the programmability of money could open up the financial industry to many possibilities in payment innovation, the adoption of such a feature would come with associated risks and challenges. For example, the dependency on external data sources (i.e. oracles) for smart contract execution could cause vulnerabilities in the system if such sources are compromised. Also, a programme glitch or malicious attack of smart contracts may result in financial losses and legal challenges (see Section 4.2).

Questions on how and to what extent the programmability feature will be made available; who can deploy a smart contract; who takes the responsibility to enact adequate controls (e.g. vetting of programme codes); and who can carry out rectification actions (e.g. a programme patch or a reversal of transactions) will all have a bearing on the overall integrity and security of the e-HKD system. Legal considerations, including the enforceability of smart contracts, would also need to be deliberated before any decision is taken on the deployment of smart contracts.

As such, the programmability of e-HKD would require a careful evaluation of the above issues. It is only by carefully addressing the above issues that the programmability attribute could support innovation without, at the same time, compromising the integrity of the system. In light of the pros and cons, it might indeed be more worthwhile to explore programmability in the wallet of e-HKD rather than in e-HKD itself. Doing so would be simpler from an operational perspective and could avoid introducing too much complexity in e-HKD, as well as better preserve its equivalence with physical cash.
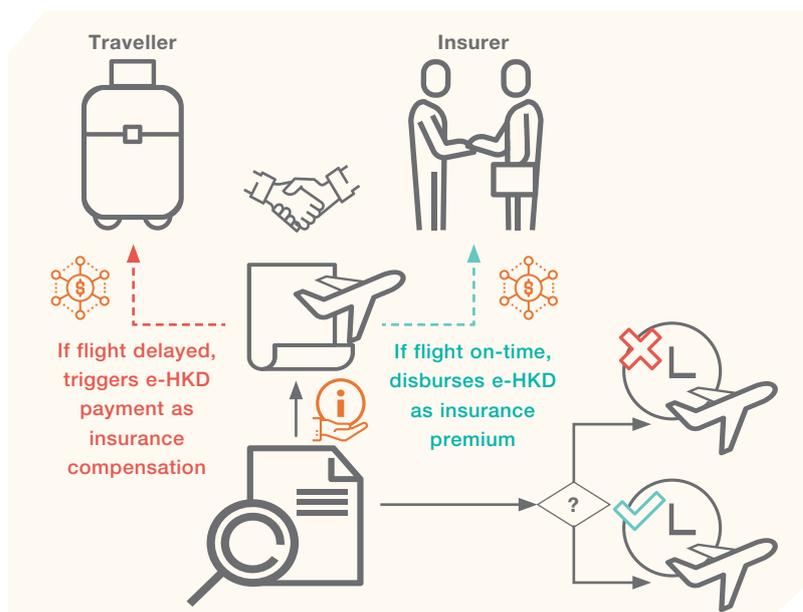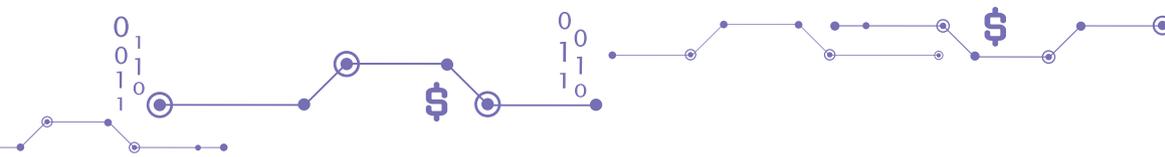

Figure 4: Smart contract application on flight delay insurance

3.4 Improving resilience and efficiency of the payment system

By providing an additional payment method with alternative design features (e.g. offline payment[10]), rCBDC could help support the operational resilience of payment systems, as it is less likely that both traditional payment networks and rCBDC network would suffer outages at the same time. On the other hand, supporting competition in payment systems is also considered as another key argument for introducing rCBDC in other economies.

In the case of Hong Kong, these rationales are less relevant as the local electronic payment systems are highly resilient and efficient, with disruption being extremely rare. Moreover, Hong Kong's retail payment landscape currently has a range of market players offering different payment options (e.g. credit cards, Faster Payment System (FPS), SVFs), and they are diverse and in healthy competition. While the introduction of e-HKD may create a perception of intensifying the competition, it is worth noting that the objective of introducing e-HKD is to provide consumers with an additional payment option that may address certain limitations of the existing payment options (Table 1), instead of removing or becoming a substitute for these options.

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[10] e-CNY can support offline payments and has been piloted in Shenzhen, Suzhou, Xiong'an, Chengdu, Shanghai, Hainan, Changsha, Xi'an, Qingdao, Dalian, and at the Beijing 2022 Olympic Winter Games.

	Cash	e-HKD	Existing SVFs	Bank channels (via FPS)
Free of credit & liquidity risks	✓	✓	✓* (statutory and supervisory requirements in respect of float protection)	✓* (up to HK$500,000 under the Deposit Protection Scheme)
Resilient to network outage	✓	✓* (if offline payment is supported)	✗* (except for Octopus as it supports offline payment)	✗
Merchant acceptance	✓	✓* (subject to service charge consideration)	✓* (subject to service charge consideration)	✓* (subject to service charge consideration)
Anonymity	✓	✓* (assumed for small-value transactions)	✓* (small-value domestic payments may be made by unverified accounts)	✗
Universally accessible	✓	✓	✓	✓

Table 1: Comparison between e-HKD and other payment methods
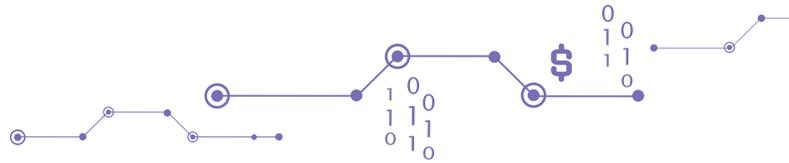
3.5 Reinforcing the transmission of monetary policy

In theory, remunerated rCBDC could reinforce the transmission of monetary policy to the real economy, as remunerated rCBDC could directly transmit any policy rate change to the private sector and influence their consumption/investment choices, whereas currently, such policy transmission would be indirectly carried out through banks, therefore subjecting policy transmission to the additional influence of bank funding conditions.

In addition, rCBDC, if replacing physical cash in circulation, could also relax the effective lower bound on policy rates. Currently, central banks would not cut their policy rates deep in negative territory, because commercial banks may not help transmit the negative rate to depositors for the reason that depositors may hoard physical cash, thereby making commercial banks bear the cost of negative rate policies. By replacing physical cash, a remunerated rCBDC could help relax the effective lower bound and allow policy rates to become more negative than otherwise.

In the case of Hong Kong, there are a few reasons why the monetary policy transmission consideration does not serve as a rationale to introduce e-HKD. First, remunerated e-HKD would differ from unremunerated physical cash, raising public communication challenges about the equivalence of e-HKD with physical cash. Second, to strengthen monetary policy transmission, remunerated e-HKD must be in widespread circulation in order to influence bank interest rates, but doing so would lead to a greater disintermediation of banks, as remuneration would make e-HKD more akin to bank deposits but with the added advantage of being free from credit risk (see Section 4.1). Finally, in the scenario where a negative interest rate policy is warranted, the continued existence of physical cash would mean that the public could still hoard cash, which would undermine the effectiveness of direct monetary policy transmission through remunerated e-HKD.

