

Envisioning Programmable Payments in Hong Kong

How could an e-HKD further
improve payments in Hong Kong?



Acknowledgement

Co-authors of the white paper



Appraised as the “Best Retail Bank in Hong Kong” by The Asian Banker for six consecutive years, Hang Seng Bank is a leading financial institution in Hong Kong. Hang Seng Bank offers a wide range of financial products and services to individuals, businesses, and institutions, including personal banking, commercial banking, wealth management, and insurance.

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Hang Seng Bank is one of the sixteen firms that participated in Phase 1 of the e-HKD Pilot Programme. One of their use cases was awarded the “Best Use Case Award” at the Global Fast Track 2022’s CBDC Track Pitching Competition in November 2022.

For more information, visit www.hangseng.com



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Foreword

Gilbert Lee

Head of Strategy & Planning and Chief of Staff to Chief Executive of Hang Seng Bank

We are delighted to present the final report of our e-HKD real-life simulation, conducted as part of the Hong Kong Monetary Authority's e-HKD Pilot Programme. This report summarises valuable feedback collected from participants, reflecting the potential of e-HKD and providing references for regulators, policymakers, and industry players.

As a leading advocate of central bank digital currency ("CBDC") in Hong Kong and Mainland China, Hang Seng actively participates in CBDC research and development. In 2023, we successfully created innovative e-HKD use cases and conducted real-life simulations in collaboration with strategic partners and industry players.

Looking ahead, we will continue to actively participate in discussions, share insights, and contribute to CBDC development in the region while supporting other HKMA initiatives.

Special thanks to our partner on this report, Oliver Wyman, and our partners in the e-HKD Pilot Programme, including Hong Kong Cyberport Management Company Limited, The Chinese University of Hong Kong, and FORMS Syntron Information (HK) Ltd.

Ronald Fung

Partner, Digital and Financial Services Practices, Oliver Wyman

Central bank digital currencies (CBDCs) come with exciting potential, yet many industry practitioners are still in the exploration stage, with hesitations. To contribute to the responsible community in exploring the future of money, Oliver Wyman has been working collaboratively with policymakers, traditional financial institutions, disruptors and civic society in thought-leadership and various pilot endeavours.

Through this joint report, Hang Seng and Oliver Wyman aim to crystallise the various characteristics and benefits of an e-HKD. Additionally, this report identifies the key enablers required to unlock the future potential of e-HKD. We believe this report can facilitate the industry in gaining a better understanding and confidence to embark on this exploration together, creating much-needed collaboration between the private and public sectors.

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Executive summary

Central bank digital currencies (CBDCs) have gained widespread interest from around the world. A CBDC is a digital form of a fiat currency that is issued by a central banking institution. Some countries, like China and the Bahamas, are running advanced pilots (e.g., e-CNY in China and Sand Dollar in Bahamas), while others, such as the United Kingdom and Europe, are in the design stage (e.g., digital pound and digital euro). We see CBDCs come with exciting potentials — it may unlock additional economic value by facilitating new types of transactions and enhancing their efficiency and transparency.

In Hong Kong, the Hong Kong Monetary Authority (HKMA) has been researching CBDCs as part of its “Fintech 2025” strategy. As part of the HKMA’s three-rail approach in paving the way for the potential implementation of an e-HKD, being a retail CBDC in Hong Kong, the HKMA launched the e-HKD Pilot Programme in November 2022 to explore commercially viable use cases for an e-HKD in collaboration with the industry.

Sixteen participants, including Hang Seng Bank (Hang Seng), were involved in Phase 1 of the programme, which commenced in May 2023. Hang Seng collaborated with FORMS HK to develop a hypothetical e-HKD e-Wallet prototype. The prototype was used to test the effectiveness of a hypothetical e-HKD to streamline the use cases of government grant disbursement, merchant reward programme, and Peer-to-Peer (P2P) transfer.

Drawing from the feedback gained during the pilot, we observe three strategic implications:

- **An e-HKD has the potential to enable wider adoption of retail payments.** With increasingly various types of retail business models, the demand for conditional payments has become ubiquitous, such as long-term service subscriptions that necessitate payment over a period, and peer-to-peer marketplaces where payments are required upon the receipt of goods. As a retail CBDC, an e-HKD could be linked to various digital payment methods, allowing conditional payments to be applied regardless of the payment methods being selected by the users.
- **An e-HKD could empower small businesses in using digital payment & programmability features.** Due to ingrained business norms and the lack of technology capabilities of many small businesses, they tend to embrace digitalisation in the retail commercial world at a slower pace. An e-HKD has the potential to reduce technology barriers and enable small businesses to set specific conditions for transactions, e.g., customised rewards and payments in instalments.

- **Clear incentives will be required to drive adoption for both individuals and businesses.** Should an e-HKD be launched in the future, the pilot study has shown that certain criteria have to be met to drive adoption. For individuals, the adoption could be driven by improved user experience and certain level of payment incentives. Conversely, for merchants and government organisations, the main incentives are cost efficiency and ease of implementation.

Based on the pilot experiences, there are three key enablers which should be addressed in order to realise the full potential of an e-HKD, should it be launched in the future:

- **Collaborative participation model:** Private sector participation is not only critical for continuing experiment of e-HKD in the current stage, but also key for future implementation and promotion if an e-HKD is to be launched. Therefore, a participation model that defines who and to what extent private sector could participate would become a key design question. A model that allows active participation from the private sector could encourage competition among intermediaries, leading to customer-oriented innovation, improved services, and lower price.
- **Accessible and user-friendly programmability features:** To incentivise small merchants and government organisations to adopt e-HKD, we view that the biggest challenges to be addressed are 1) the conditions that need to be made available when deploying transactions with conditional payments, and 2) the ease of this deployment process. However, providing innovative programmability features on a large scale might also cause implementation issues. Therefore, the offering of programmability features should be designed with considerations of user experiences, system performance, and risk management.
- **An innovation-friendly platform:** This refers to a platform that is easy for eligible intermediaries to innovate and implement use cases. Based on Hang Seng's experience in the pilot, a private-blockchain-based platform with APIs and interoperable standards to connect different intermediaries would appear to be ideal to foster innovation.

We acknowledge that certain non-technical factors such as ingrained business norms and preferences may not be necessarily solved by an e-HKD and, hence, can influence e-HKD's uptake should it be issued. With that said, the pilot proves that e-HKD could have the potential to deliver other substantial and equally important benefits to individuals, merchants, and government organisations. These valuable insights would not only hold significance for Hong Kong but also provide some reference for other advanced economies currently exploring the implementation of retail CBDCs.

Now is an opportune moment for collaboration between the public and private sectors to deepen the examination of the key benefits that an e-HKD could bring to Hong Kong, and to set out necessary frameworks and architectures to fully realise the potential benefits.

