WORLD ECONOMIC FORUM

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CBDC Policy-Maker Toolkit – Appendices

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This document is a supplement to the World Economic Forum *Central Bank Digital Currency Policy-Maker Toolkit*, published on 22 January 2020. All authors, contributors and acknowledgements listed in that report also pertain to this document.

Note: The research papers mentioned in these appendices are samples of top reports on various subjects related to central bank digital currency (CBDC). Additional suggested reading on this subject is listed on the World Economic Forum's curated research list. For brevity, reports appear only once although they may be relevant for multiple sections. Those published under the names of central banks are typically staff discussion and research papers and do not represent the views of the particular central bank.

Phase 1 – Preliminary analysis

Appendix to Section 1: Background assessment and project management

Case: Countries have taken different approaches to engaging the legislature and population when considering CBDC. Sveriges Riksbank's 2019 "Petition to the Riksdag: The state's role on the payment market" serves as an example of how central banks can formally engage parliament or the legislature in the decision. Here, CBDC is part of a broader question concerning the role of the state and the private sector in the future of payments markets, a review of the concept of legal tender and an investigation of CBDC as legal tender. Additional information related to the Riksbank's e-krona initiative can be found on its homepage and in the 2019 paper "The e-krona – now and for the future".

Research: Policy-makers may also benefit from reviewing the frameworks in the Center for Latin American Monetary Studies (CEMLA) 2019 policy report "Key Aspects around Central Bank Digital Currencies". Notably, the annexes within this report feature an array of questions and considerations for policy-makers in CBDC project management, evaluation and design. The Bank of Canada Staff Discussion Paper "A Policy Framework for E-Money" similarly discusses key questions policy-makers may need to consider when evaluating CBDC.

Additional recommended research for this section includes the following:

- Bank for International Settlements, "Impending arrival – a sequel to the survey on central bank digital currency" (2020)
- Bank for International Settlements, Lecture by Agustin Carstens, "Money in the digital age: what role for central banks?" (2018)
- Bank for International Settlements, "Proceeding with caution - a survey on central bank digital currency" (2019)
- Bank of Canada, "Central Bank Digital Currencies: A Framework For Assessing Why and How" (2016)
- Bank of Canada, "Should the Central Bank Issue E-money?" (2018)
- Bank of Canada, "Crypto 'Money': Perspective of a Couple of Canadian Central Bankers" (2019)
- World Economic Forum, "Central Banks and Distributed Ledger Technology: How Are Central Banks Exploring Blockchain Today?" (2019)

Appendix to Section 2: Problem identification and analysis

Discussion: The tables and notes below provide a summary of the top policy objectives that CBDC could help achieve, along with their associated risks and alternative solutions.

CBDC can address various policy goals. However, several risks to CBDC have been identified in policy and academic research. The following section provides a literature-based summary of the key opportunities or motivations for issuing CBDC, and the risk factors and downsides. Where potential benefits are identified, alternative solutions to reach the same outcomes are also discussed. Where probable risks are identified, select mitigating strategies are also outlined. The Appendix to Section 8 lists research reports relevant to CBDC with respect to macroeconomic and financial policies and issues.

As is the case throughout this document, the relevance and value of each issue in this section depend on the economy's unique conditions and context; policy-makers should closely consider the needs of their own economies. There may also be issues and opportunities beyond this list that policy-makers should consider.

- Wholesale CBDC is for specific financial institutions, such as commercial banks and clearing houses, primarily for use in domestic or cross-border interbank payments and settlements.
- Retail CBDC can be employed widely by the general public, merchants and other entities as a means of payment and potentially a store of value in the manner of cash, bank deposits or other forms of digital payments.

Policy objective: Payment system safety and resilience

- Wholesale CBDC may provide benefits to cross-border payment system safety and resilience, although it is unclear if it would provide benefits above and beyond those already available today. Retail CBDC may also provide safety and resilience benefits, although the apparent risks may outweigh the benefits. An analysis of country-specific conditions is critical to evaluate the potential for CBDC to improve domestic payment system safety and resilience.

Wholesale CBDC	Retail CBDC
Potential benefit – Wholesale CBDC for cross-border interbank payments and securities transactions with fewer intermediaries, counterparties and process dependencies could reduce risks and vulnerabilities. For instance, more direct cross-border interbank security transactions can reduce cross-currency settlement risk (Herstatt risk). It can also mitigate cybersecurity risks associated with existing global messaging networks, such as were seen in the 2016 cyberattack involving the Bangladesh Bank and Federal Reserve Bank of New York in which fraudulent SWIFT messages allowed more than $1 billion to be stolen from the Bangladesh Bank's account.	*Potential benefit* – Retail CBDC could provide diversification in payment "rails", supporting safety and resilience in terms of an alternative or contingency retail payment system.
Key consideration – In a broader context, it is not fully evident why the introduction of a wholesale CBDC would necessarily improve safety and resilience in the interbank payment system above and beyond the cybersecurity, anti-fraud, system and data redundancy, and other risk reduction measures central banks can already take today.	*Key considerations* – **Retail CBDC may introduce more security and safety risk than it addresses, depending on the country's context and technology implementation.** Compared to physical cash, counterfeiting, theft and network failure risks for digital money entail more catastrophic consequences. If a retail CBDC payment network is widely used, a system failure could cause substantial interruptions to the economy. Moreover, retail CBDC accounts could be a significant target for theft and terrorism. – **Policy-makers must strongly consider security risks introduced by retail CBDC and invest heavily in cybersecurity and system resilience.**

Policy objective: Payment system efficiency

– Wholesale and retail CBDC can both potentially increase speed and reduce costs in the payments system, particularly in cross-border payments, by reducing the roles of intermediaries and developing fit-for-purpose implementations with new technologies.

Wholesale CBDC	Retail CBDC
Potential benefits – **A domestic wholesale CBDC would in most instances operate in the same manner as today's interbank transfer systems in which the central bank clears and settles interbank payments using commercial bank reserves.** To the extent that a country struggles to achieve an efficient and effective domestic interbank payment system, a CBDC-based system, depending on implementation, could provide a solution. – **CBDC can potentially improve efficiency in wholesale cross-border payments and transactions**, including both standard interbank payments and securities, derivatives and other financial transactions. Interbank payments can potentially avoid somewhat slow, expensive and opaque processes related to today's most common SWIFT messaging practices, correspondent banking, legacy infrastructure, intermediary operating hours or cut-off times, and other processes.	*Potential benefits* – **A cross-border retail CBDC can potentially provide efficiency in terms of speed and cost reductions for citizens.** As with wholesale cross-border CBDC, the central bank would need to allow foreign entities and citizens to operate with the CBDC, and any frictions related to currency exchange would still exist. – Retail CBDC could provide alternative payment "rails", which could provide opportunities for efficiency gains in domestic or cross-border retail payments.
Key consideration – **Potential frictions related to common payment data standards and foreign exchange remain with or without CBDC.** Central banks could consider taking action to address such frictions that can be tackled without introducing CBDC (given its risks), such as by extending central bank and processor operating hours and establishing clear data messaging standards and governance.	*Key considerations* – **The value proposition of domestic retail CBDC is unclear where an efficient system exists.** Retail CBDC may not add efficiency if an economy already has a "fast payments" system supporting real-time and around-the-clock domestic retail payment settlements. Note that a CBDC could potentially be employed in a fast payments system, although it is certainly not required, or as an alternative to such a system. – A retail CBDC may not add efficiency if an economy already has effective and efficient private payment service providers (PSPs).