In sum, the absence of a fully independent monetary policy under the Currency Board system does not preclude the HKMA from exploring e-HKD. That said, the use of e-HKD for improving monetary transmission is less relevant given the continued existence of physical cash.

Section 4

What are the potential challenges brought by rCBDC?

4. What are the potential challenges brought by rCBDC?

While the introduction of rCBDC could offer potential benefits, it could also potentially lead to a drastic change in the financial system landscape, affecting financial and monetary stability. This section discusses the potential challenges brought by rCBDC and ways to mitigate the accompanying risks.

4.1 Implications for bank funding and its consequences

Although rCBDC is meant to be a digital extension of cash, its potential demand is highly uncertain. The potential holders may need to switch funds out of their deposit accounts for rCBDC, which would affect the balance sheets of commercial banks and lead to disintermediation of banks.

In the case of Hong Kong, as e-HKD would be part of the Monetary Base, the designated distribution banks would be required to submit USD to the HKMA for the right to make e-HKD available to the public amid the fall in banks' retail deposits. If the substitution from deposits to e-HKD is significant, this may lead to disintermediation of banks (Figure 5). Box 2 discusses the risk of bank disintermediation in the context of Hong Kong's Currency Board system and why this risk does not apply to existing SVF transactions.
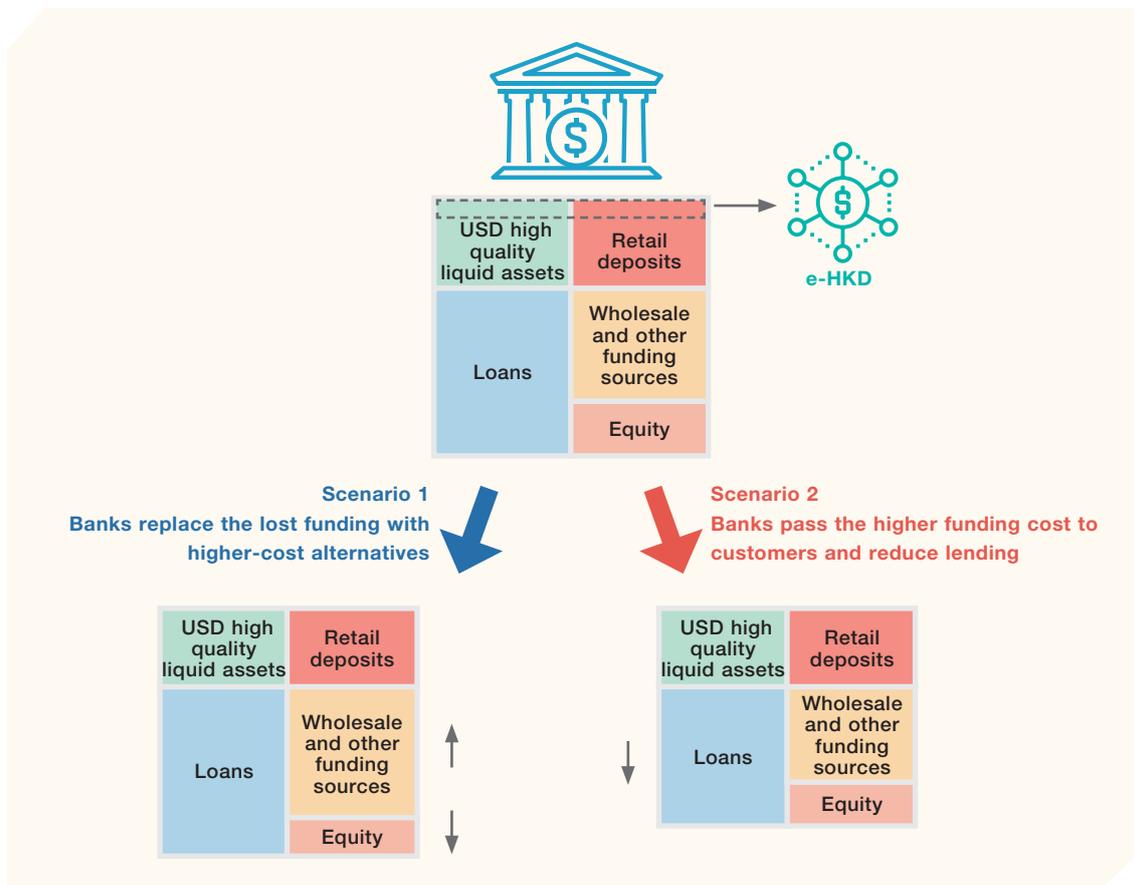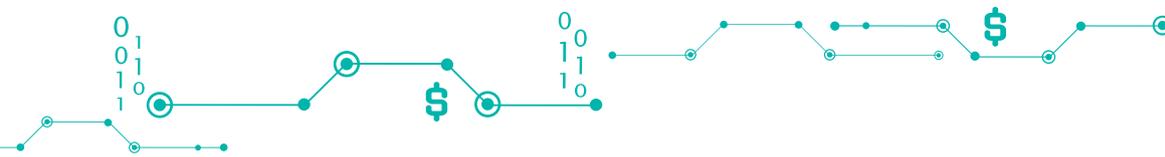
Figure 5: Banks reacting to deposit outflows

Banks may react by offering higher rates of interest on deposits or seeking to replace the lost funding with higher-cost alternatives (e.g. wholesale funding) and this would result in a higher overall funding cost (Scenario 1). The increase in funding cost would squeeze banks' net interest margins and profitability, although banks in Hong Kong typically have large capital and liquidity buffers to withstand any such shock. Alternatively, banks may also opt to pass the higher funding cost to their customers by imposing a higher lending spread (Scenario 2). In the remote case where the increase in funding cost and lending spread lead to a tightening in overall credit conditions, consumption and investment activities would inevitably be affected. However, as long as e-HKD is unremunerated, the attractiveness of e-HKD as a store of value over bank deposits should also be limited, and hence the bank disintermediation risk should be manageable.

rCBDC could theoretically expose banks to a higher risk of a bank run during a financial crisis period, especially if the rCBDC is remunerated. As rCBDC is free of credit risk, customers seeking safe-haven assets may convert their bank deposits into rCBDC. While a similar run risk also exists with physical cash, the introduction of rCBDC may increase the risk as (a) it would be easier and faster to obtain than cash or other safe assets; and (b) the associated costs (as compared, for example, to the costs of storing and securing cash) of holding large sums of rCBDC would be negligible. That said, our assessment is that run risk for banks in Hong Kong would be very low given depositors' confidence in the Deposit Protection Scheme and the HKMA's prudential regulations and oversight, and e-HKD would not change the picture.

To further mitigate these adverse impacts, safeguards and design choices such as maximum account balance, daily conversion and transaction limits of rCBDC could be implemented. Such restrictions could be permanent/transitional and vary according to individuals/businesses.[11] Designing such safeguards, however, could be a challenging task and would require in-depth consideration of various aspects. While imposing more stringent rules would certainly help mitigate the abovementioned risks, an overly restrictive scheme could discourage potential users from switching over to rCBDC. Thus, striking the right balance between the two would be crucial to the success of rCBDC. To further ensure that the execution of rCBDC transactions would not be blocked in the event where the recipient's rCBDC balance reaches its limit, a mechanism could also be deployed to automatically direct any excess holding of rCBDC into the recipient's bank account.