1

Potential value of e-HKD

Central bank digital currencies (CBDCs) are gaining traction in the digital financial services market as a form of digital money. In 2022, a survey by Bank for International Settlement (BIS) revealed that 93% of the surveyed central banking institutions had launched either retail CBDC projects or both retail and wholesale CBDC projects, indicating widespread interest¹. Hong Kong, for example, has completed Phase 1 of the e-HKD Pilot Programme in 2023 to explore the use cases and unique value of issuing its own retail CBDC.

Despite the experiments and projects, many central banking institutions remain undecided on the path ahead. This section will review the motivations of central banking institutions in piloting a retail CBDC, and discuss the value of retail CBDCs in advanced economies like Hong Kong.

1.1 Rationale for piloting CBDCs

The same survey by BIS has shown that emerging economies are leading in the development of CBDCs compared to advanced economies, especially for retail CBDCs. Notably, all current live retail CBDCs are issued in emerging economies. For instance, Nigeria launched eNaria in 2021 to enhance financial inclusion as one of the motivations, leveraging the country's high mobile phone penetration rate of approximately 80%². In emerging economies, retail CBDCs have the high potential to improve financial inclusion and payment efficiency. Whilst in advanced economies, the aforementioned pain points are nearly well-addressed due to well-banked population and developed digital payment ecosystems. As a result, many advanced economies are still exploring the value of retail CBDCs, focusing on enhancing customer experience, improving payment efficiency, ensuring safety, and promoting financial stability.

¹ Bank for International Settlements, July 2023, *Making headway — Results of the 2022 BIS survey on central bank digital currencies and crypto*.

² International Monetary Fund, March 2023, *Nigeria — Fostering Financial Inclusion through Digital Financial Services*.

For example, the European Central Bank (ECB) is looking into the possible issuance of a digital euro to strengthen its role in the payment market, which could “help reduce Europe’s dependence on private, non-European payment providers”³. It was explored that more “pan-European payment innovations” could be fostered and more healthy competition in the European payment landscape could be introduced, showcasing the diverse capabilities and solutions offered by CBDCs.

1.2 Value of a CBDC to Hong Kong

Hong Kong, a prominent financial hub in Asia, boasts a highly sophisticated payment market, with 91% digital payment adoption rate⁴ and HKD 350 billion retail sales in a year⁵. However, despite its accessibility and convenience, many merchants, especially the small-and-medium-sized ones, still experience pain points such as high cost and operational inefficiency to customise payments on their purposes. Although some digital payment methods are able to provide transaction record and simple reward options for merchants, some small-and-medium-sized merchants may still hesitate to adopt these new technologies due to entrenched business practices and limited operational and technological resources to analyse customer data and create personalised reward programmes. Furthermore, small and medium-sized merchants often face the challenge of having to select one or several payment e-wallets to implement such reward programmes, given there is a lack of existing solution that provides customers with access to all merchants, which can be less efficient.

An e-HKD, a digital version of the Hong Kong dollar that is being examined in the pilot, could potentially address the gap by embedding the potential features of programmability, traceability, and interoperability.

- Programmability is defined as the ability to set conditions for money or payments for specific purposes. For example, a merchant could programme a customised discount into transactions based on certain time and counterparty criteria. This could not only streamline the process of merchants adopting conditional payments and reward programmes, but also lower the technical and operational barrier of less tech-savvy organisations (such as small-and-medium-sized merchants) to embrace a new payment method, bearing any resistance they may have towards these new methods as a result of pre-existing notions or longstanding norms.

³ European Central Bank, October 2023, *FAQ on a digital euro*.

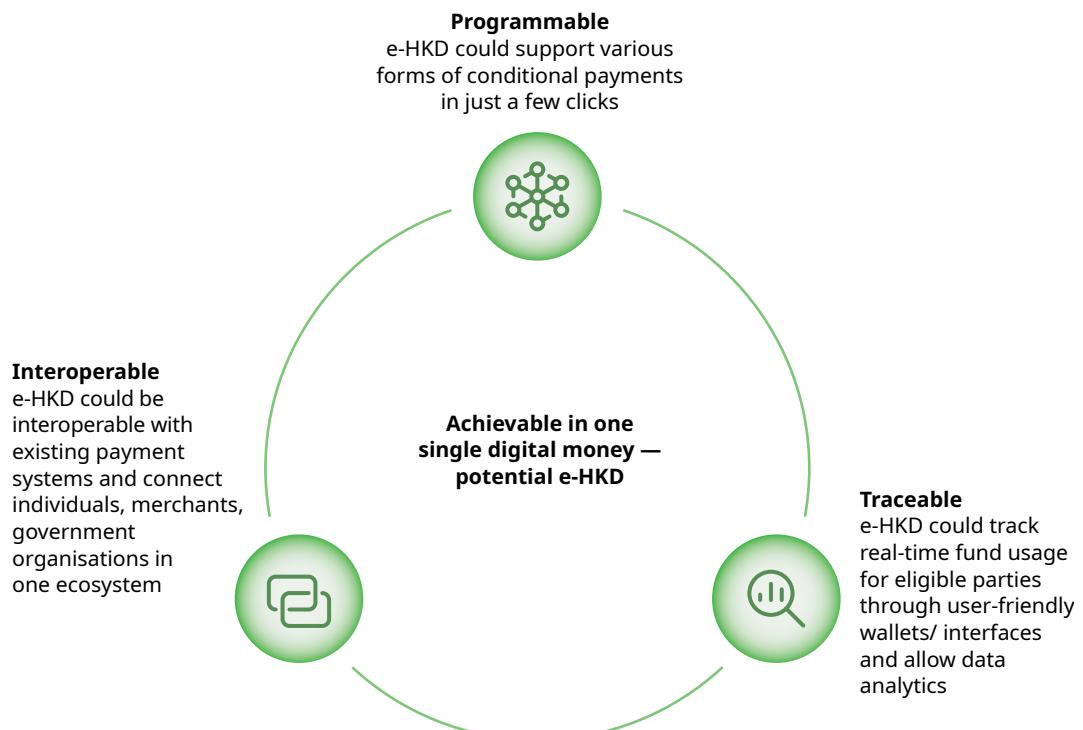
⁴ The Hong Kong Polytechnic University, April 2023, *PolyU-Asklora Fintech Adoption Index (FAI)*.

⁵ Hong Kong Census and Statistics Department, 2022, *Total Retail Sales*.

- Traceability refers to accurate documentation and automatic tracking of e-HKD movements since the time of issuance. It could enable the above merchants and organisations to track the performance of implemented reward programmes irrespective of the payment channel being utilised, and hence make more informed decisions with better understanding of the market.
- Interoperability refers to the seamless and efficient exchange of information, transaction processing, and communication across systems, such as among the existing payment systems. Depending on the design of e-HKD infrastructure, an e-HKD could potentially offer an interoperable solution applicable to the entire payment ecosystem and accessible to all individuals, merchants and government organisations whilst not cannibalising the existing market.