Policy objective: Payment system access and competitiveness

– Retail CBDC can potentially provide greater access to the country's legal tender and an efficient means of payment. It can also encourage competitiveness in retail payments.

Retail CBDC
Potential benefits – **Retail CBDC can serve as a counterweight to the monopoly power of PSPs**, increasing competition in the payments market and providing a public option for payment services that can help ensure both access and stability. – **CBDC may also serve as a counterweight to the declining use of cash in economies where cash usage is dwindling due to the rise of digital payments.** In this context, citizen access to central bank money is constrained, while a CBDC can ensure continued access. Central banks should consider the risks associated with the declining use and presence of cash, including dependence on banks and PSPs. They can consider potential methods to mitigate risks including but not limited to CBDC.
Alternative solutions – Alternative solutions to issuing CBDC for mitigating PSP market power include the regulation of PSPs and/or privately issued "hybrid CBDC".

Policy objective: Financial system stability

– CBDC may provide financial system stability, although it could also create noteworthy risks.

Retail CBDC

Potential benefits

– **Retail CBDC accounts can provide a safe-haven public option for savings** with a lower risk of default than storing savings with commercial banks.
– **Retail CBDC can also challenge commercial bank market power over retail deposits**, pressuring banks to increase interest rates and offer better financial services to depositors.

Alternative solution

– Deposit insurance can provide commercial bank customers with security in times of crisis, reducing the need for CBDC to play the role of a safe-haven public savings option.

Key considerations

– **Retail CBDC may generate substantial bank disintermediation risk**, where CBDC accounts "crowd out" bank deposits, leading to reduced bank funding. As a result, banks would likely reduce total lending activity. CBDC accounts competing with commercial bank deposits could lead commercial banks to increase deposit rates, shrinking deposit margins and bank profitability.
– **CBDC may introduce substantial digital-bank-run risk** as citizens may rapidly convert commercial bank deposits to CBDC, which offers the security of central bank money and custody.

Risk mitigating strategies

Strategies that can mitigate disintermediation and digital-bank-run risk include:

– Limits or caps on how much or how quickly users can convert funds into CBDC
– Limits on the maximum amount users can hold in CBDC accounts
– Adjustable or tiered interest rates on CBDC (potentially including negative interest rates), or adjustable conversion rates from deposits into CBDC, perhaps during crises or according to account size
– A two-tiered custody structure in which commercial banks have custody of CBDC on behalf of users, which may reduce user incentives for switching from bank deposits to CBDC in flight-to-safety situations.

Policy objective: Improvement in monetary policy transmission and effectiveness

– CBDC can potentially improve monetary policy transmission and effectiveness via three avenues.

Retail CBDC

Potential benefits

– **CBDC can potentially improve monetary policy transmission and effectiveness**, depending on interest rate policies, in three ways:
  – **Transmission of interest rate policies** - Interest-bearing CBDC can enable a direct mechanism for policy rate changes to impact households and firms.
  – **Breaking through the effective lower bound** - If retail CBDC offers negative interest rates and cash alternatives are weak, the central bank could potentially break through the current effective lower bound (the level of the policy rate below which further monetary policy accommodation becomes counterproductive).
  – **Helicopter drops of money to households** - It could be easier to provide subsidies or "helicopter drops" of funding (where the monetary authority directly transfers money) to households holding retail CBDC accounts.
– **CBDC can potentially support the continued use of the domestic currency** if *de facto* dollarization or competition from other currencies, including digital currencies, stablecoins, cryptocurrencies or foreign-country CBDC, emerges.

Key considerations

– Researchers have generally not expressed high conviction in the efficacy or value of these channels; implementing CBDC for monetary policy objectives alone may not be valuable. Researchers have also raised questions related to the legitimacy of implementing such policy tools as "helicopter drops", which may belong in the realm of fiscal policy.
– Political and social resistance, especially to breaking the zero lower bound on interest rates, needs to be carefully considered.
– Banknotes, particularly large-denomination bills, would need to be discontinued to enable breaking through the effective lower bound.
– "Helicopter drops" may require each eligible citizen to hold a CBDC account.

Alternative solutions

– Existing policy alternatives, such as tax rebates and other policies for subsidizing households today, should be considered and compared to assess the relative attractiveness of CBDC.

Other public policy objectives CBDC may support:

- **Benefits related to cash management**
  - CBDC can facilitate easier currency redenomination, as it could likely be immediately adjusted to the new redenominated unit of account.
  - Relative to physical cash, CBDC reduces costs, frictions and risks associated with the storage, transportation, management and distribution of the means of payment.
  - For dollarized economies or those that use a foreign currency in parallel with or instead of the domestic sovereign currency, CBDC could be beneficial in providing a low-denomination currency for citizens.
- **Potential to reduce tax evasion, corruption, money laundering and illicit activities** (Retail CBDC)
  - The adoption of CBDC combined with the abolition of cash (particularly large-denomination bills) would reduce the possibility of executing unreported and untraceable transactions, potentially reducing tax evasion, corruption, money laundering and illicit activities and their associated financial and welfare costs.
- **Improved data transmission and reporting to central banks**
  - Depending on the scheme, CBDC could provide greater real-time data tracking to central banks and other policy-makers. Better real-time data and reporting can reduce information asymmetries between financial institutions and regulators, enabling greater visibility for regulators and central banks. It can also inform an understanding of financial system health, inflation, the circulation of money, retail payment flows and patterns, and other trends. It may also reduce tax information asymmetries and allow for a more efficient tax system and public transfers. Notably, user data privacy must be considered with respect to retail CBDC.
- **Financial inclusion** (Retail CBDC)
  - CBDC can potentially become a gateway and improve incentives to participate in the banking sector.
  - There is potential to distribute CBDC directly to retail end users. Central banks may issue electronic wallets held on mobile devices in which citizens can hold CBDC. Know-your-customer (KYC) capabilities and user identification documents may be required.
  - Financial exclusion risks: While CBDC has the potential to support financial inclusion, it can also increase exclusion. Policy-makers must encourage unbanked populations to participate in any new CBDC regime and must be aware of the hurdles to adoption, such as usability challenges, access, costs and requisite identification documents. Populations that do not adopt CBDC may be further marginalized from the digital payment ecosystem.
- **Seigniorage**
  - The most likely effect of CBDC on seigniorage (the profit made by governments by issuing currency) is neutral or positive, as creating CBDC provides the same potential for seigniorage as cash. Seigniorage may improve if the CBDC system is cheaper to maintain than the cost of producing and maintaining cash. CBDC may also help keep seigniorage levels steady relative to the possible loss that could occur if users start using digital payment providers with low reserve ratios in place of the sovereign currency.