In the case of Hong Kong, our internal analysis suggests that, with appropriate holding caps in place, the deposit substitution effect should be manageable. Given that e-HKD is designed for settling real-time small-value retail payments, it is also unlikely that its use by regular citizens would be greatly inhibited by these fairly loose holding caps.

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[11] See Auer R., Frost, J., Gambacorta, L., Monnet, C., Rice, T., & Shin, H. S. (2021) "Central bank digital currencies: motives, economic implications and the research frontier", *Annual Review of Economics, forthcoming*.
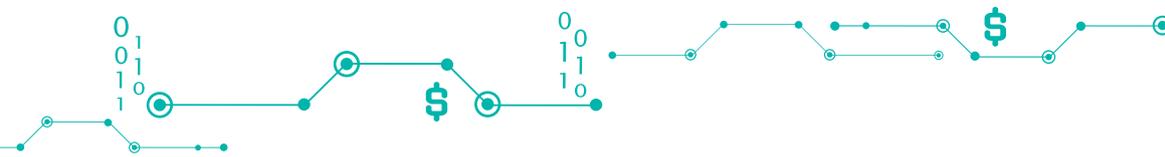
Box 2

Issuance of e-HKD and its implications for bank funding

Under the Currency Board principles, all changes in the Monetary Base must be fully matched by corresponding changes in USD assets held in the Exchange Fund. Thus, banks would be required to set aside the corresponding amount of USD as backing assets before making e-HKD available to their customers (Figure B2).
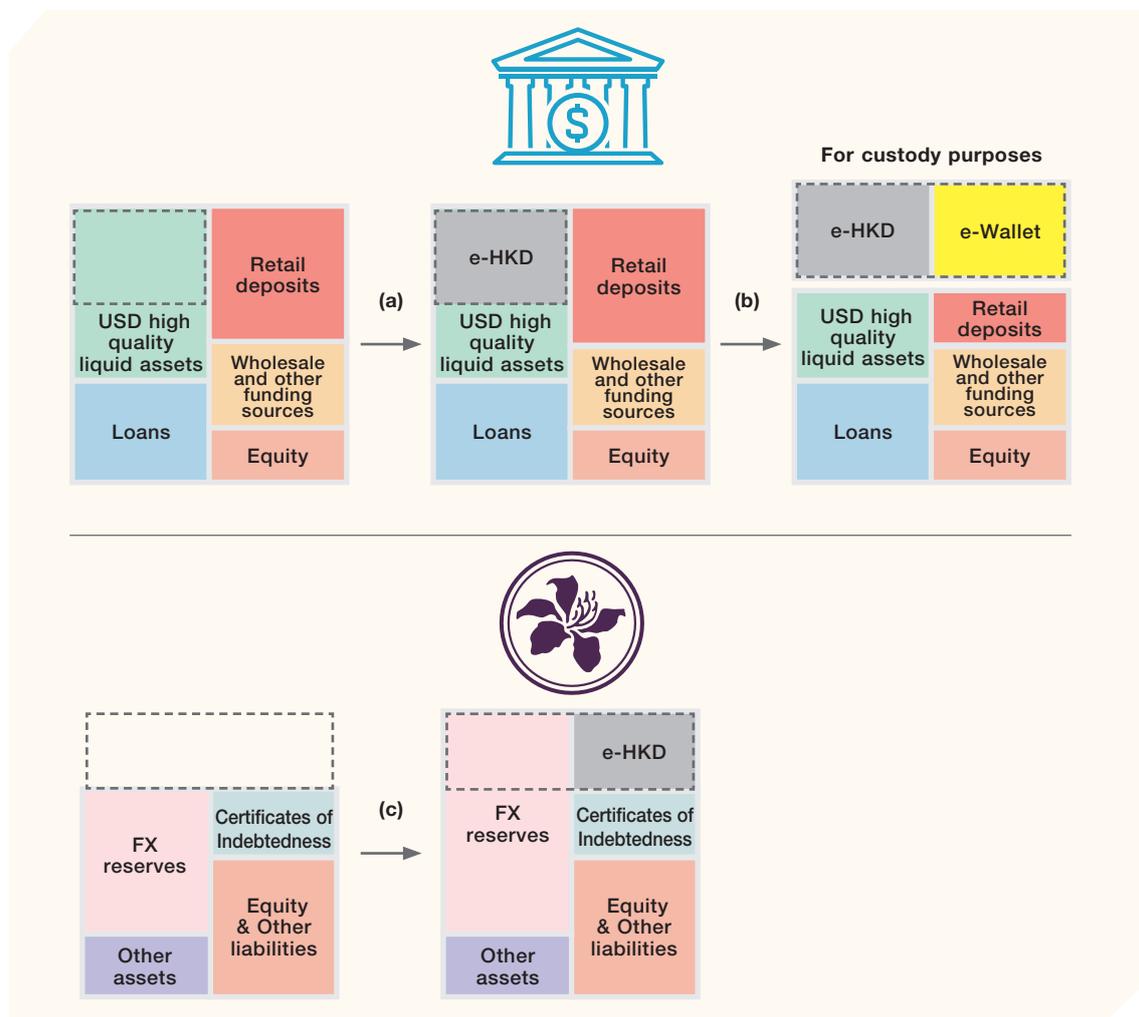

Figure B2: Impact on balance sheets of banks and Exchange Fund upon switching to e-HKD

As shown in Figure B2, part of the banks' liquid assets (green rectangle) would be tied up (turning into the dark grey rectangle) when customers request to convert their retail deposits into e-HKD. As such assets cannot be deployed for other purposes, banks' lending capacity may be affected. That said, as long as e-HKD is not remunerated, the demand for e-HKD should mainly be driven by the public's desire to replace physical cash. Thus, the increase in the demand for e-HKD is likely to be accompanied by a decrease in cash demand. Depending on the magnitude of the substitution, bank deposits may not necessarily decrease and the lending capacity of banks may not be affected much. While demand for e-HKD may be increased by heightened risk aversion during a financial crisis period, the adverse impacts should remain manageable as long as adequate safeguards (see Section 4.1) are in place.

Why would existing SVF transactions not lead to disintermediation of banks?

According to the Guideline on Supervision of Stored Value Facility Licensees[12], SVF providers are required to hold the float and SVF deposit in cash or bank deposits (unless written consent from the HKMA is obtained).

Given that a large holding of cash entails significant storage cost, it is conceivable that most SVF providers would opt to deposit the float back to the banking system. As such, the conversion from bank deposits into SVF float would be merely a reclassification of banks' liabilities (from deposits by the general public to deposits by SVF providers), leaving the asset side of banks unchanged (Figure B3). Thus, this reclassification would not affect banks' lending capacity. During this process, no conversion between commercial bank money and central bank money takes place, leaving the Exchange Fund balance sheet unchanged.