Although some of these features may as well be achievable in the existing payment channels (e.g., customised reward could be implemented in some digital payment channels), an e-HKD could potentially and uniquely combine these features in one single digital money, which makes it exceptionally versatile and easy to drive new payment innovations and create additional commercial values.

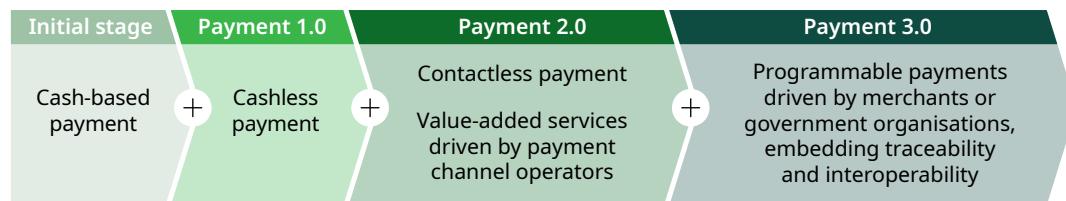
Exhibit 1: Potential features and benefits of an e-HKD



The Hong Kong payment ecosystem has evolved through several stages to become as advanced and user-friendly as it is today. This journey includes the evolution from its initial stage of cash-based payments to "Payment 1.0", i.e., cashless payments with the introduction of Octopus cards and credit cards, as well as the upgrade to "Payment 2.0", which entails contactless payments such as online digital payments. With more players entering the market, the competition has also incubated value-added services beyond pure payment, such as exclusive reward programme and financing services provided and controlled by the payment channels. Each of these stages has introduced new solutions to provide additional benefits to the users whilst not excluding the pre-existing solutions to serve diversified client needs.

With the uniquely combined features of a potential e-HKD, it has the chance to drive further evolution of the payment ecosystem from stage 2.0 to 3.0. Programmability, as being tested in multiple use cases in Phase 1 of the e-HKD Pilot Programme, could empower the less tech-savvy institutions and merchants to design and control their own payment conditions as needed, without depending on specific payment channels or requiring additional technology resources for implementation.

Exhibit 2: Evolution of Hong Kong payment landscape



2 A real-life experiment

To take deep dives into potential use cases, and implementation and design issues relating to an e-HKD, the HKMA commenced Phase 1 of e-HKD Pilot Programme in May 2023, with Hang Seng as one of the participating firms. Recognising programmability as one of the key potential features of e-HKD, Hang Seng proposed two use cases and one supplementary use case, all of which fell under the programmable payments category.

To test the three use cases, Hang Seng developed a hypothetical e-HKD e-wallet with assistance from a Fintech company, FORMS HK. This prototype utilised a private blockchain to facilitate the issuance of hypothetical e-HKD-supported tokens with specific payment conditions, enabling government grant disbursement (Government to Customers, or G2C) and merchant reward programme (Business to Customers, or B2C). In order to ensure a comprehensive coverage of retail payment scenarios, P2P transfer was also explored and enabled to supplement the first two use cases.

The remaining part of this section provides an overview of each of the three use cases and summarised the feedback collected from the pilot participants.

2.1 Use cases' design and rationale

Hang Seng's pilot encompassed three use cases, namely government grant disbursement, merchant reward programme, and P2P transfer.

USE CASE 1**Government grant disbursement**

Today, the subsidy disbursement and collection process are notably long and manual for both the government organisations and beneficiaries (i.e., the recipients). From the government's perspective, the distribution of government grant still consists of many manual processes, including handling supporting documents, notifying approval and disbursement status, conducting the subsidy transfer through cheques and other means. Although some of the processes are deliberately designed to embed extra control on the correct disbursement, the general perception of the overall disbursement process is that it can be both resources-consuming and time-consuming, as well as creating unpleasant user experiences for the beneficiaries, such as checking across multiple systems to reconcile the subsidy application and cashflow information. Furthermore, as the subsidies are managed by the beneficiaries in various bank accounts and digital wallets. It is extremely challenging to monitor the usage of disbursed subsidies, creating the potential for misuse.

As described in Exhibit 3, different potential features of an e-HKD could address the preceding issues within government grant disbursement. For instance, the programmability nature of e-HKD can enable automation in government's notifications to beneficiaries and fund disbursement once the eligibility of the beneficiaries is confirmed. Another feature of e-HKD, i.e., atomic settlement, could guarantee beneficiaries to receive subsidies instantly without any delay. Finally, the traceability could allow real-time tracking of fund usage for administrative purposes as long as it is kept as an e-HKD.

Exhibit 3: Government grant disbursement process — current vs in e-HKD pilot

	Current	In Hang Seng's e-HKD pilot use case design	Enabled by potential e-HKD features
1 Application and approval	Varying	Varying	NA
2 Notification for approval results	Manual and lengthy process Government notifies beneficiaries through mail, email and other channels	Automatic and speedy Government notifies beneficiaries via hypothetical e-HKD wallet once the approval is obtained	Programmability
3 Fund disbursement	Time-consuming In some cases, beneficiaries receive cheques and queue at branch for handling	Fast and ring-fenced fund Beneficiaries receive subsidies instantly, where subsidies are ring-fenced for eligible usage	Atomic settlement and programmability
4 Monitoring	Manual and lengthy process Government extracts data from different sources with time lag	Automatic and instant monitoring Government has access to real-time subsidy usage data on the administrative portal	Programmability with traceability

As such, the manual work of government staff could be largely streamlined and automated. They would also be empowered to monitor the usage of the subsidy, the data collected from which could benefit the design of future subsidy programme. For the beneficiaries, tracking the disbursement progress could be much easier and more instant. They might only need to tap a few times on the phone to see the disbursement, instead of navigating through multiple applications.

Taking FY2023-24 as an example — the Hong Kong government is expected to spend HKD 129 billion on social welfare (e.g., Old Age Living Allowance, Comprehensive Social Security Assistance, Disability Allowance)⁶. This amount may continue to grow in the future with economic growth and progression of the society. With the infrastructure in place, an e-HKD has the potential to facilitate future government subsidies of varying scale and criteria, resulting in efficiency savings for the government and benefiting millions of recipients.

USE CASE 2

Merchant reward programme

On the other hand, providing customised reward to facilitate business expansion and customer traction has been challenging for merchants. As shared by a food and beverage operator that participated in the pilot, small-and-medium-sized merchants are often constrained by limited capacity and capability to manage reward programmes.

An e-HKD emerges as a potential solution to address these challenges. Its programmability empowers merchants to easily design the vouchers so that they can be automatically disbursed when a customer's spending fulfils predefined conditions. For the individual users, the e-HKD platform could provide a unified system for streamlined management of diverse reward vouchers. Upon the redemption of vouchers, e-HKD leverages programmability to conduct automated checks on redemption conditions and facilitate atomic settlement to close the transaction.

“ The current digital payment means are too costly... Also, we do not have regular rewards/reward programmes since we find it hard to identify the right customers to distribute rewards.