Special considerations for retail CBDC: Additional risks and downsides

- Capital control operations and/or implementation may be affected by a CBDC.
- Relative to physical cash, the concentration of financial transaction data introduces noteworthy consumer data privacy and protection risks.
- Relative to physical cash, CBDC introduces increased exposure and vulnerability to cybersecurity risk and to power outages as it depends on the use of the internet whereas cash can be used anytime and anywhere. Substantial cybersecurity investment will be needed.
- CBDC might introduce the potential for governments to more easily appropriate citizen funds (“bail-in risk”).
- The issuing central bank may suffer reputational damage if a CBDC fails or does not fulfil its objectives.
- CBDC entails high operational risks and costs related to customer interfacing, data management, wallet management and security.
- Consideration should be given to whether there is incremental risk of a speculative currency attack on CBDC relative to the existing monetary system.
- CBDC is a relatively new concept so it might introduce unknown risks.

Phase 2 – Initial evaluation

Appendix to Section 3: CBDC form

Research: The following papers can provide valuable information related to CBDC form:

- Bank for International Settlements, Committee on Payments and Market Infrastructures, "Central bank digital currencies" (2018)
- Bank for International Settlements, Committee on Payments and Market Infrastructures, "Wholesale digital tokens" (2019)
- Bank for International Settlements, Quarterly Review, "Central bank cryptocurrencies" (2017)
- International Monetary Fund, "Casting Light on Central Bank Digital Currencies" (2018)

Appendix to Section 4: Digital payments ecosystem and landscape evaluation

Research: The following papers relate to the digital payments ecosystem and landscape:

- G7 Working Group on Stablecoins, "Investigating the impact of global stablecoins" (2019)
- Bank of France, "Monetary Policy and Digital Currencies: Much Ado about Nothing?" (2017)
- Bank for International Settlements, Committee on Payments and Market Infrastructures, "Fast payments – Enhancing the speed and availability of retail payments" (2016)
- Bank for International Settlements, Quarterly Review, "Regulating cryptocurrencies: assessing market reactions" (2018)
- Eichengreen, Barry, "From Commodity to Fiat and Now to Crypto" (2019)
- European Central Bank, "In search for stability in crypto-assets: are stablecoins the solution?" (2019)
- European Central Bank, "Innovation and its impact on the European retail payment landscape" (2019)
- European Central Bank, Crypto-Assets Task Force, "Crypto-Assets: Implications for financial stability, monetary policy, and payments and market infrastructures" (2019)

Discussion:

Domestic or overseas payment service providers

- Examples: Alipay and WeChat in China, Swish in Sweden, Paytm in India, M-Pesa in Kenya, Bitt.com in the Caribbean, Venmo in the US

Payment service providers (PSPs) facilitate peer-to-peer payments within a mobile application, and some also allow for point of sale payments to merchants, often using scannable QR codes as means to update account balances held in a digital wallet. These wallets can be connected to a commercial bank account, but connection to a bank account is not always required. As such, PSP services are particularly popular in regions where a high percentage of the population does not have access to traditional banking services or where trust in financial institutions is low. Users and merchants are incentivized to keep transactions within the PSPs' ecosystem since there are no transaction fees to transfer value within the application and settling external transactions may incur fees. In some cases, PSPs heavily incentivize merchants to integrate with their services. In China, merchants are known to sometimes refuse to take cash or alternative forms of payment. The vast network of merchants that PSPs such as Alipay and WeChat in China have created leads users to rarely need to cash out of the system. As a result, these systems tend to rely on deferred settlement, backstopped by private institutions, raising potential concerns about financial stability depending on the context. The implications can be wide-reaching for PSPs with vast scale. PSPs may tend towards monopolies given inherent network effects, the high costs of entry and their access to unique user data.

Fast payment systems with same-day settlement

- Examples: BiR in Sweden, FPS in the UK, FAST in Singapore, CD/ATM system in South Korea, IBPS in China, IMPS in India, TIPS and RT1 in Europe, FedNow Service in the US (under development)

As PSPs gain traction, consumers and merchants have come to expect seemingly instant digital payments. While these payments appear to be instantaneous, in many cases, as expressed by the U.S. Federal Reserve's Board Governor Lael Brainard, payments "currently rely on a patchwork of systems that can result in inefficiencies and delays, as well as uneven access". Fast payment systems are created by the central bank or other public institutions and support retail payments that are settled and available to payees nearly instantaneously and on a near 24/7/365 basis. According to a 2016 report by the Bank for International Settlements, some traditional banking infrastructures are not currently equipped to handle real-time retail payment settlement and traditional banking infrastructures may need to be upgraded to support fast payments.

Globally available crypto-assets

- Examples: bitcoin (BTC), ether (ETH)

While there is no universally agreed upon definition of a cryptocurrency, which can also be referred to by the broader term "crypto-assets", common characteristics include that they are digital, permissionless (anybody can participate in transactions or transaction verification in the network) and pseudonymous (KYC and customer identification is not native within the system but could be implemented in specific applications, and transactions are often traceable to public addresses). The European Central Bank's Crypto-Assets Task Force refrains from referring to these assets as currencies in part because they do not represent a claim on an issuer and because their volatility inhibits their use as a store of value, discourages their use as a medium of exchange, and makes it difficult to use them as a unit of account. The value of these crypto-assets is not tied to a real word asset or derived intrinsically, but instead fluctuates in response to demand, which is currently heavily driven by speculators. Given the speculative nature of these assets, investors may be exposed to potentially large losses.

"Stablecoins"

– Examples: CENTRE Foundation's USDC, Tether, Libra token, MakerDAO's Dai

Stablecoins are crypto-assets that utilize different stability mechanisms to minimize price fluctuations. This stability can be achieved via reserves composed of off-chain or on-chain collateral, or via algorithmic adjustments of supply. Off-chain collateral most commonly consists of funds or other assets held by an issuer or custodian. Funds could include fiat currencies, traditional bonds or other assets. CENTRE's USDC, Tether and the Libra token are all examples of off-chain collateralized stablecoins. On-chain collateral most commonly consists of crypto-assets or other assets that can be recorded on a blockchain ledger. MakerDAO's Dai is an example of an on-chain collateralized stablecoin. Stablecoins that rely on algorithmic adjustments of supply are generally untested and may require further research and development.

CENTRE, founded by Circle and Coinbase, has created an open-source framework for the development of asset-backed, fully collateralized stablecoins. It has created a fully off-chain collateralized US dollar stablecoin called USD Coin (USDC). The reserves backing USD Coin are held with regulated financial institutions and audited to provide transparency. USDC has a decentralized, membership-based governing body and is one of the most widely used stablecoins.

Tether is another stablecoin, issued by Tether Operations Limited and meant to be backed 100% by off-chain collateral. Tether has been subject to controversy regarding the lack of transparency around reserve audits. The controversy surrounding Tether illustrates the importance of regular audits, transparency and effective governance in the issuance and maintenance of stablecoins.

The Libra Association is an independent, non-profit membership organization founded by Facebook, Inc. and headquartered in Geneva, Switzerland. The Libra Association's mission is to create a lower cost, more accessible and inclusive retail payment tool built on the Libra blockchain. In June 2019, the Association announced the development of a new stablecoin called the Libra token, which plans to be collateralized off-chain by a basket of developed country sovereign currencies and short-term investment securities. Libra was initially scheduled for a 2020 launch and will be supported by the Calibra wallet, which integrates with Facebook Messenger and WhatsApp. The Calibra company is a subsidiary of Facebook, Inc. and operates independently from Facebook. The Libra token can also be employed within other wallets developed around the world.