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[12] https://www.hkma.gov.hk/media/eng/doc/key-functions/finanical-infrastructure/Guidelines-on-supervision-of-SVF-licensees_Eng.pdf
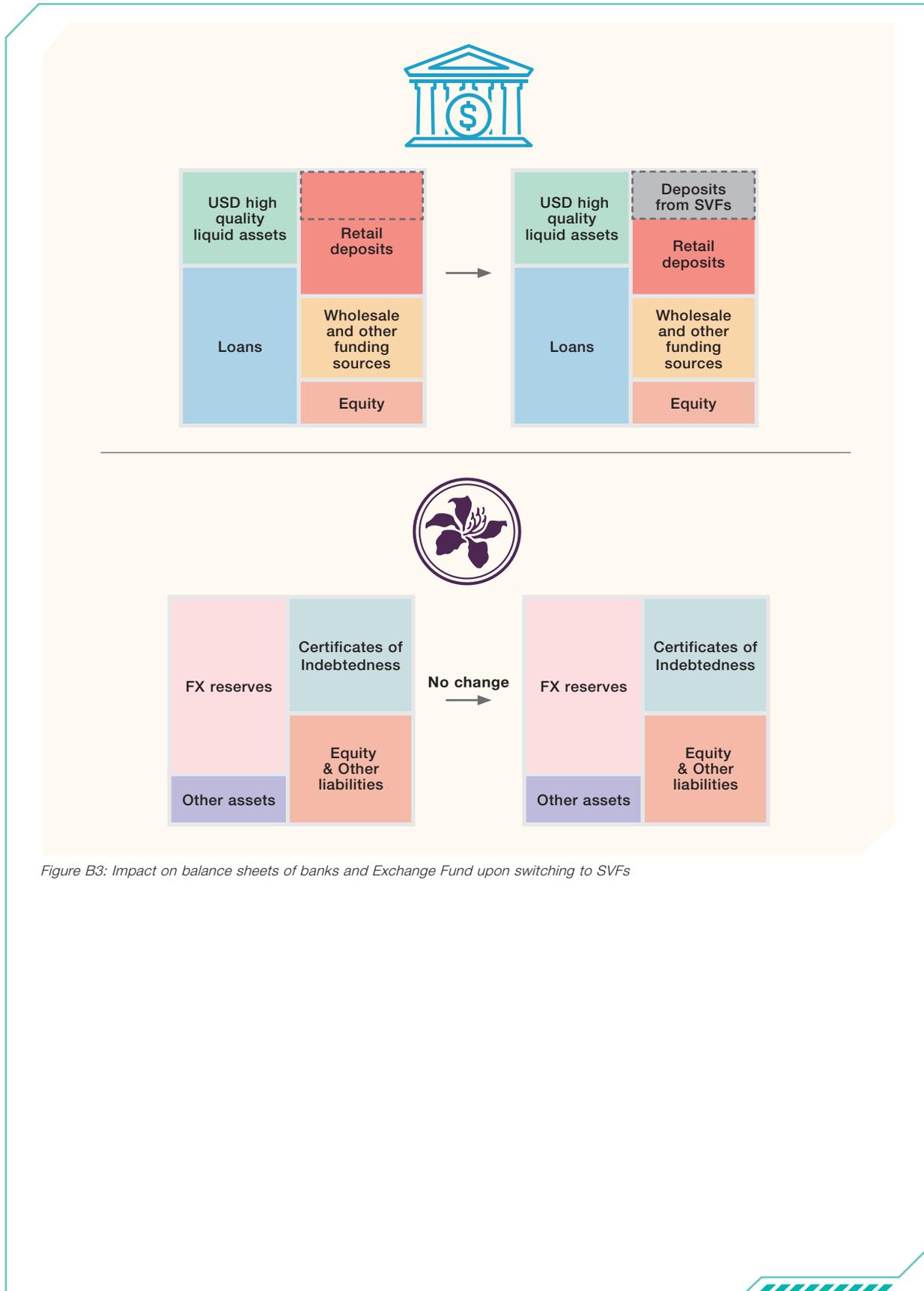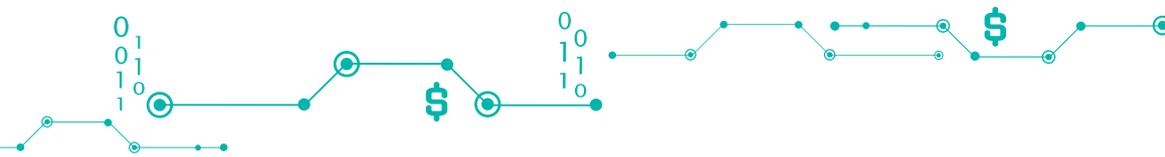
Figure B3: Impact on balance sheets of banks and Exchange Fund upon switching to SVFs

4.2 Increasing cyber security and software risks

Much akin to the adoption of any new technologies, transitioning from physical cash to rCBDC is subject to various risks and challenges. In particular, given the high monetary value of the rCBDC system, it could become an attractive target of cyber attackers.

In the case of Hong Kong, under the proposed structure outlined in the e-HKD technical whitepaper, the system would still have to deal with risks such as distributed denial-of-service (DDoS) attacks:

(i)   Wholesale system

The only participants of the network are the intermediaries (i.e. banks and PSPs) in a supposedly private network. There is no inlet for internet traffic. The only possibility for an adversary to send in an enormous amount of traffic is through a compromised bank server (which is relatively less likely).

(ii)   Retail system

Banks' customer-facing servers are the only entry points to the payment infrastructure. DDoS attacks against them with internet traffic would be possible (same as the scenario today for online banking).

(iii)   Validator infrastructure

Only banks/PSPs can access. Hence, launching a DDoS attack against it requires compromising the bank server (whose protection should follow the respective Technology Risk Management guideline and which is relatively less likely). A successful DDoS attack against a bank server would only bring down the respective bank's wallet service, and the customers of other banks and PSPs should not be affected.

As for the retail front, the mobile wallet apps provided by financial institutions are also subject to cyber risks faced by existing e-wallets (e.g. fake QR codes).
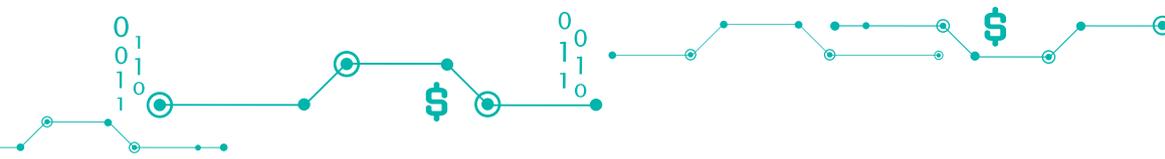
Apart from the risks arising from the payment system itself, there are also cyber risks associated with the adoption of smart contracts, including:

(i)   Coding risk (software bugs)

Although smart contracts provide a trustworthy alternative to existing commercial models where agreements are enforced by external parties, these contracts are coded by human beings and therefore remain susceptible to human error.

(ii)   Oracle risk (ability to verify conditions)

Oracles retrieve and verify external data for smart contracts. As the data extracted by oracles (e.g. flight delay information) determines how a smart contract will be executed (e.g. whether compensation should be paid to a policyholder), trustworthiness of oracles is crucial for smart contract execution. If the data retrieved by oracles is compromised, it could result in contracts being executed under incorrect circumstances.

It should be noted that no cyber security study of the e-HKD distribution infrastructure has been conducted so far. A proper evaluation would require rigorous modelling, enumeration of attack vectors and assessment of likelihood of these attacks, preferably based on a commonly adopted framework like STRIDE.[13]

4.3 Increasing economic vulnerability to power/network outages

Like most other types of digital payment systems, transactions of rCBDC would still rely on the availability of electricity and data networks.