A food and beverage operator

⁶ Hong Kong 2023-24 Budget.

In Hong Kong's bustling retail landscape, with over 63,000 retail outlets⁷, catering to personalised rewards for over 4 million potential users⁸ could enhance customer loyalty, engagement, as well as overall customer experience.

Exhibit 4: Merchant reward programme — current vs in e-HKD pilot

	Current	In Hang Seng's e-HKD pilot use case design	Enabled by potential e-HKD features
1 Design	Manual work and lengthy process Merchants design terms and conditions and layout	Automatic, fast and low-cost Merchants set customised conditions and distribute the vouchers via the administrative portal	Programmability
2 Distribution	Expensive Merchants print and distribute vouchers		
3 Storage	Difficult to manage Customers receive different formats of rewards with no customisation	Ease of management Customers receive vouchers instantly and manage them on a single platform	Programmability
4 Redemption	Time-consuming Customers queue at shops to use the vouchers		
5 Verification	Manual work Merchants manually verify the terms and conditions of vouchers	Automatic, fast and low-cost Merchants verify and settle the vouchers without manual checking	Atomic settlement and programmability
6 Reconciliation	Manual work Merchants manually reconcile and settle transactions with banks		

Supplementary use case: P2P Transfer

Similar to merchant reward programmes, P2P transfers could also embed programmability and traceability with an e-HKD. In the pilot, Hang Seng enabled conditional and traceable P2P transfer so that the payers could customise the prerequisites for the fund to be further used and track the fund utilisation. It could enhance the payers' control and visibility on the fund usage, which is valuable to people engaging services such as errand services and purchasing agents.

7 Hong Kong Retail Management Associations, based on the disclosure as of 15 November 2023.

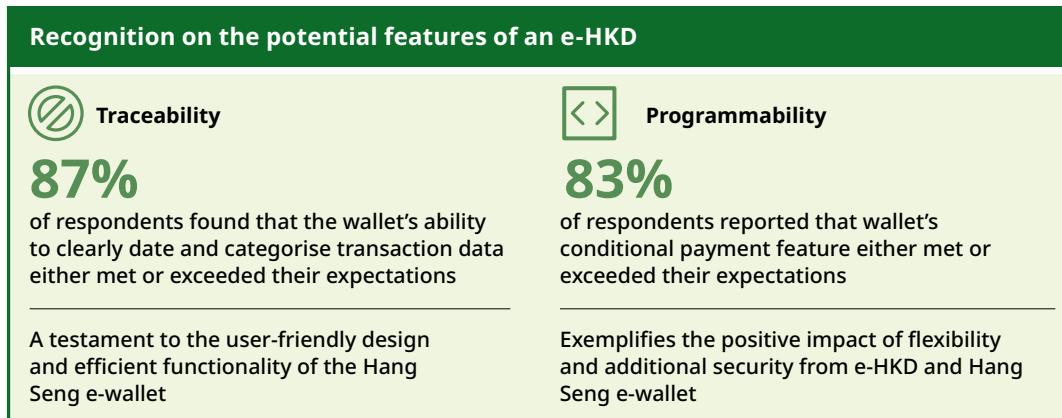
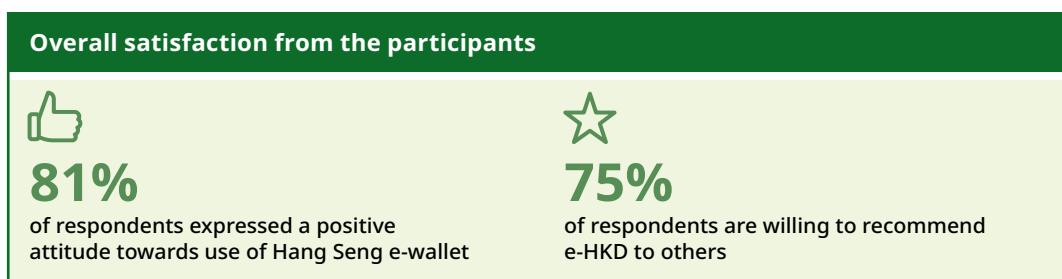
8 Referring to Hong Kong population who are aged between 15-64 and own at least 1 smartphone; Hong Kong Census and Statistics Department, May 2023, *Thematic Household Survey Report No. 77*.

This use case supplements the aforementioned two use cases and allows the pilot e-wallet to cover all retail payment scenarios comprehensively.

2.2 Feedback from the pilot and its implications

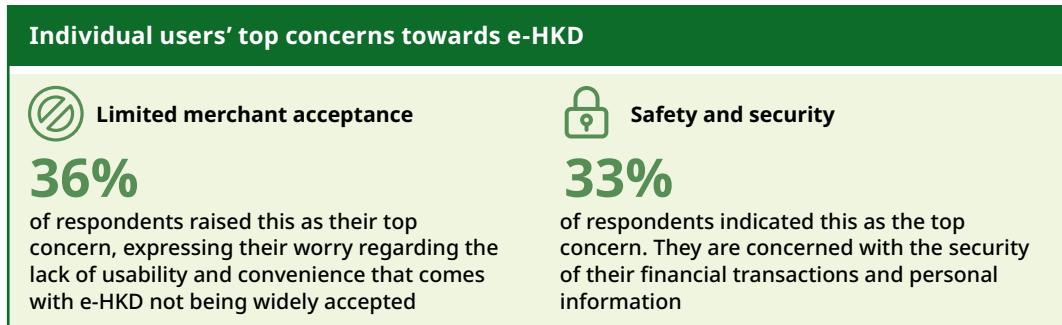
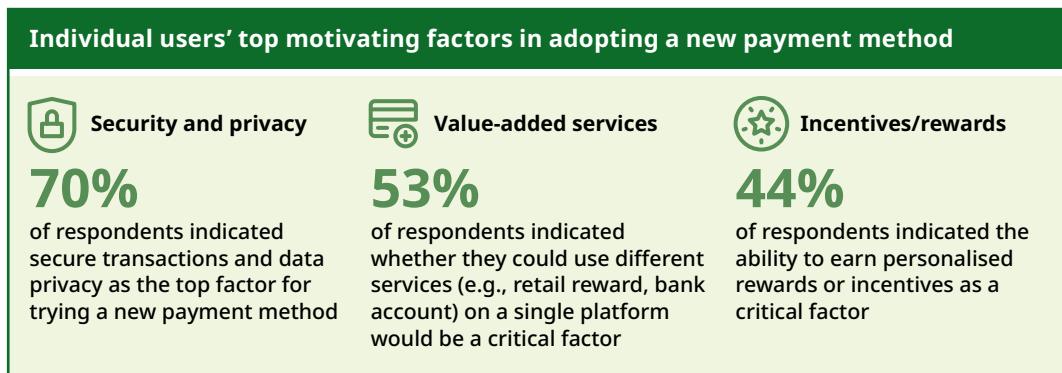
Using the hypothetical e-HKD e-wallet prototype (Hang Seng e-wallet), Hang Seng successfully completed four pilot tests involving 176 individual participants, together with seven merchants and one government organisation. A total of 1,296 transactions and transfers, including issuance of coupons from government organisation and merchants, as well as P2P transfers were performed during these pilots.