Dai is a stablecoin issued by MakerDAO and backed by crypto-assets. MakerDAO requires over-collateralization in order to account for the risk inherent in the anonymous borrowing it supports. To create Dai, users deposit a minimum of 1.5 times the equivalent amount of ether to MakerDAO's smart contract as collateral. The collateral remains locked up in MakerDAO's smart contract until a user closes this "collateralized debt position" (now referred to as a "vault".) MakerDAO token holders (MKR) determine the "stability fee", or interest rate, which is required to be paid back in full upon redemption. This rate has fluctuated widely (0.5% to 20.5% within one year), given its use as a mechanism to control supply and demand, adjusting for the volatility of ether. The peg to $1 has historically held roughly in place despite an approximately 90% decline in the price of ether, although this has historically required up to 2% of the total supply of ether to be locked up as collateral in the process. MakerDAO recently launched multi-collateral Dai, allowing for other crypto-assets or tokenized assets to serve as collateral. The launch of multi-collateral Dai will include the introduction of the Dai Savings Rate, which is a mechanism by which Dai will accrue interest. Dai is most widely used within the emerging decentralized finance (DeFi) ecosystem built on top of the Ethereum network. Dai is not backed by fiat reserves, and the underlying collateral of crypto-assets is subject to a high degree of volatility.

The regulation and classification of stablecoins are even less clear than those of crypto-assets, given their relative nascence and their potential impact on global monetary systems. Developments are progressing rapidly as regulators around the world grapple with the best ways to ensure stablecoins meet the highest regulatory standards. In its 2019 stablecoins report, the G7 stated that "no global stablecoin project should begin operation until the legal, regulatory and oversight challenges and risks outlined [in the report] are adequately addressed, through appropriate designs and by adhering to regulation that is clear and proportionate to the risks".

Foreign-country issued CBDC

CBDC issued by other countries may possibly influence the domestic payment environment, depending on country dynamics. Representatives from the People's Bank of China (PBoC) have stated that the institution is nearing deployment of its Digital Currency/Electronic Payment (DC/EP) CBDC. The DC/EP is intended to serve as a traceable substitute to M0, the physical cash in circulation. As reported by Bloomberg Businessweek, patents filed by the PBoC indicate that the currency would be accessible via a mobile wallet that would allow users to swap their yuan for the DC/EP, which could then be used to make and receive payments.

Collaboratively developed distributed ledger technology-driven interbank payment systems

– Example: Utility Settlement Coin (USC)

More than a dozen commercial banks and financial institutions have formed a consortium backing blockchain start-up Fnality to issue the Utility Settlement Coin (USC). The USC would be a digital representation of existing currencies (potentially the US dollar, euro, British pound, Japanese yen and Canadian dollar), held with full fiat currency reserve backing at the respective central banks, to be used to settle cross-border interbank payments. USC could be considered a potential alternative to wholesale cross-border CBDC in addressing issues related to cross-border wholesale payment efficiency. The Fnality platform aims to be interoperable with blockchain and legacy systems, provide faster settlement times and reduce settlement risk in cross-border wholesale financial transactions.

Additional digital assets designed for inter- or intrabank payments and settlements
– Examples: JPM Coin, XRP

JPM Coin and XRP are additional digital assets, like USC, that are designed to facilitate more efficient and rapid cross-border interbank payments. Like USC, they can be seen as alternatives to wholesale cross-border CBDC in attaining these goals.

JPM Coin is considered a stablecoin, keeping a steady value from full reserve backing and 1:1 redeemability in fiat currency, namely US dollars, held within J.P.Morgan accounts (off-chain collateral). The JPM Coin system is currently being piloted for use internally at J.P.Morgan with the goal of facilitating faster interbank transfer and settlement between businesses and institutions while benefiting from J.P.Morgan's balance sheet, security, controls and compliance, and regulatory oversight. JPM Coin is compatible with J.P.Morgan's Quorum blockchain and is currently accessible to select institutional clients only.

Ripple is a blockchain start-up that was founded in 2012 and that operates RippleNet that utilizes the crypto-asset XRP as a bridge currency. On RippleNet, customers can, but do not need to, use XRP to source liquidity in cross-border interbank transactions to increase transaction efficiency. XRP is not a stablecoin and its price fluctuates according to demand.

Innovations in market infrastructure providers
– Examples: SWIFT gpi initiative

SWIFT (the Society for Worldwide Interbank Financial Telecommunication) has been innovating with new systems to address the demand for more efficient cross-border interbank payments. SWIFT is a global messaging system used by banks and other financial institutions to securely send and receive information, such as wire transfer instructions. At each point in cross-border transfers that occur with SWIFT today, correspondent banks within the system typically take a fee and foreign-exchange margin and the client may not be able to choose the optimal payment path. There is generally low transparency as to where the payment is within the system and it may be blocked at certain points as correspondent banks span differing regulatory regimes. The SWIFT gpi initiative aims to dramatically improve the existing process across correspondent banking networks by enabling the same-day use of funds, tracking payment routes among parties, increasing the transparency of fees, and creating end-to-end tracking of cross-border wire transfers.

Discussion on trends and the future of digital payments
FinTech, both the incorporation of technology into traditional financial institutions and the introduction of financial products by new or traditional technology companies, can be said to be transforming the banking industry. FinTech companies are increasing competition within banking and payments services as they often bring agile, customer-centric solutions to market. Simultaneously, "Big Tech" companies are expanding their product sets to include financial products as they look to diversify their business models and either gain access to more valuable payments data or leverage the vast amounts of data they already possess.

FinTech payment innovation can be separated into two main categories. The first encompasses solutions aimed at improving existing payment infrastructure, but that are still subject to the existing limitations of legacy structures and systems (such as correspondent banking, licences, etc.). The second type of FinTech payment innovation is based on new payment "rails", reducing legacy limitations.

Appendix to Section 5: "Hybrid CBDC" evaluation

Discussion: Increasingly, PSPs and other forms of payment providers play an important role in the digital economy. Stablecoins may also play an important role in the future if their adoption is high. "Hybrid CBDC" is an alternative approach to CBDC and regulation to control risks associated with the large-scale growth of these platforms. Enabling these private payment providers to hold reserve accounts at the central bank could provide stronger oversight and protections on user funds. Put otherwise, it may effectively lead providers to be more akin to "narrow banks" than to "shadow banks" operating outside the realm of traditional banking regulations.

Source: Provided by Tobias Adrian and Tommaso Mancini-Griffoli, 2019

In a "hybrid CBDC" scheme, central banks provide licences to payment providers to hold central bank reserves with strict conditions, such as those related to data security, interoperability, monitoring, KYC/anti-money laundering (AML)/countering the financing of terrorism (CFT) compliance, and other issues. They may also set varying "reserve requirements" to providers, whether 100% or a different requirement.

The exact design of a country's "hybrid CBDC" system would be determined on a case-by-case basis. According to the International Monetary Fund's lead authors on the subject, Tobias Adrian and Tommaso Mancini-Griffoli, a common principle is creating a legal structure that ensures client funds are "bankruptcy-remote", or secure from other creditors in the case of payment issuer default. This may be achieved in multiple manners, potentially including a trust or escrow account.

A "hybrid CBDC" construct could provide a low-disruption and rapid way to implement a quasi-form of (privately issued) retail CBDC to the public. Policy-makers and citizens can achieve some of the same advantages and objectives as retail CBDC, with a likely faster development time and the potentially more direct ability to support payment system stability.