While Hong Kong has one of the most reliable power grids and network systems, power/network outages do occur, especially during extreme weather events.[14] If e-HKD replaces physical cash as the main way of settling retail transactions, economic activities in Hong Kong could be severely disrupted during these rare but possible
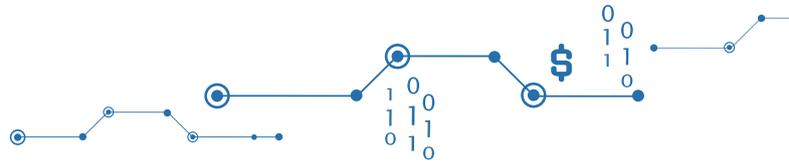
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[13] STRIDE is a model developed by Loren Kohnfelder and Praerit Garg of Microsoft in 1999 to identify potential cyber security threats. It is derived from an acronym for six threat categories: Spoofing identity, Tampering with data, Repudiation, Information disclosure, Denial of service, and Elevation of privilege. More details could be found at: https://msdn.microsoft.com/en-us/library/ee823878(v=cs.20).aspx.

[14] For instance, around 13,500 households suffered from power outages for more than 24 hours as typhoon Mangkhut hit Hong Kong in 2018.

events.[15] That said, given the acceptance of/need for of physical cash remains high in Hong Kong, physical cash is likely to remain a major means of retail payment even with the introduction of e-HKD. Therefore, such a concern may be less relevant to the case of Hong Kong.

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[15] One way to mitigate such a risk would be to incorporate offline payment features into e-HKD wallets.

Section 5

Design considerations

5. Design considerations

Apart from understanding the opportunities and challenges, careful consideration is also required in the following areas when designing e-HKD:

5.1 Issuance mechanism of e-HKD

The issuance and redemption mechanism of e-HKD would have to comply with the Currency Board principles under the LERS. In particular, any change in the Monetary Base would have to be fully matched by corresponding changes in foreign reserves. Accordingly, there are three possible issuance mechanisms for e-HKD:

(i) **Banks submitting USD in exchange for e-HKD (Coins approach)**

As a natural extension of the existing framework for the Government's issuance of HKD coins and $10 notes, agent banks could be appointed to handle all customer-facing activities related to the distribution of retail e-HKD. Specifically, when a customer requests to convert HK$7.80 of deposits to e-HKD, the agent banks would first need to submit US$1 to the HKMA in exchange for e-HKD (Figure 6), before transferring the HK$7.80 e-HKD to the customer electronically. The whole process would resemble the current way of the Government's dissemination of HKD coins and $10 notes through agent banks to customers, and this issuance mechanism has the merit of being easily understandable to the public as well as being consistent with the Currency Board principles.
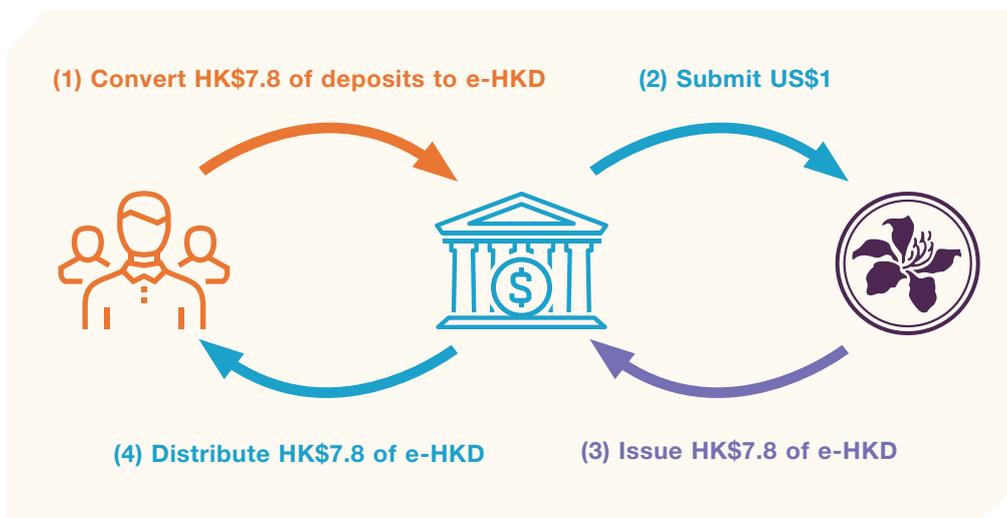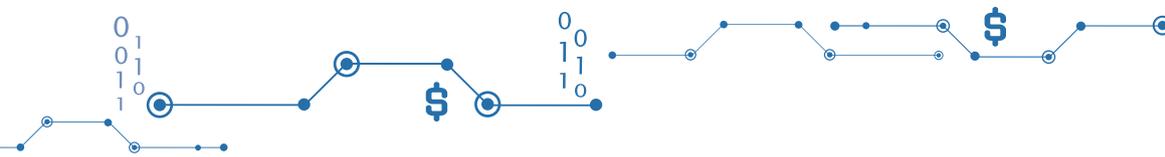

(1) Convert HK$7.8 of deposits to e-HKD   **(2) Submit US$1**

(4) Distribute HK$7.8 of e-HKD   **(3) Issue HK$7.8 of e-HKD**

Figure 6: Mechanism of issuing e-HKD by submitting USD to the HKMA in exchange for e-HKD

(ii)   Banks submitting USD in exchange for Certificate of Indebtedness (CIs) (Banknote approach)

As a natural extension of the existing framework for banknotes (except the $10 note), e-HKD could also be issued in a way similar to the existing banknote issuance arrangement through the note-issuing banks. Specifically, when depositors request to convert HK$7.80 of deposits to e-HKD, designated banks would be required to submit US$1 to the HKMA to purchase HK$7.80 of CIs before issuing HK$7.80 e-HKD to the depositors (Figure 7). Under this approach, e-HKD would be issued by the designated banks and hence would become the liabilities of the designated banks instead of the Government, but with full backing by the USD via CIs.
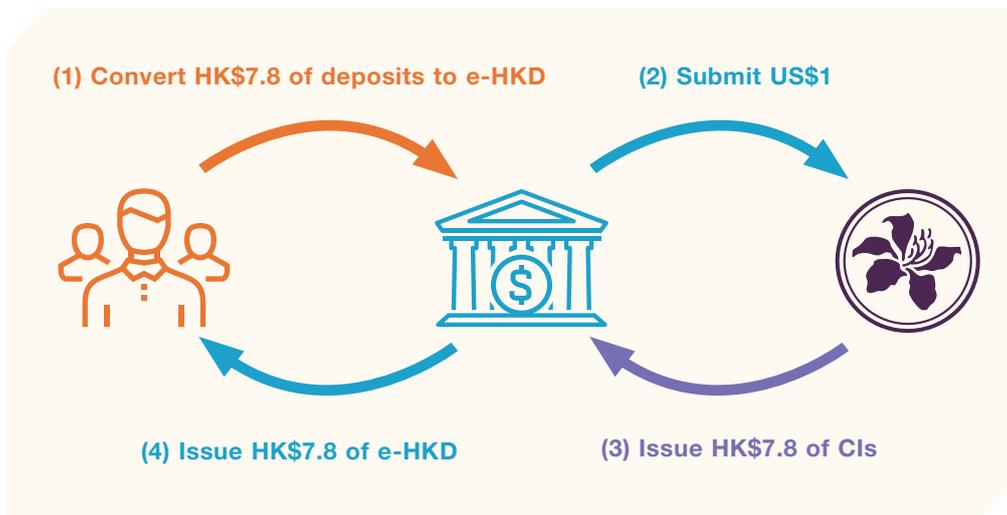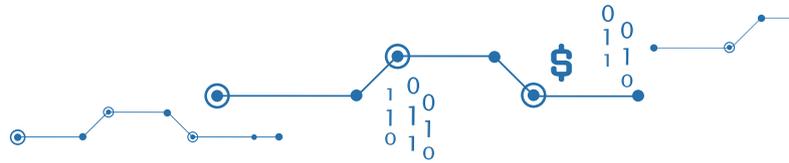
(1) Convert HK$7.8 of deposits to e-HKD   **(2) Submit US$1**