To garner valuable insights from the pilot, feedback from the participating individuals, merchants and government organisation were collected through survey and interviews. The results show a high level of satisfaction in processing e-HKD transactions. After trying the Hang Seng e-wallet, the participants also recognised traceability and programmability to be key strengths of e-HKD. Small merchants, in particular, have expressed enthusiasm in digitising their payment collection processes and streamlining their operations.



However, while the participants mostly welcome new payment options, they also acknowledged that Hong Kong has a generally mature payment ecosystem, and it will require more to convince users to adopt a new payment means.

Exploring the motivations in adopting a new payment method, a large proportion of survey respondents highly valued security and privacy, which we believe as the “basic requirement” for users to consider adopting a new payment method. When the “basic requirement” is met, users would further pay attention to value-added services and financial incentives which might ultimately convert their willingness to try into actual adoption.



Shall an e-HKD be implemented, for merchants and government organisations, low cost and user-friendliness were identified to be the two major enablers for their adoption.



“ We try to keep the operation simple and hence we would only be using 1-2 payment means with high operational speed and low fees. It will also help digitalise our operation for small businesses like us.

A food and beverage operator

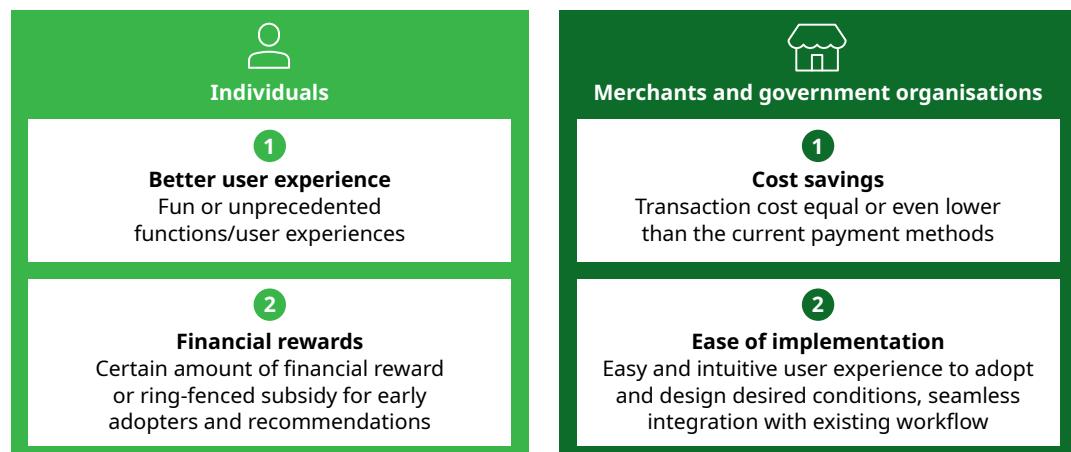
“ I think e-HKD is very suitable for large-scale subsidy programme (with 1k+ beneficiaries). It could help optimise and streamline the operational process, and thus cut time and cost. With e-HKD, we could potentially save 25% of the time used in payment approval and verification process...

A government organisation

In conclusion, to ensure that there is a meaningful uptake of an e-HKD if it is to be launched, the pilot feedback suggest that the following criteria have to be fulfilled for different end users.

- For individuals, better user experience is one of the key motivations. It means that future services enabled by e-HKD should be able to offer impressive or even unprecedented experiences to attract attention and usage. Additionally, to echo the survey results, certain level of financial reward or ring-fenced subsidy could also effectively incentivise rapid and widespread adoption.
- For merchants and government organisations, cost would be crucial for the decision on adoption. The transaction cost would likely be an important consideration for merchants, and an equal or lower transaction cost compared to existing payment methods may be necessary to drive adoption of an e-HKD. In addition, the e-HKD application and POS machines have to support easy and intuitive user experiences for both basic functionality (such as payment acceptance) and more advanced processes (such as condition programming). It is also ideally integrated with the existing workflows in merchants and government organisations to make adoption easier.

Exhibit 5: Essential criteria for end users to adopt an e-HKD



2.3 Reflection on enabling e-HKD's future success

To fulfil the aforementioned criteria, we have identified three key enablers that need to be in place for the design of an e-HKD.

1. Collaborative participation model

The involvement of intermediaries is key to facilitate the adoption of e-HKD if it launches, from use case design and customer outreach to customer education. Competition among intermediaries would drive customer-centric innovation and benefit end-users with improved services and lower prices. For example, intermediaries could provide additional benefits or rewards to customers when they pay with e-HKD. In light of this, it is essential to establish a participation model that provides fair opportunities for market participants to achieve commercial value, such as revenue uplift from new services and customers and operational cost optimisation through streamlined KYC processes.

2. Accessible and user-friendly programmability features

A key motivation from merchants and government organisations are the ease of implementation. This entails not only a user-friendly payment gateway infrastructure but also comprehensible and manageable programmability functions, ensuring that the cost and efforts required to adopt these functions are minimal and straightforward for small-and-medium-sized players. In other words, the programmability features should firstly be accessible, intuitive and easy to use from design perspective (e.g., providing a repository of smart contract templates for common business activities). Additionally, the infrastructure of programmability should consider proper governance and legal implications, such as potential disputes regarding the effectiveness of programmed payments.

3. An innovation-friendly platform

A flexible and agile platform is crucial for intermediaries to experiment with different use cases of e-HKD and create differentiated solutions. This lowers the threshold for intermediaries to innovate new service propositions and generate additional revenue streams. Eventually, this would benefit the end-users with better user experiences and potentially more financial incentives to drive adoption.

The results and findings mentioned above are derived from Hang Seng's e-HKD pilot, which has certain limitations. It is important to note that the pilot was conducted on a small scale and may undergo changes during full-scale implementation with a larger number of participants, integration with government or merchant systems, and a longer duration etc. Furthermore, the pilot setup does not represent the final design of e-HKD, should it be launched. Despite these considerations, the pilot findings remain valuable in identifying the key benefits and enablers of e-HKD, providing insights for the direction of the next phase of the e-HKD Pilot Programme.

3 From vision to operation

As an e-HKD is still in the pilot stage of evaluating its commercial viability, many design questions on the technology, legal and risk management framework, commercial business model are yet to be explored and researched, which are crucial factors in assessing the feasibility of launching an e-HKD.

With the three key enablers being identified from Hang Seng's experiences in HKMA's Phase 1 pilot, this section will primarily focus on the design considerations related to these enablers. It aims to provide insights into the technical aspects of an e-HKD rather than delving into the legal and risk management.