"Hybrid CBDC" is a very new concept, with important design, risk management and governance questions yet to be answered. That said, it has quickly become a prominent

consideration for policy-makers seeking alternatives to CBDC that may be faster to implement while achieving other policy goals, such as safeguards applied to systemically important domestic payment providers.

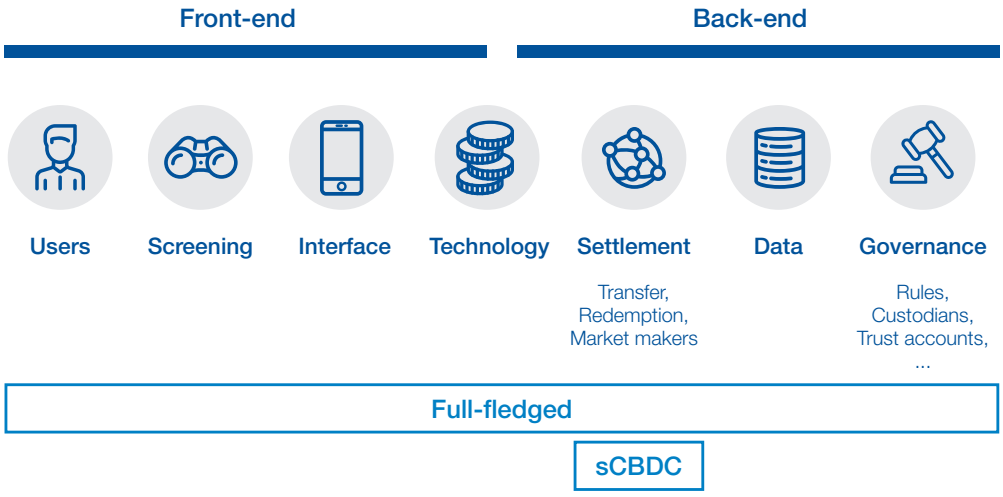
For digital payment providers, a "hybrid CBDC" could allow technology innovators the opportunity for payment innovation and for providing compelling end-user services to consumers, as expressed by Adrian and Mancini-Griffoli in the 2019 blog post, "From Stablecoins to Central Bank Digital Currencies". Moreover, central banks, such as the Reserve Bank of India, the Hong Kong Monetary Authority, the Swiss National Bank and the Central Bank of Brazil, currently allow non-bank FinTech firms to hold reserve balances, subject to an approval process. The Bank of England is discussing similar prospects, while the PBoC already requires Alipay and WeChat to house reserves at the central bank. Policy-makers may seek to study and learn from these examples.

From a citizen's perspective, the e-money they employ from the payment provider has greater safety from custody with the central bank and legal protections in the case of default. A country could have multiple "hybrid CBDCs" if suitable, allowing for private-sector competition and consumer choice. Importantly, "hybrid CBDC" is always a liability of the provider and not the central bank, and thus users do not receive the same degree of backing as they would with CBDC.

At the most basic level, a candidate for a good "hybrid CBDC" provider could be a form of e-money or digital currency created and issued within the country and with the potential for high adoption or an existing wide customer base within the country. To the extent that a stablecoin provides a stable store of value and efficient means of payment, enjoys wide adoption and concentration in the country, and stores its reserves in-country, it could be a suitable "hybrid CBDC".

The payment provider performs the tasks in line with its core competencies, namely technological innovation, customer screening and due diligence, user interface and experience, software development and integration, customer service, potentially digital currency wallet creation, cybersecurity and customer data management. It likely continues to assume operational and other risks. Meanwhile, the central bank focuses on its core competencies, such as transaction settlement. It also creates related regulatory frameworks, such as technological standards that can enhance interoperability for payment providers at both the application and the transaction settlement layers and increase payment sector competition.

The chart below shows one model where the central bank performs settlement functions related to the "hybrid CBDC" while the payment provider performs the other requisite functions. "Synthetic CBDC" (sCBDC) is another name for "hybrid CBDC".



sCBDC: synthetic CBDC
Source: Provided by Tobias Adrian and Tommaso Mancini-Griffoli, 2019

Regulatory and policy gaps remain with "hybrid CBDC". The following issues, among others, must be addressed:

- Examination of monetary impacts associated with the "hybrid CBDC", including with respect to effects on seigniorage and commercial banks that would compete for deposits with the new "hybrid CBDC"; the need for strong policies to ensure financial stability for commercial banks
- Clear guidelines to "hybrid CBDC" issuers as they develop their governance structures and technology implementations
- The need for strong regulatory and compliance policies; extra care from regulators in emerging economies to ensure all participants have strong cybersecurity and KYC/AML/CFT compliance systems
- The need to specify reserve policies and legal structures and protections for user funds in case of issuer bankruptcy, such as first *liens* or claims on reserves and other issuer assets in the event of issuer bankruptcy.

Appendix to Section 6: Operational risks and financial inclusion in retail CBDC

Research: Research, in the papers listed below among others, conveys the value of cash for financial inclusion and maintaining competitiveness in the payments and banking sectors:

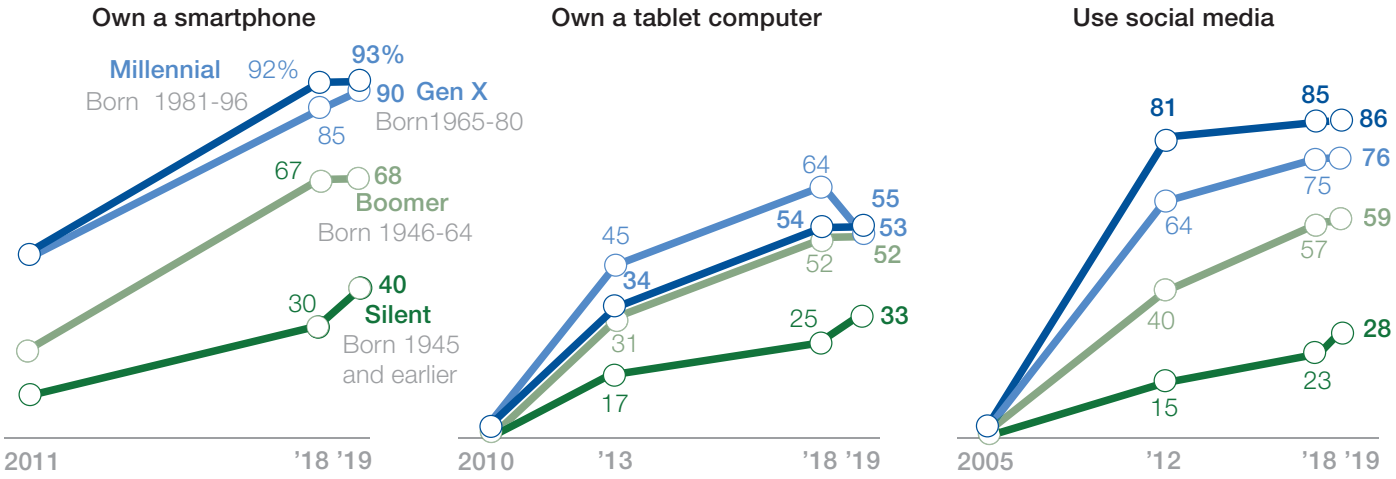
- Alvarez, Fernando and David Argente, "Consumer Surplus of Alternative Payment Methods: Paying Uber with Cash" (2019)
- Brunnermeier, Markus and Dirk Niepelt, "On the Equivalence of Private and Public Money" (2019)
- Lagos, Ricardo and Shengxing Zhang, "On Money as a Medium of Exchange in Near-Cashless Credit Economies" (2019)

Discussion:

Technology adoption by demographics and implications for financial inclusion
While technology adoption is increasing among older populations in the US, the gap between younger generations and older generations' use of technology is still wide. According to a study from the Pew Research Center conducted in 2019, about one-third of US adults 65 and older say they never use the internet while 60% of this demographic does not own a smartphone. This compares to almost no millennials who report not using the internet and 7% who do not own a smartphone. These noteworthy demographic differences could have important implications for financial inclusion and should be considered when evaluating or deploying CBDC.