(4) Issue HK$7.8 of e-HKD   **(3) Issue HK$7.8 of CIs**

Figure 7: Mechanism of issuing e-HKD by submitting USD to the HKMA in exchange for CIs

(iii)   Banks converting existing Aggregate Balance (AB) into e-HKD (AB approach)

Under this approach, e-HKD would be issued through converting designated banks' clearing account balances with the HKMA into e-HKD (Figure 8), and this is in a way similar to the current way of issuing Exchange Fund Bills and Notes to subscribing banks. As the AB is a component of the Monetary Base that is fully backed by USD reserves, such a conversion would simply represent a change in the composition of the Monetary Base, and would be consistent with the Currency Board principles.
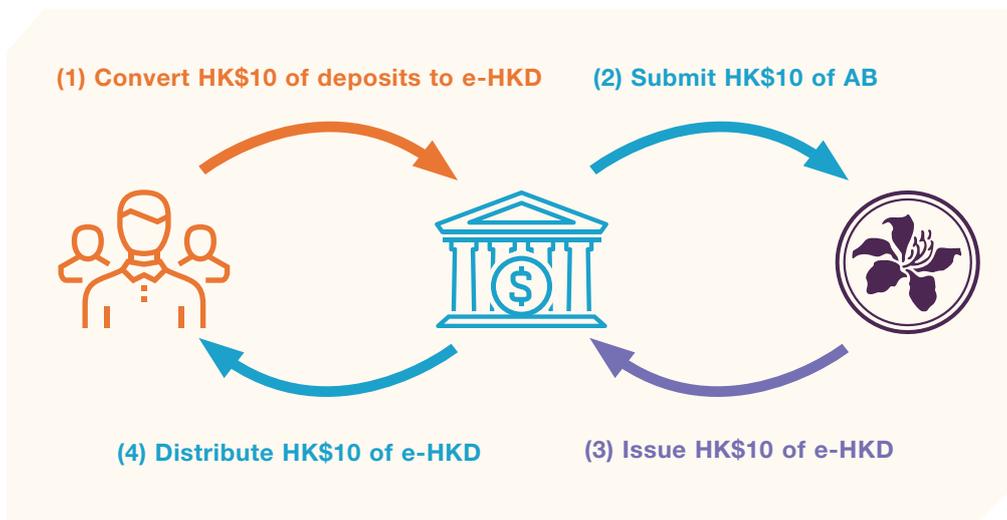

(1) Convert HK$10 of deposits to e-HKD   **(2) Submit HK$10 of AB**

(4) Distribute HK$10 of e-HKD   **(3) Issue HK$10 of e-HKD**

Figure 8: Mechanism of issuing e-HKD by converting AB with the HKMA into e-HKD

Among the three potential issuance mechanisms, the AB approach is considered less suitable than the Banknote approach and the Coins approach for two reasons:

1.   Unless adequate safeguards (see Section 4.1) are in place, the issuance and redemption of e-HKD under the AB approach may lead to increased volatility of the AB and hence HKD interbank liquidity conditions. The effect could be material if the AB were to drop to low levels, for example, during a financial crisis period with a deposit flight into e-HKD.
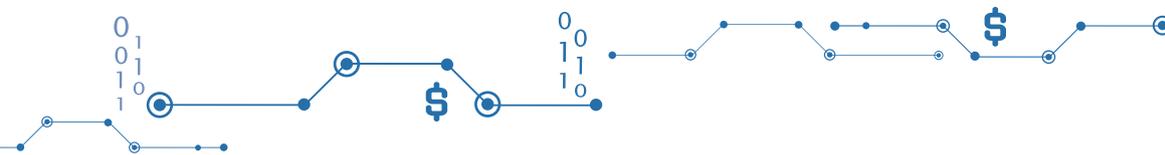
2. The AB approach may give people a wrong impression that e-HKD is not fully backed by foreign reserves, as the indirect backing of e-HKD through the AB is much less straightforward than the Banknote approach and the Coins approach, both of which could make it easier for the general public to understand e-HKD as simply a digital extension of physical cash.[16]

In comparing the Banknote approach with the Coins approach, the HKMA is inclined towards the Coins approach under which e-HKD would be solely issued by one single authority, but would still have the advantage of tasking agent banks to handle all customer-facing activities relating to the distribution of e-HKD. This approach would be simpler from an operational perspective and could avoid the unnecessary confusion of the public over the potentially different forms of e-HKD issued by different designated banks.

5.2 Interoperability with large-value and retail payment systems

As the purpose of developing e-HKD is not to replace existing payment methods, it is also important to ensure that e-HKD would be fully interoperable with other payment systems for more efficient payments to be made by the general public. The design of e-HKD should avoid creating a closed-loop payment system which impedes payments made between e-HKD users and users of other payment systems. Instead, e-HKD should also provide connectivity among other payment service providers such that cross-platform payments can be easily conducted.

In addition, the functionality and infrastructure of e-HKD should be able to evolve over time. In particular, e-HKD infrastructure should also be designed in a manner that paves the way for the possibility of future extensions to support unseen innovative use cases.

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[16] See Joseph Yam, "A Modern Day Currency Board System". https://www.hkma.gov.hk/eng/other-information/a-modern-day-currency-board-system/
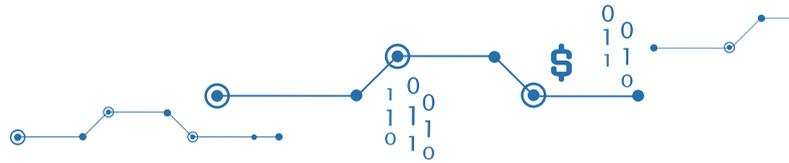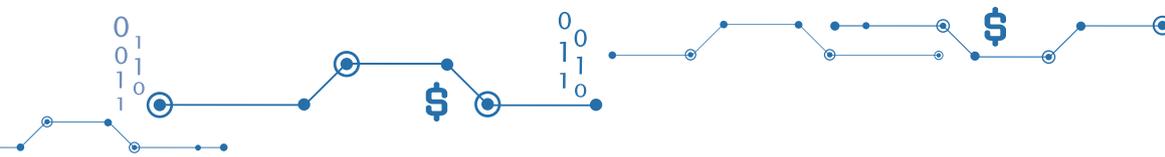
5.3 Privacy and data protection

A key design feature of rCBDC to consider is whether it should be token-based or account-based. The token-based approach would rely on the ability of the payee to verify the validity of the payment object. This could allow more anonymity in payments between different parties (e.g. customers, merchants) and such privacy could protect against abuse of individual data by commercial entities, but at the same time may risk facilitating illegal activities. The account-based approach would require the recording of balances and transactions of rCBDC holders. This approach would rely on the ability to verify the identity of the account holder, and could help comply with AML/CFT requirements.