Specifically, this section will consider:

- **Participation models:** What intermediaries should participate in the hypothetical e-HKD ecosystem? What roles should they play (such as issuance, circulation, service provision)? How to ensure fair competition in the market to foster innovation?
- **Programmability setup and ownership:** Whether programmable payment or programmable money is more ideal for the launch of e-HKD? Who could be given the access to programmability? How should access to programmability features be managed?
- **Innovation-friendliness of e-HKD platform:** What features should be in place to encourage market participation and innovation?

In the following, we will review the potential design options and draw on the experiences in pilot programme to uncover the pros and cons of the designs.

3.1 Participation models

The HKMA has been looking into various participation models as part of its effort in Project e-HKD and in the collaboration with BIS Innovation Hub under Project Aurum and Project Sela. As the outcome of initial research, Project e-HKD proposed “two-tier architecture” due to its advantages in privacy-preserving transaction traceability and cross-ledger synchronisation of decoupled ledgers⁹.

The “two-tier architecture” consists of two layers: a wholesale system for the central banking institutions to issue and redeem CBDC, and a retail system for commercial banks to distribute and circulate either retail CBDC or CBDC-backed e-money. This is in contrast to a “single-layer architecture” where a central banking institution directly issues and distributes CBDC to end users.

This report will continue to assume “two-tier architecture” in considering the participation model. In addition to the benefits mentioned in Project e-HKD and Project Aurum reports, the pilot results have also demonstrated the importance of intermediary involvement in delivering the benefits of an e-HKD. Compared to the central banking institutions, the intermediaries, such as commercial banks and Stored Value Facilities (SVFs), are much closer to the end users during daily interactions. Therefore, the intermediaries could understand the end users’ latest pain points and therefore design targeted applications to enhance user experience.

Given the importance of intermediary involvement, three fundamental questions about the participation model have surfaced.

1. What role could the intermediaries play?
2. What kind of intermediaries may be allowed to play these roles?
3. How to incentivise participation and competition to drive innovation?

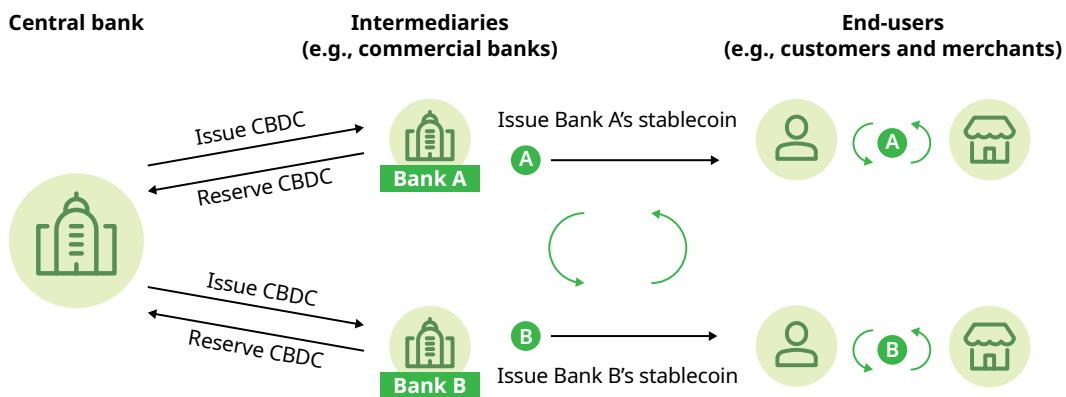
⁹ Hong Kong Monetary Authority, October 2021, *e-HKD: A Technical Perspective*.

Question 1: What role could the intermediaries play?

Based on Hang Seng's experience in Phase 1 of the pilot, there are three major roles¹⁰ that could be taken by the intermediaries as described below.

- **CBDC distribution and management:** At a minimum, intermediaries' role could be connecting individuals to the CBDC system, which is managed by the central banking institution. And, more extensively, the intermediaries could operate parts of the CBDC infrastructure. For example, Project e-HKD discussed a CBDC-backed e-money model¹¹ as one of the three potential "two-tier architecture" options. The intermediaries could issue CBDC-backed tokens for retail usage and, hence, need to operate the infrastructure for the token issuance. This would give issuing banks more incentives to drive innovation in the CBDC system and achieve commercial value by monetising from increasing transaction volume.

Exhibit 6: Illustrative relationship between central bank, intermediaries, and end-users in CBDC-backed e-money model



- **Wallet and payment services:** This role is to provide customer-facing services include user interfaces, value-added functionality, customer support, merchant services, payment gateways, and potentially other forms of programmability.
- **Account and transaction KYC:** This role is to ensure Anti-Money Laundering ("AML"), Counter-Financing of Terrorism ("CTF"), fraud and other compliance watchpoints are adequately checked and cleared for account opening and transaction processing. However, the substance of this role may vary extensively based on the design of CBDC infrastructure, especially whether a CBDC has anonymity and whether the infrastructure is distributed ledger technology (DLT) based. If a CBDC is not entirely anonymous and the infrastructure is built on blockchain, there is potential that only a few intermediaries have to do the KYC

¹⁰ In addition to the two types of roles, there may be other roles possible to be taken by intermediaries in a retail CBDC infrastructure while not extensively explored in the pilot.

¹¹ Hong Kong Monetary Authority, October 2021, *e-HKD: A Technical Perspective*.

checks and the results could be shared to other market participants without disclosing any other information. This could reduce duplicated efforts across entities and therefore save costs for the market as a whole.

Question 2: What kind of intermediaries may be allowed to play these roles?

Depending on the nature of the roles being permitted, the requirements on the participating intermediaries would also vary.

- **CBDC distribution and management:** Regardless of the extent of the CBDC distribution and management roles that intermediaries may be permitted to play, it will necessitate the participating players to possess sufficient technological, operational, and risk management capabilities, as well as to allocate appropriate resources. Using the CBDC-backed e-money model as an example, the infrastructure of issuing banks should be capable of connecting with the wholesale CBDC ledger and enabling efficient processing of potentially high-volume retail transactions at the same time. As such, only **intermediaries with the aforementioned capabilities and resources (such as large banking institutions)** should be allowed to play these roles, and proper governance on assessing, monitoring and reviewing these conditions would be essential.
- **Wallet and payment services:** This is the role with the biggest potential to drive innovation. **Not only should commercial banks be encouraged to play this role, but customer-facing FinTech companies such as SVFs should also be welcomed.** This would allow them to adapt their services to support the delivery of CBDC, foster healthy competition, and provide innovative solutions for the benefit of society as a whole.
- **Account and transaction KYC:** If a CBDC is not designed to provide full anonymity, all participating intermediaries would have KYC responsibilities, which is similar to the current banking and digital payment systems. Therefore, **only intermediaries that possess sufficient KYC and AML capabilities** could be considered in providing account management and transaction services. However, adopting blockchain technology for an e-HKD infrastructure could potentially streamline these efforts by enabling different entities to access and verify KYC data. Instead of each institution conducting independent KYC checks, they can rely on the verified data stored on the blockchain, reducing duplication of efforts. Additionally, under proper risk management governance, larger intermediaries with more established KYC capabilities and more extensive client data may be able to outsource these capabilities to other players. This could result in cost savings for the industry and create new source of revenue for the larger players.