Millennials lead on some technology adoption measures, but Boomers and Gen Xers are also heavy adopters

% of U.S. adults in each generation who say they ...



Notes: Those who did not give an answer are not shown; survey conducted between 8 January and 7 February 2019.
Source: Vogels, Emily, "Millennials stand out for their technology use, but older generations also embrace digital life", Pew Research Center, 9 September 2019

Appendix to Section 7: Data protections and compliance for retail CBDC

Research: The European System of Central Banks' "Exploring anonymity in central bank digital currencies" is one of the most detailed reports published to date discussing and developing a proof-of-concept (PoC) for a CBDC that provides privacy to users according to various transaction size thresholds. It may serve as a model to policy-makers considering anonymity within CBDC.

Discussion:

Transaction privacy and confidentiality in CBDC
With modern cryptography techniques, all CBDC information, including account owner details, balances, transaction amounts and transaction sender/receiver identities, can be obfuscated selectively or completely. Moreover, sophisticated techniques can safely enable the selective disclosure of certain transaction details when needed or even calculations on confidential transactions.

To explore possibilities for data privacy within CBDC, policy-makers may wish to ask themselves the following questions:
- What types of privacy and confidentiality would be beneficial within the CBDC system?
- What creative functionalities can be unlocked if privacy and confidentiality needs were addressed and not a concern?

From there, it would benefit policy-makers to explore modern cryptography techniques such as zero-knowledge proofs (ZKP) and secure multiparty computation (MPC) that are increasingly accessible and available for implementation.

For instance, modern cryptography techniques like ZKP and MPC could address the following concerns in CBDC, among others:
- Challenges for the central bank to pay interest rates or subsidies ("helicopter drops") to households in retail CBDC if account balances are not visible to the central bank
  - Zero-knowledge range proofs can indicate to the central bank whether an account balance is within certain ranges without revealing the specific balance and while hiding information from all other parties.
- Concerns regarding the confidentiality of commercial bank transaction information (wholesale CBDC) in a CBDC system based on distributed ledger technology (DLT) with multiple participants
  - ZKPs, such as ZK-SNARKs or ZK-STARKs, can mask sender, receiver and transaction values from all parties. If valuable, functionality could be developed such as that developed in the Zcash privacy-focused cryptocurrency enabling selective disclosure of specific transaction details. Selective disclosure could be provided to a central bank, regulator, law enforcement or other party, for instance.
- Interest in generating insights by performing computations across wholesale or retail CBDC payment data that is encrypted to preserve privacy
  - Secure MPC could enable calculations across encrypted accounts or transactions.

Note: Policy-makers should conduct additional research into these technologies if interested, including an analysis of the trade-offs.

If considering "hybrid CBDC", policy-makers may note that while "hybrid CBDC" shifts some responsibility for user data protections and compliance to the payment providers involved, the central bank must still ensure the payment providers follow clear, enforceable and strong policies and procedures, and meet requirements that reduce risks to consumers and society.

Appendix to Section 8: Evaluation of macroeconomic and financial risks and opportunities

Research:
- Andolfatto, David, "Assessing the Impact of Central Bank Digital Currency on Private Banks" (2018)
- Bank of Canada, "A Tale of Two Countries: Cash Demand in Canada and Sweden" (2019)
- Bank of Canada, "Central Bank Digital Currency: Motivations and Implications" (2017)
- Bank of Canada, "Central Bank Digital Currency and Banking" (2019)
- Bank of England, "Broadening narrow money: monetary policy with a central bank digital currency" (2018)
- Bank of Japan, "Digital Innovation, Data Revolution and Central Bank Digital Currency" (2019)
- Bindseil, Ulrich, "Central Bank Digital Currency - Financial System Implications and Control" (2019)
- Bordo, Michael and Andrew Levin, "Central Bank Digital Currency and the Future of Monetary Policy" (2017)
- Bordo, Michael and Andrew Levin, "Digital Cash: Principles and Practical Steps" (2019)
- Bordo, Michael and Andrew Levin, "Improving the Monetary Regime: The Case for U.S. Digital Cash" (2019)
- Cecchetti, Stephen and Kermit Schoenholtz, "Fintech, Central Banking and Digital Currency" (2017)
- Danmarks Nationalbank, "Central bank digital currency in Denmark?" (2017)
- Keister, Todd and Daniel Sanches, "Should Central Banks Issue Digital Currency?" (2019)
- Universita Bocconi and Société Universitaire Européenne de Recherches Financières (SUERF), "Do We Need Central Bank Digital Currency?" (2018)
- Williamson, Stephen, "Central Bank Digital Currency: Welfare and Policy Implications" (2019)

Appendix to Section 9: CBDC design elements

Research:
- Bank of Israel, "Report of the team to examine the issue of Central Bank Digital Currencies" (2018)
- European Central Bank, "Tiered CBDC and the financial system" (2020)
- IBM and the Official Monetary and Financial Institutions Forum (OMFIF), "Central Bank Digital Currencies" (2018)
- International Monetary Fund, "Designing Central Bank Digital Currencies" (2019)
- Reserve Bank of New Zealand, "In search of gold: Exploring central bank digital currency" (2018)

Discussion: The following are key design parameters for CBDC, as discussed in the toolkit document.

Availability/access
- Operational, technological and financial constraints, capital control policies, and goals and risks associated with the availability and access of CBDC domestically and overseas should be assessed.
- It may be more difficult to constrain access to a given entity or jurisdiction with token-based CBDC than with account-based CBDC.
- Universal retail CBDC requires very high network scalability capabilities.

Custody and storage
- Token-based retail CBDC has a potentially greater risk of loss or theft if the physical device storing CBDC (via a digital wallet) is lost, or from digital theft or loss of account information.
- In a two-tiered CBDC system, it may be the case that the central bank remains liable for KYC and other compliance responsibilities and requirements. Policy-makers must consider and clearly define the share of compliance responsibilities and liabilities between the central bank and intermediaries in a two-tiered system.