Nonetheless, both token-based and account-based approaches could be structured to trace users, as both would be in digital forms and would require a ledger.[17] Therefore, the question is what parties (e.g. central bank, wallet operators/banks and merchants) should have access to what degree of information (e.g. user identity, transaction history), and of particular importance is the degree of anonymity vis-à-vis the central bank.[18]

Privacy and data protection are key considerations of an e-HKD arrangement. In order for e-HKD to be generally accepted and used by the public, these considerations should be embedded in the system design and operation of e-HKD. In particular, the e-HKD system should at all times comply with the Personal Data (Privacy) Ordinance and relevant codes of practice, guidelines and best practices issued by the Office of the Privacy Commissioner for Personal Data from time to time.

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[17] See "Central bank digital currencies: foundational principles and core features" and "Central bank digital currencies: system design and interoperability", Reports No. 1 and No. 2 in a series of collaborations from BIS, Bank of Canada, European Central Bank, Bank of Japan, Riksbank, Swiss National Bank, Bank of England, and Federal Reserve.

[18] See "Central bank digital currencies", BIS Committee on Payments and Market Infrastructures (2018).

While most central banks put great emphasis on user privacy and data protection when designing their CBDCs, it is generally agreed that full anonymity is not plausible as a design option, given central banks' responsibilities in ensuring that CBDC transactions comply with AML/CFT requirements and guarding against illicit transactions and tax evasion. In managing such a trade-off between privacy and the integrity of the CBDC system, it is not uncommon for central banks to opt for a tiered wallet approach, under which a greater degree of anonymity is allowed for wallets with a lower maximum holding and transaction limit.[19] Therefore, in determining the most suitable privacy and data protection model for e-HKD, Hong Kong will take into account the experience of other central banks so as to ensure that e-HKD upholds user privacy while maintaining public trust and assuring the integrity of the e-HKD system.

5.4 Legal considerations

Design choices in relation to its architecture will inevitably affect the legal analysis and assessment of how best to ensure that any e-HKD enjoys a robust legal foundation, and whether it is necessary, or otherwise advisable, to enact specific legislation in order to achieve a sufficient degree of public confidence and certainty.

To the extent that any e-HKD is designed to be "currency", in essence the digital version of Hong Kong dollar cash, its legal mandate and legal tender status would logically be expected to align with that of existing Hong Kong currency in the form of currency notes and banknotes issued under the Legal Tender Notes Issue Ordinance, and coins issued under the Coinage Ordinance. The amendment of existing ordinances, the consolidation of existing currency-related ordinances to include also provision for the e-HKD, or the enactment of a new stand-alone ordinance tailored specifically to accommodate e-HKD, would ensure that the issue and legal tender status of all forms of Hong Kong currency are clearly prescribed by law in a consistent and coherent manner.

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[19] For example, e-CNY follows the principle of "anonymity for small value and traceable for high value", and the PBoC has come up with a tiered design of e-CNY wallet with different caps on transactions and balances for different types of e-CNY wallets. The lowest-tier wallet has lower transaction and balance caps but users are able to make payments in an anonymous manner. The upper-tier wallets have higher transaction and balance caps but require the registration of a Chinese identity card to ensure compliance with AML/CFT requirements.
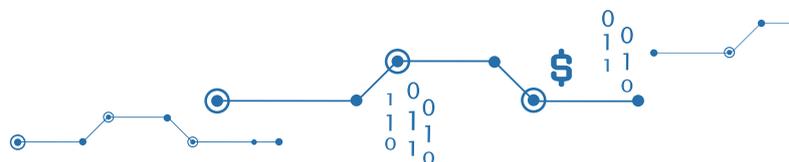
The architecture adopted for any e-HKD will also be relevant in relation to the imposition of AML/CFT requirements to "know your customer". To prevent a CBDC from being used to facilitate large-scale criminal activities, there will be a need for some level of AML/CFT controls, but there is also a need as discussed above to protect user privacy. A two-tier issuance and distribution structure (as discussed in the e-HKD technical whitepaper) would offer the advantage that customer-facing financial institutions, who already have considerable experience in both AML/CFT compliance and the maintenance of customer confidentiality, could be tasked with undertaking the required customer due diligence and keeping the required records. The offering of a tiered selection of digital wallets to hold e-HKD could, if adopted, provide greater anonymity for small-value payments (mimicking cash usage) whilst making higher-value payments traceable. A review of the Anti-Money Laundering and Counter-Terrorist Financing Ordinance conducted in the light of the architecture (including any tiered thresholds) ultimately adopted, should ensure suitable coverage of e-HKD related activities.

Differing design choices may also influence how "settlement finality" (finality in the transfer of money) is achieved with e-HKD. For e-HKD in the form of currency, when it is transferred, it would seem logical and necessary that ownership should (as now with notes and coins) pass upon "delivery" – that is upon being paid over – and the point of delivery (in the absence of physical possession) may fall to be determined by reference to the "ledger" technology used to record the transfer of e-HKD. Whether, for the sake of certainty, additional legislative or administrative provision is needed regarding the characteristics of "delivery" within the selected electronic environment, will require further consideration once the design choices are more refined.

Also from a security perspective, in addition to technology-based measures to secure the authenticity and restrict any "double-spending" of e-HKD, consideration should be given to any benefits of adopting criminal law protections (a "digital equivalent" of current anti-counterfeiting provisions) to protect and bolster confidence in the e-HKD.

More broadly, a review will need to identify other ordinances referring to concepts of "money", "currency", "cash" and "virtual assets" to ensure that the e-HKD is appropriately accommodated or excluded, as necessary, depending upon the underlying policy rationale for the relevant piece of legislation.

Section 6

Use cases of e-HKD

# 6. Use cases of e-HKD

While central banks around the world have been exploring the potential use cases of rCBDC in their studies, currently there are only a handful of central banks which have actually launched or are conducting pilot trials of their rCBDC projects. For example, in The Bahamas, the launch of the Sand Dollar aims to further financial inclusion goals and promote the public's access to payments, given that the island topography of the region makes distribution of cash and provision of financial services difficult and costly. In Mainland China, the pilot use cases of e-CNY include making payment for utility bills, transportation and government services and in automatic vending machines and unattended supermarkets at the venues of the Beijing 2022 Olympic Winter Games. In Sweden, the Riksbank is exploring the use of e-krona in digital payments in its proofs of concept against the backdrop of declining use of physical cash in the country.

As regards the central banks which are yet to conduct proofs of concept or pilot trials, they generally consider that rCBDC would improve payments between households and businesses (Bank of England), encourage greater innovation by the private sector in the payment space (Bank of Thailand), and provide a safe form of money in the fast-changing digital world to their citizens (European Central Bank). As illustrated by the central banking community, the emergence of concrete use cases of rCBDCs would depend to a large extent on the development of the local payment landscape and digital economy and the underlying policy objectives that are intended to be achieved.