Question 3: How to incentivise participation and competition to drive innovation?

Ultimately, the incentive of intermediaries' participation depends on the commercial value that could be generated from the potential e-HKD ecosystem, which usually lies in new revenue-generating business opportunities and cost savings.

- **New revenue-generating business opportunities:** It could come from new innovative propositions for certain customer segment and thus creating new revenue streams, such as charging merchants to use conditional reward functionality on transaction or subscription basis¹². More extensively, if the future e-HKD could facilitate transactions of virtual assets (e.g., virtual currencies or digital collectibles) or tokenised assets (e.g., tokenised bonds)¹³, the intermediaries may be able to provide related products and services to capture the unprecedented market demand, thus potentially charging end-users based on transaction volume or amount. Advanced intermediaries could even output their institutional capabilities to enable smaller players in pursuing e-HKD opportunities, such as account KYC. Intermediaries could potentially charge other intermediaries on a pay-per-use model.
- **Cost savings:** For example, it would be easier for banks and other wallet operators to trace the transactions and analyse the transaction patterns in order to capture fraud more accurately. The efforts required to reconcile information across multiple intermediaries would be significantly eliminated.

However, to enable such commercial value for intermediaries, the governance on data accessibility would be key, which defines the scope of data accessible and utilisable to the intermediaries. Expanding the data accessibility could empower intermediaries to pursue more innovative initiatives. However, this approach also raises concerns regarding data privacy and cybersecurity, which holds paramount significance for individual users to consider adoption (as mentioned in Section 2.2). Conversely, imposing strict limitations on data accessibility can safeguard data privacy but may hinder the commercial viability of e-HKD business for intermediaries as well as the investigation into potential fraud and other financial crimes.

Meanwhile, it should also be watched out for any exclusive data accessibility, which could become a "double-edged sword" for the entirety of the market. On one hand, it provides a competitive advantage to the data recipients, and thus fostering innovation; but on the other hand, it may exacerbate the disparity among market participants.

12 Although this implies additional cost for the merchants, the services would create additional value for merchants in attracting and serving the customers. Similar to the case of credit cards, the fees paid by merchants could potentially fund the operation of the reward programme as well as provide incentives to individuals for wider adoption.

13 Settlement of tokenised asset is one of the use cases in Phase 1 of e-HKD Pilot Programme, which explores use of tokenised real estate assets for granting a home equity line of credit as well as tokenisation of pledging rights to an asset. Hong Kong Monetary Authority, October 2023, *e-HKD Pilot Programme Phase 1 Report*.

3.2 Programmability setup and ownership

As mentioned in earlier sections, programmability is at the heart of the benefits brought by a potential e-HKD. However, the implementation of programmability still awaits two key design questions to be decided:

- Whether programmability is embedded in the payment or the digital money?
- What control mechanism is required to guardrail implementation of programmability in a large scale?

Question 1: Whether programmability is embedded in the payment or the digital money?

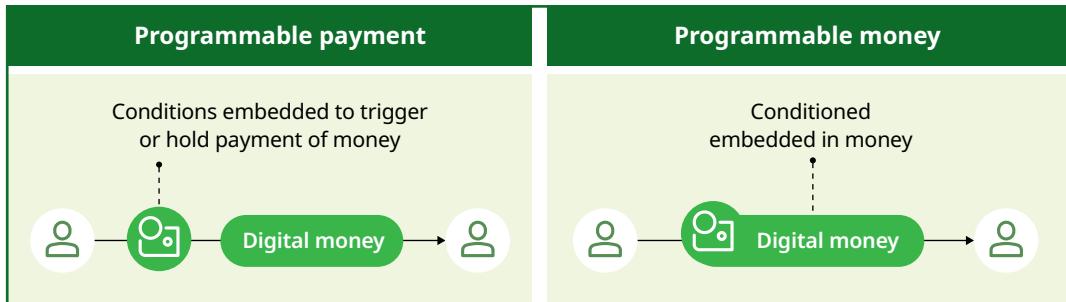
“Programmable money” is a concept where predefined conditions are embedded into the money regardless of who it is transferred to. In contrast, programmable payments could set conditions to trigger or hold the payment. But the transferred money still represents a form of value without restrictions on how the money can be spent after the payment. Individuals possessing the money have the freedom to utilise the money for any purpose desired. It is important to discuss and differentiate the two concepts as the nature of programmability can have implications on both operational aspects and policy considerations.

In Phase 1 of the e-HKD Pilot Programme, programmability is used as a key component in a number of use cases which could have much upside should an e-HKD be launched, such as loyalty programmes, retail escrow products, and fund investments with atomic settlement. It shows that programmable payments could already meet much of the rising demand for programmability without the need to push for programmable money.

The consideration of using programmable money mainly lies in the operational design and the issue of public perception. With programmability inherently built in, programmable money could enable conditional transactions irrespective of the transaction service providers, like digital wallets or intermediaries, reducing the complexity to implement programmability. But in the meantime, programmable money may cause concerns on the singleness of money, which refers to the concept of having a unified and consistent form of currency within an economic system. For instance, if an e-HKD is subject to restrictions on its usage or has an expiration date, it may be perceived as having less value compared to other forms of HKD, undermining its status as a universally accepted form of currency.

In light of these potential concerns, central banking institutions exploring retail CBDCs have shown to be more reserved about programmable money. For example, ECB stated that a digital euro will “never be a programmable money” that has limitations on where, when or to who people can pay with it. The HKMA has not yet made a policy decision on whether a potential e-HKD should be programmable and it would depend on a wide range of factors, such as the actual progress of the work under Rail 1 and Rail 2, and the pace of relevant market development, both local and international.

Exhibit 7: Programmable money and programmable payment



Question 2: What control mechanism is required to guardrail implementation of programmability in a large scale?

As mentioned in Section 1, one of the major benefits that an e-HKD could potentially bring is to empower the small-and-medium-sized and less tech-savvy institutions to enjoy the programmability and digitisation. As such, the implementation of programmability in a large scale would be one of the prerequisites. To assess the feasibility of potential large-scale implementation, the following aspects have to be carefully considered with a holistic consideration of protecting fair market competition, room for innovation, customer data protection, cybersecurity, etc.

- **Who could define the types of conditions that are allowed to be used?**
Should all of the wallet operators or only selected intermediaries define the eligible condition types? How can innovation and competition be continuously and consistently fostered? Who should bear the cost of development and operation fees?
- **Where would the programmability conditions be implemented?**
Should it be hosted in the CBDC infrastructure or implemented through APIs to the wallet operators? The considerations on network resources and transaction processing speed should be taken into account.
- **Who could access to the programmability functions?**
Do users (such as merchants and government organisations) need to fulfil certain requirements to implement the desired conditions in their transactions and money transfers? Do any intermediaries hold any responsibility to control or monitor the use of programmability in a CBDC infrastructure?