Anonymity
- Greater anonymity would likely encourage more consumer adoption and trust; CBDC is more "cash-like" in this case.
- Greater anonymity would make payment monitoring, recovering lost funds, controlling illicit and illegal activity and reversing fraudulent transactions more difficult, all else equal. It would also make achieving KYC/AML/CFT compliance and goals more difficult. If one of the primary goals of CBDC is to reduce illicit activity or to increase the monitoring and visibility of capital flows, then less anonymity is preferable (at the cost of user privacy, adoption and trust). Policy-makers should remember that actors seeking to conduct illicit activity can continue to use physical cash and other alternatives.
- Different degrees of privacy and disclosure can be established for various tiers of transactions or account sizes, or by transaction type.
- Traceability and account/transaction information could be granted selectively and conditionally to counterparties, regulators, central banks or intermediaries. For instance, third parties could potentially receive user transaction information if transaction limits or other parameters are breached, or if there is suspicion of wrongdoing.
- Account-based CBDC entails less anonymity of the CBDC holder, all else equal.
- Token-based CBDC generally entails the potential for greater anonymity, all else equal.

Account and transaction limits
- Transaction size limits can mitigate money-laundering and illicit-activity risks. They can also potentially control digital-bank-run risk, reducing the risk of rapid transfers from commercial bank accounts into CBDC accounts. However, limitation policies could potentially also complicate CBDC supply and availability, creating value premia relative to cash.
- Transaction and account size limits would also reduce the ability for CBDC to serve as a convenient means of payment for larger-size transactions or as a savings account for large account balances, respectively.

Interest payments
- Non-interest-bearing CBDC is more "cash-like".
- Of note, while several macroeconomic research reports about CBDC include non-zero interest payments, most current CBDC conceptions and pilots within central banks do not.
- Retail CBDC:
  - Policy-makers can consider adjustable or tiered interest rates to meet policy objectives and reduce the macroeconomic and financial risks of CBDC.
  - Interest rates can be employed to control the relative attractiveness of CBDC relative to bank deposits. This can help mitigate risks associated with financial disintermediation or digital bank runs in crises.
  - Interest rates could potentially be employed as a monetary policy tool (e.g. transmitting policy rate changes or imposing negative rates on households).
  - Policy-makers should consider the unintended consequences of interest rates and the effects they can have on monetary policy and financial stability goals and risks. It is advisable to study existing research on these subjects.

Conversions and redemption rates
- The central bank can consider how different end users (wholesale or retail) may have different conversion or redemption rates and costs in order to better control financial stability risks. Full convertibility supports CBDC redeemability and use as a means of payment and store of value for retail users. However, it can potentially increase financial instability.
- The convertibility of bank deposits to retail CBDC could potentially be restricted by limitations in time and amount, explicit or implicit guarantees, or other criteria. Policy-makers should consider how convertibility policies may lead to the existence of differently valued domestic currencies (e.g. CBDC valued at a premium or discount to cash) and resultant non-fungibility complications.
- Redemption may be restricted to central bank operating hours.

Settlement times and finality
- Settlement times and finality refer to the speed and frequency at which retail or wholesale CBDC transactions settle and become final between payer and payees. Instant settlement and finality provide greater liquidity for participants; daily or longer settlement times provide more robust security and safety capabilities.
- Transaction settlement mechanisms can vary between centralized (most likely with the central bank) or decentralized (with DLT). DLT-based transaction settlement could increase coordination capabilities with various entities if relevant.

Programmability features
- The programmability of CBDC can support more innovation yet may also create risks. One example is the potential to employ wholesale CBDC in cross-border securities transactions to achieve delivery-versus-payment and reduce settlement risk.
- Purposes for retail CBDC programmability could include automatic subsidies or tax payments, reduced settlement risk in cross-border payments and restrictions on the use of retail CBDC for illicit payment activity.

Lending activity
- Policy-makers could consider whether the central bank or intermediaries should lend retail CBDC balances to stimulate credit availability. The most common approach seen today is that CBDC accounts will not be used for lending activity.
- Policy-makers should consider the core competencies and mandates of central banks, which do not currently include retail lending, along with the complexities, costs and effects on the banking sector associated with retail lending. They may also consider effects to the central bank balance sheet, including exposure to losses from non-performing retail loans.
- Central banks may consider allowing the "packaging" of CBDC balances to third parties who may wish to lend to them, depending on policy goals and risks.

Note: If considering "hybrid CBDC", while the payment providers may be responsible for implementing many design features, the central bank should consider the ideal design and, if possible, may wish to co-design these elements with the providers to achieve better outcomes for the public and the financial and payment systems.

Appendix to Section 10: Technology choices, considerations and risks

Research:
- Bank for International Settlements, Committee on Payments and Market Infrastructures, "Distributed ledger technology in payment, clearing and settlement - an analytical framework" (2017)
- Bank for International Settlements, Annual Economic Report, "Cryptocurrencies: looking beyond the hype" (2018)
- Bank of Canada, Project Jasper collection (2017-2019)
- Bank of Canada, Bank of England and Monetary Authority of Singapore, "Cross-Border Interbank Payments and Settlements" (2018)
- Brainard, Lael, Speech, "Distributed Ledger Technology: Implications for Payments, Clearing, and Settlement" (2016)
- Catalini, Christian and Joshua Gans, "Some Simple Economics of the Blockchain" (2019)
- Financial Stability Board, "Decentralised financial technologies: Report on financial stability, regulatory and governance implications" (2019)
- Gans, Joshua and Neil Gandal, "More (or Less) Economic Limits of the Blockchain" (2019)
- U.S. Federal Reserve Board of Governors, "Distributed ledger technology in payments, clearing, and settlement" (2016)
- Several central bank CBDC experiments conducted since 2016 involve the use of DLT. These experiments appear on the Forum's aforementioned research list.

Discussion:

Selecting the technology solution
Decision-makers should critically evaluate the trade-offs and opportunities associated with a centralized or DLT-based technology solution, noting the risks associated with DLT-based solutions indicated in the toolkit. This analysis should be accompanied by extensive research that might include consultation with neutral technology and policy experts.

How could a DLT-based CBDC be implemented?
If DLT is deemed appropriate, the next step entails evaluating various DLT protocols and their tradeoffs, seeking to learn from existing CBDC pilots and experiments employing DLT. Until the final stages of development, it may benefit policy-makers to keep the proposed design of CBDC technology- or ledger-agnostic. There are many enterprise blockchain and DLT solutions, but betting on one when the market is still relatively immature might be risky and increase vendor lock-in.

Permissioned blockchain networks are the most likely type of DLT to be used to support CBDC as they can afford greater transaction scalability and confidentiality, all else equal. On a permissioned network, capacity is not shared with other applications and transactions. The consensus algorithm is also more flexible as it can be determined explicitly by the central bank, favouring higher throughput if preferable. However, blockchain consensus algorithms often require trade-offs between network security and transaction scalability. Central banks must ensure the highest reliability and security of their systems while meeting other transaction performance goals, which further limits the set of suitable technological solutions.

The technology used to support a CBDC is dependent on the CBDC's design, and DLT may be appropriate at certain points in the system and not others. For example, in the first tier of a two-tiered CBDC, the central bank would create and issue the CBDC to commercial banks without the involvement of DLT. In the second tier, commercial banks or other intermediaries could redistribute the CBDC to the end citizens over the DLT network if desirable.

Interoperability across blockchain networks is also required to achieve "cross-chain" transactions of retail or wholesale CBDC. Standards to support cross-chain communication would also be beneficial in this context. Central banks can look to examples of cross-chain transactions in Phase 3 of Project Stella between the European Central Bank and Bank of Japan, and the PoC between the Bank of Canada's Project Jasper and the Monetary Authority of Singapore's Project Ubin.