In our case, the HKMA has so far received a few suggestions on the potential use cases of e-HKD. It is generally believed that the introduction of e-HKD could further enhance private sector innovation at the retail wallet layer. Other suggestions raised include the use of e-HKD in offline payments, and as a compliance tool to perform functionalities not available previously (e.g. AML regulatory compliance checking). While such possibilities have a lot of potentials, mass retail adoption would only occur when the public see very tangible benefits for them. Given the plethora of convenient retail payment options in Hong Kong, that would require an rCBDC that would address some existing pain points, open up new or innovative use, provide complementarity with private money, or is more convenient than existing payment options. In light of these considerations, further studies would be required to deliberate how a potential e-HKD platform should be designed. We would also be mindful that such an e-HKD platform must be forward compatible and future-proof to accommodate the objectives and possible use cases specific to Hong Kong's circumstances.

Section 7
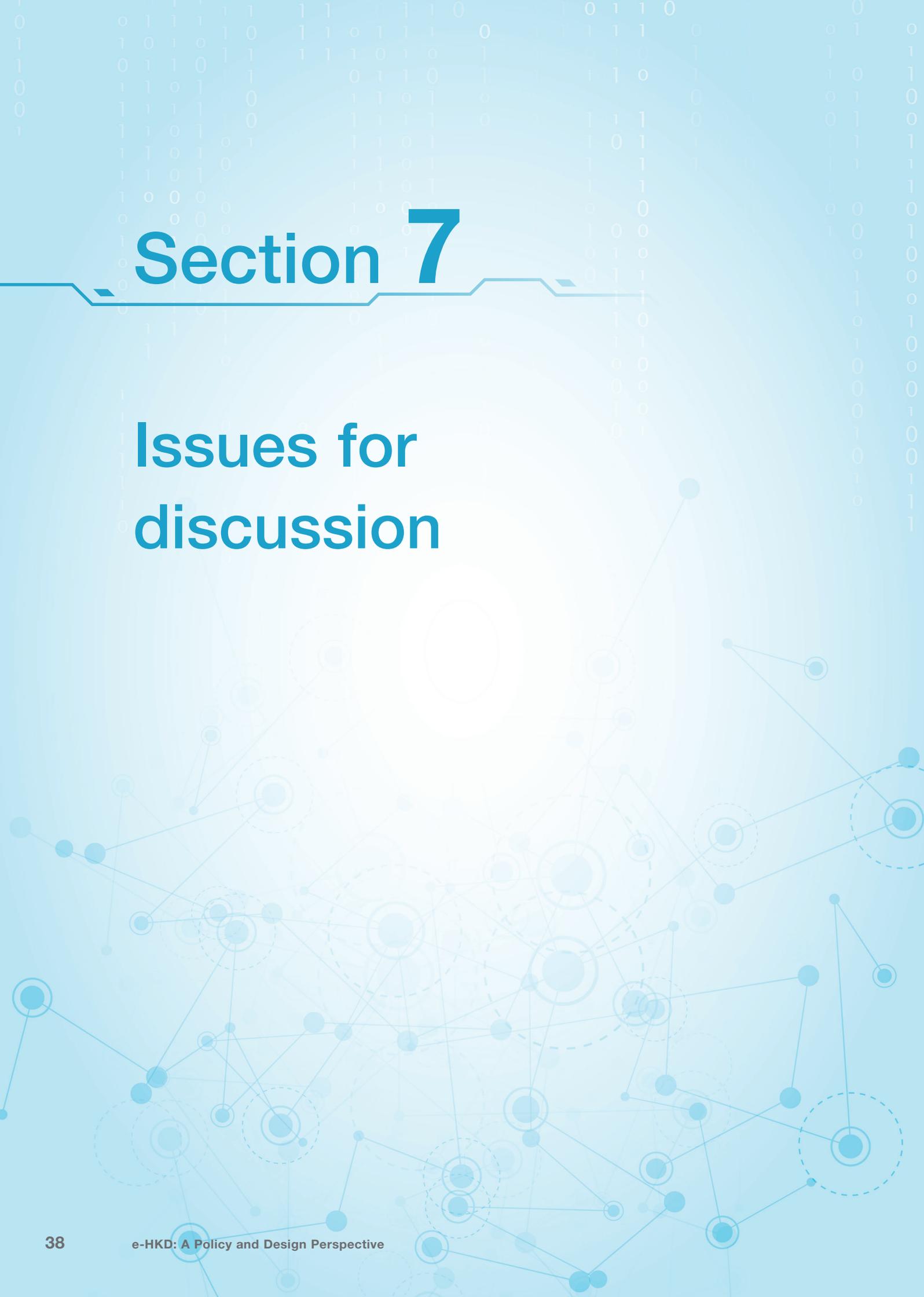
Issues for discussion

7. Issues for discussion

This paper lays out the policy issues involved in introducing e-HKD in Hong Kong, noting that e-HKD could bring both opportunities and challenges. This paper also covers certain design considerations of e-HKD, including its issuance mechanism, interoperability with other payment systems, privacy and data protection, as well as legal considerations. Specifically, any e-HKD issuance mechanism would have to comply with the Currency Board principles under the LERS, just like the existing frameworks adopted for the issuance of HKD coins and notes.

In light of the wide range of policy issues involved and their relative merits and challenges, the HKMA invites your feedback on the following list of issues. Please note that the HKMA has not yet made a decision on whether and when to introduce e-HKD. Please submit your response on or before 27 May 2022 to ehkd_feedback@hkma.gov.hk.

1. Do you agree that e-HKD can bring potential benefits as described? Do you see other potential benefits?

2. How can e-HKD implement the suggested use cases better than the existing e-payment means? Apart from programmability, what other technologies would bring new use cases for e-HKD?

3. How do you see the demand for e-HKD as a means of payment? What other design features would promote the use of e-HKD?

4. Do you agree with the description of challenges brought by e-HKD? Do you see other challenges? Are there any other measures that can mitigate the adverse impacts of e-HKD? How would these measures affect the attractiveness of e-HKD?

5. How can e-HKD assist in the detection of illicit activities while preserving user privacy at the same time?
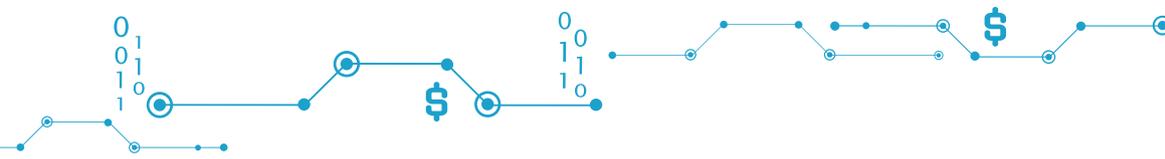
6. What types of financial institutions should be responsible for distributing e-HKD? Should the functionalities of the e-HKD wallet be allowed to differ among the financial institutions?

7. How should e-HKD be designed to achieve interoperability with existing payment systems? Are there any technological barriers that would prevent the acceptance of e-HKD?

8. Should there be different types of e-HKD wallets based on the level of personal information required? If so, what should the corresponding transaction/holding limits for each type of wallet be?

9. Are there more design considerations to be included in the e-HKD study? Would you be able to identify some trade-offs around such considerations?

10. How could the private sector contribute to the e-HKD journey?

11. Are there any other legal considerations, in addition to those discussed in this paper, which should be considered in designing a legally robust e-HKD?

12. Are there any other policy considerations which are relevant to e-HKD but not covered in this discussion paper?