3.3 Innovation-friendliness of e-HKD platform

An innovation-friendly e-HKD platform is crucial for enabling market participants to explore new use cases and provide services to end-users. Factors such as security, ease of implementation, and interoperability with existing systems directly impact the number of participants and their willingness to engage with the e-HKD platform. Based on the pilot experiences, we have identified three key enablers which are particularly vital for private sector companies interested in serving as intermediaries or e-HKD service providers:

1. API and sandbox environment

APIs foster innovation by providing developers with easy access to e-HKD services, enabling them to build novel use cases. With a standardised interface for communication and controlled access, APIs play a crucial role in ensuring the security and flexible integration between the e-HKD platform and private sector infrastructure. Additionally, the sandbox environment serves as a vital testing environment for intermediaries to simulate use cases and continue innovating for e-HKD.

2. Interoperability standards

To ensure an open-loop system for e-HKD, the establishment of interoperability standards would be the key, such as message protocols, security protocols, and data standards. These standards enable seamless integration between different intermediaries and could potentially save the cost and effort of system development or connection in later stage. By adhering to interoperability standards, private sector participants can build on a common infrastructure while maintaining compatibility with other payment platforms. This promotes collaboration and facilitates the development of interconnected services, expanding the possibilities for end-users.

3. Use of private blockchains

In the pilot, Hang Seng e-wallet utilised DLT as the infrastructure, specifically employing a private blockchain. However, it should be noted that the use of DLT is not necessarily required to achieve programmability and the decision to use DLT or non-DLT technologies for e-HKD has not been finalised by the HKMA. Solely based on the pilot experience, if DLT and blockchain is used, a private blockchain is deemed more favourable than a public blockchain.

Public blockchains provide widespread adoption and a global infrastructure for peer-to-peer transactions, fostering innovation and ecosystem development. However, public blockchains face challenges in terms of accountability and governance due to their decentralised nature. Additionally, the absence of a well-defined service level agreement in public blockchains makes it difficult to ensure consistent performance and reliability. This lack of predefined expectations may not be suitable for a financial market infrastructure where clear service standards are essential for establishing trust and stability.

From the pilot, private blockchain networks appear to be a more suitable solution for the programmable e-HKD use cases. Private blockchains provide enhanced accountability and governance by explicitly defining the responsible entities for network operation. They also demonstrate superior scalability and performance compared to public blockchains. With smaller network sizes, private blockchains can process transactions faster, ensuring efficient performance even during high-demand periods. This reliability and predictability are vital for financial market infrastructure, where trust and stability are paramount.

By leveraging these enablers, the e-HKD platform, if it launches, could attract a diverse range of participants, including private sector companies, intermediaries, and FinTech players. This will foster innovation, drive the creation of new use cases, and ultimately enhance the overall user experience within an e-HKD ecosystem.

4

What's next for stakeholders?

The completion of Phase 1 of e-HKD Pilot Programme is not the end of the endeavour. Rather, it leads us to more systematic questions to be solved in the future. Looking forward to further exploratory studies, we would like to draw the market's attention to the following three areas:

- **Explore the technical design of e-HKD infrastructure to optimise future opportunities and risk management:** From the opportunity aspect, the design should consider encouraging innovation and maintaining healthy market competition. From risk management aspect, considerations around data privacy and cybersecurity should be rigorously laid out and assessed. Section 3 has set out several key components of the technical design, i.e., participation models, programmability setup and ownership, and the innovation-friendliness of e-HKD platform.
- **Define the position of e-HKD in Hong Kong's monetary and financial systems:** Apart from retail CBDCs, other forms of digital money are also emerging as potential solution to deliver the features of programmability, interoperability, etc. It requires careful consideration of potential digital money landscape in the future, i.e., among different types of digital money, what would be the role of e-HKD? Whether it will be one of the digital money options for payment and innovation, or more to support the issuance of other digital money (e.g. tokenised deposits, stablecoins) due to its central bank backing? What roles would different digital money play in Hong Kong's monetary and financial regulatory systems and how would they interoperate with conventional payment systems?
- **Explore the feasibility of the programmable payment use cases in large scale:** Despite the benefits identified in the Phase 1 Pilot, they are mostly substantiated in small-scale use cases. Hence, to validate the use case benefits in real life, further design, analysis and testing should be conducted. Meanwhile, the future study on e-HKD use cases presents a valuable opportunity to reassess businesses' long-established norms and processes, and address their non-technical inefficiencies related to payments.

Exhibit 8: Example questions to explore the feasibility of the programmable payment use cases in large scale

Purpose	USE CASE 1 Government grant disbursement	USE CASE 2 Merchant reward programme
To ensure user desirability for future adoption	 Government organisations <ul style="list-style-type: none"> • What additional functionalities should be embedded in the solution in order to create a better user experience (e.g., seamless integration with government workflow)? • If e-HKD system/application could be connected to the government system, how to ensure a secure integration to control cybersecurity risks?  Beneficiaries (recipient of the subsidies) <ul style="list-style-type: none"> • How to design an intuitive and streamlined customer journey for individual beneficiaries to receive subsidies? Do they need to download new applications or could receive the subsidy through existing applications? • If subsidy usage is to be tracked, who could monitor the usage and how to ensure data privacy? 	 Merchants <ul style="list-style-type: none"> • How to best integrate with merchant systems (e.g., point of sales, customer relationship management systems) for easy reward programme management? • What reward programme programmability would be desired by both large and small retailers, given some merchants may already have their own loyalty programmes? • What value-added services should be enabled in the solution in order to create a better user experience? (e.g., ability to view customer data and run some analytics)  Individual users (customers) <ul style="list-style-type: none"> • What incentives would be viable to the individual users to adopt e-HKD? • Who should provide the incentives to drive adoption?
To assess the feasibility of large-scale implementation	 <ul style="list-style-type: none"> • How to ensure a scalable system design to cater for the throughput of large-scale government grant disbursement? • How to ensure inclusion which all beneficiaries could receive the funds given some may be less tech-savvy? 	 <ul style="list-style-type: none"> • How to ensure a scalable system design to cater for the large throughput and diversified types of rewards being facilitated?

In conclusion, we have seen the potential of an e-HKD to revolutionise the retail payment landscape in Hong Kong by its uniquely combined features in programmability, traceability and interoperability. Leveraging these features, Hong Kong can empower its citizens and businesses with smarter, more seamless and more cost-effective payment solutions, which may also serve as reference for other advanced economies exploring retail CBDCs.

However, it is crucial for regulators and industry stakeholders to collaborate closely to further explore and validate the value of e-HKD in full-scale implementation. Through rigorous testing, validation, and ongoing dialogue, Hong Kong could become a global leader in the realm of retail CBDCs, fostering a vibrant and inclusive digital economy for the benefit of all.

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