Cybersecurity considerations
It is critical to consider cybersecurity across the technology "stack" involved with a CBDC, including the use of application programming interfaces (APIs), data storage and other layers of the technology solution. In addition, the system should be designed in a manner that accommodates important security updates and upgrades when new risk exposures or vulnerabilities are identified.

Considerations for wholesale domestic CBDC
For economies with an efficient real-time domestic settlement and payment system, implementing wholesale domestic CBDC may simply be limited to updating an existing system to enable CBDC and supporting capabilities where relevant.

Considerations for retail CBDC
Interoperability with existing payment providers is also crucial to the success of a retail CBDC. Well-designed APIs and the use of open-source software to the extent possible are important to avoid vendor or platform lock-in. Various payment institutions can connect with these tools, potentially facilitating the provision of additional value-added services from these providers to CBDC users. As with each layer of the technology "stack" comprising these networks, these API integrations must operate at the highest level of security.

Loss from theft or fraud must be strongly considered in CBDC development. Recovery procedures may be needed for end-user wallets. Victims of fraud should be subject to existing compensation and other remedial measures. Provisions for recovery against loss of CBDC must also be considered. Account and password/private key recovery procedures must be in place to allow users who lose digital wallet devices, including mobile phones, or passwords/private keys to access wallets and accounts.

As discussed, retail CBDC requires higher transaction throughput than wholesale CBDC, and any technology implementation must support very high transaction volumes and speeds.

Considerations for "hybrid CBDC": Standardization and interoperability
New, open-standards schemes could provide a framework for broad-based technical collaboration on standards for "hybrid CBDC". Just as the creation of common protocols and standards (e.g. HTTP, SMTP, SMS, VOIP, MP3, JPG) was crucial to the early development of the internet, interoperability will be critical for enabling network effects and realizing the full benefits of "hybrid CBDC". Standardization with already widely adopted protocols could significantly lower the barrier to entry for software developers to build new applications that support "hybrid CBDC". Easier integration and the opportunity for experimentation and innovation are also important in allowing new entrants to create products that can potentially help improve competitiveness and inclusion in payments.

Just as with retail CBDC, a "hybrid CBDC" platform should be able to interact with various systems and applications, including end-user devices and applications, PSPs, clearing organizations, internal support systems and settlement systems so the asset can move seamlessly through the financial system.

Appendix to Section 11: Governance

Discussion: Central bank money can be said to be a public good, and involvement in the decision about whether to issue CBDC should likely not be made by the central bank in isolation. Involvement and engagement with the public and other institutions can be highly valuable in identifying public needs and demands related to possible CBDC solutions. Consultations with the public, directly or through parliament, may support buy-in and broad-based consensus on features and functions for a successful CBDC deployment.

Moreover, legal and regulatory provisions may be required prior to implementation. Where legislation is unclear or restrictive, changes may need to be made to allow full legal tender status and fungibility of CBDC with other central bank money and to provide legal certainty to CBDC use. It may be the case that the adoption of CBDC can be accomplished under the provisions of maintaining smooth and effective payment operations.

Case: Lessons can likely be drawn from the case of Ecuador's *dinero electrónico,* a token-based retail CBDC pilot introduced by the central bank in 2015 with the goal of increasing financial inclusion. The central bank created mobile-phone based applications for citizens to employ *dinero electrónico*, and the central bank centrally settled transactions (it did not use DLT). The CBDC programme closed in 2018 due to lower adoption than targeted and failure to meet financial inclusion goals. While the central bank attempted incentive schemes such as tax incentives when paying with *dinero electrónico*, adoption was ultimately limited. Reasons may include resistance from the banking sector, insufficient user outreach and education, and low interoperability with existing electronic payment networks.

The 2019 paper "Mobile Money Networks with Tax-Incentives" by Ivan Rivadeneyra, Daniel D. Suthers and Ruben Juarez studies the effects of the central bank's tax incentives in encouraging the adoption of *dinero electrónico* in Ecuador. Additional writing on the case of Ecuador has been limited, with exceptions including a 2018 Cato Institute blog post by Lawrence H. White.

Phase 5 – Preparing to deploy

Appendix to Section 12: Implementation strategy

Case: The National Bank of Cambodia (NBC) has likely developed the first full-scale deployment of a quasi-form of CBDC as part of the Bakong project, which launched as a pilot test with a live and confined environment on 18 July 2019 and plans to go live in early 2020. The NBC identified a specific problem in its economy that a new payment system could address: it needed to connect the fragmented payments market, dominated by heavy cash usage and PSPs, with commercial banks, merchants and the country's largely underbanked population in order to reduce payments frictions and increase financial inclusion. The new Bakong National Payment System employs a wallet-based digitized fiat currency on a permissioned DLT network (an implementation of the Linux Foundation's Hyperledger Iroha framework). According to the NBC, PSPs, commercial banks, commercial institutions, merchants and citizens are united through the single platform to seamlessly send payments to one another using the digitized fiat currency.

The NBC has taken a two-tiered approach, issuing the digitized fiat to commercial banks who distribute them to users, including the public and commercial entities. The commercial bank performs all compliance requirements. The general public can download a mobile-phone application created by the central bank that contains a digital wallet, where funds can be converted from balances in over 10 participating commercial banks into the digital fiat currency. The programme stimulates financial inclusion by first requiring registration with commercial banks. People can make payments by scanning QR codes to recipients or sending funds to other mobile-phone numbers connected to Bakong accounts.

While the system operates on DLT with banks and financial institutions as participants, the NBC performs all transaction validation. While DLT is not employed for transaction validation, it serves two purposes according to the NBC. The first is to enable an accessible platform for PSPs, merchants and institutions to easily connect to the system. The second is to provide instant transaction finality when the central bank approves transactions in the system, rather than relying on a deferred settlement system. Instant finality reduces risks of overdraft among the PSPs in the system.

There is no interest rate associated with accounts. The commercial banks involved in transactions have visibility to account identities and payment details, yet the central bank only sees anonymized serial numbers for accounts, enabling it to perform transaction validation without specifically knowing user identities. The size of the NBC's balance sheet does not grow, as the Bakong Settlement Account is provided in exchange for commercial bank reserves already held at the central bank (liability transformation). Finally, account balances are limited based on the demand of the market, with transfer sizes limited to a cap determine by the NBC.

Discussion:

Designing a proof-of-concept or pilot

Before proceeding with a PoC or pilot of CBDC, the central bank must identify and test the appropriate solution architecture and features. The PoC or pilot should aim to source standard technology solutions where possible and use custom developments highly selectively in order to reduce risks. Depending on the technology, several features, including those standard in alternative technologies, may require original developments. The solution architecture should be designed with a view to facilitating integration with existing payments and core banking solutions where appropriate. Participants in the PoC or pilot should ideally include all future participants of a solution to identify and accommodate user-specific needs.

The range of pilots and PoC conducted by several central banks offers a broad library of possible technology solutions for CBDC.

Deployment

Deployment may be phased-in stages by user group, functionality and/or geography. Additional adjustments to the design of CBDC may need to be made if issues with the initial CBDC design are identified. Finally, for retail CBDC, consideration should be given to issues such as merchant acceptance and costs.

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